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of the
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National
Conference of

**ORGANIC AGRICULTURE PROFESSIONALS
IN TERTIARY INSTITUTIONS IN NIGERIA**



Theme

Organic Agriculture: Wealth Creation and Sustainability

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Olusegun Olubode, Omodele Ibraheem and M.A. Jesuyon

ORGANIC AGRICULTURE: WEALTH CREATION AND SUSTAINABILITY

Proceedings of the

17TH ANNUAL CONFERENCE ON ORGANIC AGRICULTURE “ORGANIC OYE-EKITI, 2024”

Held at

**FEDERAL UNIVERSITY OYE-EKITI,
EKITI-STATE, NIGERIA**

March 24 - 28, 2024



**Organic Agriculture Professionals in Tertiary Institutions
in Nigeria
(OAPTIN)**

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Brief information about Organic Agriculture Professionals in Tertiary Institutions in Nigeria (OAPTIN)

OAPTIN is a University-based project with outreaches to Universities, Polytechnics, Colleges of Education and Monotechnics in Nigeria. It was established as a non-profit non-governmental project in June 2004 and registered as a non-profit organization and non-government organization with the Corporate Affairs Commission and reference CAC/IT/No. 133017. OAPTIN's concept of organic agriculture is the production of food and fibre without the use of agrochemicals which are harmful to human health and the environment in the short and long run. It also includes environmentally-friendly technologies that help upgrade marginal production resources and deploy them for increased food production.

OAPTIN VISION: “Good food, safe food and plenty to eat at all time”.

OAPTIN MISSION: Sustainable food security.

PROJECT FOCUS

The focus of OAPTIN project includes:

- **Capacity building:** The development of skilled man-power through degree programme and ad-hoc training courses and workshop
- **Strategic Research:** Research undertaken in diverse Ecologies leading to the development of commercialisable, farmer adoptable, cost effective, highly productive and Sustainable production systems
- **Advocacy:** This is to increase support for the practice of organic agriculture and consumption of organic produce
- **Information dissemination:** For efficient resource utilization and the operation of profitable Organic Agriculture Enterprise through conferences, publications and building partnership.

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MISSING LINKS IN ORGANIC AGRICULTURE PRACTICES IN NIGERIA AND WITH FOCUS ON OAPTIN MISSION

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LEAD PAPER ADDRESS PRESENTED AT THE ANNUAL CONFERENCE OF
ORGANIC AGRICULTURE PROFESSIONALS IN TERTIARY INSTITUTIONS IN NIGERIA
(OAPTIN)

INTRODUCTION

Organic agriculture entails the production system that sustains the health of soils, ecosystems, biodiversity and people. It is also a system of production which does not use synthetic fertilizers, drugs, pesticides, herbicides, growth regulators, antibiotics, hormones, stimulants and livestock feed additives to grow crops and animals. It combines traditional knowledge, innovation, modern science, technologies and practices to benefit the shared environment and promote fair relationship and a good quality of life for all involved. The aims of organic agriculture are all embedded in the four principles of health, ecology, fairness and care. Organic agriculture is about our health, our environment and our future.

The theme of this year's conference is Organic Agriculture, Wealth Creation and Sustainability with the following Sub-themes -

1. Organic Agriculture, Climate Change and Crop/Animal Adaptation.
2. Organic Agriculture, Technological Innovations and Farming Practices.
3. Organic Agriculture, Soil Quality and Plant Health
4. Organic Agriculture, Products Handling, Processing and Preservation.
5. Organic Agriculture, Biosafety and Consumer Health.
6. Organic Agriculture and Economic Perspectives in Production.
7. Organic Agriculture, Adoption, Motivation and Challenges.
8. Organic Agriculture, Restorative Aquaculture in a Rehabilitative Ecosystem.
9. Organic Agriculture and Natural Science

WHO WE ARE/ HISTORICAL BRIEF

The Organic Agricultural Project in Tertiary Institutions in Nigeria is a University based project with an outreach to Nigeria and the rest of sub-Saharan Africa. It was established as a non-profit project in June 2004. Its vision is good food, safe food, plenty to eat all the time'. Its mission is 'sustainable food security'.

Consequently, the Project in collaboration with the Coventry University, UK is organised the 1st National Workshop on Curriculum Development for Organic Agriculture in Tertiary Institutions, 11-15 March 2008 at the University of Agriculture Abeokuta, Nigeria.

- Its activities focuses on capacity building and networking of academics in organic agriculture

FOCAL AREAS

The OAPTIN focal areas included the following:

- Capacity building (The development of skilled manpower through degree programmes and ad-hoc training courses and workshops)
- Strategic research in diverse ecologies leading to the development of commercialisable, farmer adoptive, cost effective, highly productive and sustainable production systems
- Advocacy to increase support for the practice of organic agriculture and the consumption of organic produce
- Dissemination of information for efficient resource utilization and the operation of profitable organic agriculture enterprises through conferences and publications
- Building partnership. The project will gradually reach out to other African countries sharing its expertise and learning from the success stories of others

WHERE ARE WE?

1. CAPACITY BUILDING

The major thrust of OAPTIN in fulfilling the OAPTIN's primary agendum as enunciated by the founding fathers, is capacity building in tertiary institutions. At the 1st National Workshop on Curriculum Development, we were enjoined to work on our respective curricula, to as much as possible, include Organic agriculture courses. I think there are living witnesses here who can attest to this. How much have we fared in this respect? On my own, I infused one Organic agricultural course each into the Master's (CPS 800) and one into the Doctorate (CPS 900) degree programs at the Delta State University, Abraka. It was a smooth sail for me as we were developing the Postgraduate curriculum. I could not do same for undergraduate program, because it was overloaded.

- We just concluded CCMAS curriculum development, a replacement of BMAS, for the University. How many of us used the opportunity to include Organic Agriculture courses into the new curriculum? I added one course to be taken by Crop and Soil Science students (Table 1). If you had the opportunity and you did not do anything, I doubt whether you will have such opportunity again in the near future. I appeal to those who still have the opportunity again in the near future, to do something worthwhile to capture the benefits of organic agriculture in our curriculum.

- Beyond including courses in programs, time is rife for us, especially the older institutions to go beyond the traditional courses. Beyond this shore, you hear of Sustainable Agriculture, Ecological Agriculture and Regenerative Agriculture offered as degree programs in Tertiary institutions. It is strongly proposed here that

Organic Agriculture be taken as programme. It is versatile. It covers almost all the courses in Agriculture, namely Crop Science, Soil Science, Horticulture/Landscaping, Forest Resources and Wildlife Management, Animal Science, Food Technology and what have you? We have come of age and it is possible. Most of the founding fathers of OAPTIN are at the Academic corridors of power. Some are Vice Chancellors, Deputy Vice Chancellors, "Ex-this" and "Ex-that". I do not see why such institutions cannot run full programmes in Organic Agriculture. Let us mushroom relevant programmes instead of mushrooming universities.

Skills Development: The competency levels of employee skills were evaluated for Higher Educational Institutions (HEIs) in core areas of Organic Agriculture by Olowe *et al.* (2018). They reported that of the 10 core identified skills, none was adjudged adequate, while three crop based skills (crop rotation, composting and organic vegetable production) were adjudged inadequate, whilst the remaining seven were grossly inadequate, suggesting that much works will need to be done to improve the capacity of employees in HEIs before they can effectively handle the training of manpower. The story has not changed today. All hands should to be on deck.

There is a dearth of conventional plant breeders. The one under training now are like bat that are neither here nor there. They are partly in conventional breeding and partly in molecular techniques. Depending on where the opportunity swings, they can be directed by the new available fortunes, and I can bet you, it is more in favour of the molecular techniques. We must wake up to this reality.

2. STRATEGIC RESEARCH

According to Rahmann *et al.* (2018) Organic Agriculture is fast emerging as a common household slogan amongst most African families because of rising awareness on the need to consume wholesome food that can nourish the body, improves livelihood and family income. Paradoxically the 1.7 million hectares of land under Organic Agriculture in Africa constitutes just 3% of the World's Organic Agriculture land. There is need to scale up all the modest achievements hitherto recorded. Organic research and corresponding conferences reports have been skewed towards plant production to the neglects of the following important areas as listed in Organic Agriculture Standard in Nigeria (NOAN, 2018): Animal production, Bee-keeping, Aquaculture, Produce Handling, Storage and processing. These areas should be looked into.

Ssekyewa, George and Muller (2013) reported that the most active research bodies in the Sub-Sahara Africa appear to be in Nigeria, where several universities are engaged in projects focused on organic agriculture and are involved in partnerships with other African and non-African bodies. The organic agriculture projects in Tertiary institutions in Nigeria (OAPTIN), based at Nigeria's Universities of Agriculture, Abeokuta, is engaged in both capacity building and research. Similarly, they reported that much of the research being conducted typically to date on organic agriculture in Africa is at the crop and management practice level and is concerned with the impact of compost and soil amendment on crop yields, the identification and evaluation of efficacy of bio-pesticides, and the use of legumes for nitrogen fixation. They reported that there is not much research conducted on organic livestock production in Africa.

The EXPERIMENTAL TREATMENTS in most Organic Research studies, still to a large extent, include conventional agriculture contents, mostly as CHECK. What is the purpose? Is it to accept the CHECK, if it turns out to be most viable alternative? We should begin to move to a level where all the TREATMENTS are Organic.

Time is matured enough for each tertiary institutions to have dedicated plots of not less than 5 hectares for Real Organic Agriculture Teaching and Research. It could also act as Demonstration plot for interested persons. From this humble level, we can expand and begin to assert the dreams of Organic Agriculture. It is doable.

1. ADVOCACY

Delineating Conventional Agriculture from Real Organic Agriculture Research

I strongly believe that our Advocacy to increase support for the practice of organic agriculture should derive strength from our will to convert from conventional to Certified/Real organic agriculture. Furthermore, we are conducting most of our Organic Research on conventional fields. Today I can conveniently predict that a very high proportion of the articles to be presented for this conference are from conventional agriculture and not from the certified/real organic agriculture component. That, to me, is not good enough. That was not the dream of the founding fathers of this noble organization. It would be necessary for the organizers of this conference, to in future, create a line of divide or sectionalize the themes of conferences, such that we begin to separate the grain from the chaff.

We should be more alive in making statements, and regularly too, on **things** that could interfere with Organic Agriculture such as the threat of GMOs

As an academic organ for organic agriculture, there is the need to be proactive and interrogate most of the crop introduction and releases in the country through advocacy.

We should watch out for back-door releases of Genetically Modified Organisms in the name of 'TRANSGENIC HYBRID'. This is going on unabated.

We are all enjoined to openly express our displeasure to any move being made to import or introduce any genetically modified product or produce into the nation's agricultural system. Interestingly, NOAN has been proactive in this direction (NOAN, 2018)

The war against genetically modified crops is a tall order. The struggle against its dominance has been long and the backdoor beneficiaries are not giving up (ERA, 2004).

"Nigeria has approved GM cotton and cowpea, TELA is the first GM maize variety to move toward adoption. The variety offers resistance to the destructive fall armyworm and stem borer pests and can also tolerate moderate drought. The Nigerian variety of TELA maize (Plate 1) was developed by researchers at the Institute for Agricultural Research (IAR) at Ahmadu Bello University. Prof. Rabiu Adamu, principal investigator for TELA maize in Nigeria, expressed optimism in the maize variety's ability to alleviate the production deficits if widely adopted in the country".

If the dream of wide adoption comes true, we shall:

1. Be eating what we do not know.
2. Have the existing traditional maize types and varieties contaminated (Fig 1). By this we must have eroded the rich biodiversity of maize on the altar of a single genetically modified crop species of maize
3. Render the business of organic maize production in the country, impossible.

RECOMMENDATIONS

1. It is recommended that highly powered body be inaugurated by this body to drive the process and drive the message down to all tertiary institutions in having Organic Agriculture as full programme in the tertiary institution's curricula.
2. There is need to create greater visibility with relevant agencies such as
 - TETFUND ---Access to annual National Research Fund
 - National Universities Commission, - Recognition and inclusion of organic courses in curriculum
 - National Board for Technical Education
 - Ministry of Science and Technology (Federal and State)
 - Ministry of Education (Federal and State)
 - Ministry of Agriculture and Natural Resources
3. OAPTIN is 19 years today. It has come of age. It is proposed that the founding fathers and those 'that have kept the faith' be recommended for Fellowship of the Organization. It is better done today than posthumous award. It is time to recognize the founding father and those pushing this dream.

CONCLUSION

We are not there yet.

However, I am happy that the dreams conceptualized by the founding fathers have not capitulated. We are doing well, but I think we can do better.

MY humble submissions, ladies and gentlemen. Thank you for listening.

DELTA STATE UNIVERSITY, ABRAKA FACULTY OF AGRICULTURE , DEPARTMENT OF AGRONOMY B. Sc. CROP SCIENCE and B. Sc. SOIL SCIENCE Programmes DELSU-CPS 403 Organic Agriculture (2 Units; Core) Objectives The objectives of this course are to: 1. explain the concept of organic and traditional farming; 2. explain horticultural crops grown under organic and traditional farming; 3. expose students to the importance and peculiarities of organic farming; 4. inculcate in students the concept of gardening of horticultural crops in relation to organic and traditional production technologies; 5. inculcate in students techniques in bioconversion of wastes to organic manures (composting, vermicomposting, compost tea); 6. introduce students to organic certification and organic market. Course Contents Definition of organic and traditional farming. A comparison of the philosophy, scientific principles and practices of organic and traditional methods of home and market gardens. Sources of organic materials. Classification of organic materials. Sorting/sieving of organic wastes. Importance of organic farming. Peculiarities of organic farming. Concepts of home gardening, market gardening and commercial gardening of horticultural crops in relation to organic and traditional production technologies. Bioconversion processes of wastes to organic manures. Composting techniques. Vermicomposting techniques. Compost tea production. Organic certification procedures. Organic markets and markets requirements in Delta State. Gains in organic farming production system. Constraints to organic farming in Nigeria
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Figure 1. Organic Agriculture input in recent 30 % content of NUC CCMAS



Plate 1. Genetically Modified Maize variety, Tela released as “Transgenic Hybrid”

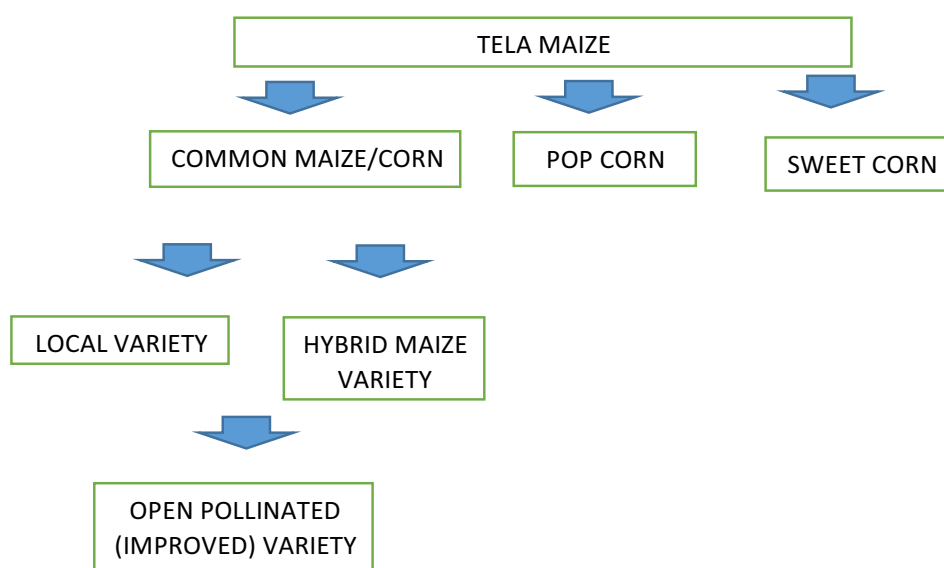


Figure 2: Possible contamination of maize genome by a typical genetically modified maize (Tela)

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THE 17TH NATIONAL ORGANIC CONFERENCE OF ORGANIC AGRICULTURE PROFESSIONALS IN TERTIARY INSTITUTIONS IN NIGERIA (OAPTIN) HELD IN OYE-EKITI, EKITI STATE, NIGERIA, FROM 24TH – 28TH MARCH, 2024

**THE OYE-EKITI 2024 DECLARATION ON:
ORGANIC AGRICULTURE: WEALTH CREATION AND SUSTAINABILITY**

We, the over 84 participants from 12 Higher Educational Institutions (HEIs) in Nigeria attending the 17th National Conference of OAPTIN held in Oye Ekiti, Ekiti State from 24th to 28th March, 2024, having deliberated on the theme "**Organic Agriculture: Wealth Creation and Sustainability**"

AGREE

- * That organic agriculture today is the fastest growing sector of agriculture in the world with a market worth of 134.8 billion euros.
- * That organic producers in Nigeria should start exploring the global and national lucrative market of organic agriculture.
- * That there is need to create greater visibility in relevant HEIs across the six geopolitical zones, ministries, agencies and parastatals such as Ministries of Education, Science and Technology, Agriculture and Natural Resources levels, Tertiary Education Trust Fund (TeTFund), National Universities Commission (NUC), National Board for Technical Education (NABTECH).
- * There is need to strengthen organic input supply chain, enhance market access and value addition, implement education, training and awareness about organic farming, enhance policy support and institutional framework, and lastly community engagement in organic farming practices.

WE APPLAUD

- * The Federal Government of Nigeria for including organic agriculture for the first time in the history of this country in the nations agricultural policy, National Agricultural Technology and Innovation Policy (NATIP) 2022 – 2027.
- * That Organic Agriculture is now a Division within the Department of Farm Input Supply and Services of the Federal Ministry of Agriculture and Rural Development (FMA&RD), Abuja with the oversight function of introducing organic inputs into the farming operations in Nigeria.
- * The Federal University Oye-Ekiti (FUOYE) for hosting a well befitting conference this year.
- *FUOYE for establishing "Green Revolution" project that involves the cultivation of 5 ha of maize and cassava with a view to expanding the field to 20 ha, 5 ha oil palm plantation, as well as construction of two big greenhouses. These initiatives are geared towards proffering solutions to food insecurity in the country by suppressing hunger, alleviating poverty and improving rural livelihoods.

RECALLING

- * That the theme of the conference is very apt at this critical time, as one of the strategies to improve food production in Nigeria.

* That organic agriculture is an integral part of two (2) of the 17 United Nations Sustainable Development Goals (SDGs) firstly, End Hunger, Achieve Food Security, and Improve Nutrition, and secondly, Promote Sustainable Agriculture, and Ensure Sustainable Consumption, and Production Pattern.

* That organic agriculture is one of the eight policy objectives of the current National Agricultural Policy tagged NATIP due to end in 2027.

* That Organic Agriculture has now been approved for National Diploma (ND) programme in Nigeria through NABTECH.

WE RESOLVE THAT

* Henceforth, strategic research projects with clearly defined aims and objectives that are demand driven should be executed in the HEIs with a view to marshalling practical solutions to the problems confronting the stakeholders in their various categories.

* Presentation of papers at future conferences should focus more on the latter part of the organic value chain i.e. processing, marketing, utilization and transportation than the early part (production).

* The hitherto neglected areas of specialization such as Animal production, Bee-keeping, Aquaculture, Produce Handling, Storage and Processing should be looked into in the nearest future.

* More sensitization on understanding Nigeria Organic Standard should be carried out to build the capacity of the practitioners.

* Our budding researchers should be trained on how to lay out experiments on organic agriculture without causing any commingling in the field layout. This will significantly reduce the rejection rate of our publications by reputable journals in organic agriculture.

* The capacity of the upcoming scientists should be built to improve the quality of their presentations (ppt slides) at subsequent conferences.

* Training workshops be carried out as side events during conferences to build the capacity of members in the area preparing manuscripts that can be published in reputable journals.

WE PLEDGE

* That future OAPTIN Conferences will serve as an avenue for organic agriculture practitioners to come and receive solutions to their problems.

* That as key stakeholders (researchers) and repository of knowledge in organic agriculture that our future research endeavors will be demand driven and address real life challenges facing our stakeholders across different categories with a view to generating evidence based interventions that will increase the productivity of the agricultural sector of Nigerian economy.

* That hitherto neglected latter part of the value chain and lesser addressed research areas such as organic animal production, apiculture, aquaculture etc. will be accorded greater attention in the nearest future

WE ACKNOWLEDGE

* That OAPTIN has been in existence for nineteen years especially in most of the Universities across the six geopolitical zones.

* That there is need to review the impact of the curriculum developed in March, 2008 and see how to improve its content to address the emerging problems.

* That there is need to execute the seven point agenda of the interim executives with a view to repositioning OAPTIN in the next one year.

* That OAPTIN conferences have been held in nearly all the six geopolitical zones of Nigeria.

* That there is presently a challenge on the level of awareness about organic agriculture as a production system in Nigeria.

* That not many of the organic agriculture practitioners have adequate knowledge of the content of organic standards. Consequently, there is a paucity of data nationwide to appropriately drive any meaningful policy on organic agriculture in Nigeria.

WE CALL FOR

1. Massive advocacy on the benefits of organic farming across the six geopolitical zones of Nigeria.
2. Regular training of practitioners of organic farming and the certification of their production system to enable them become producers of organic products
3. Establishment of standard organic farms for research and practical activities in the HEIs.
4. Ready availability of organic inputs at very affordable rates, which can also be at subsidized rate.
5. Comprehensive documentation of the membership status of OAPTIN members across the nation.
6. Documentation of the competencies of all members of OAPTIN nationwide.
7. Reinvigoration of organic activities across the six geopolitical zones of Nigeria through the Zonal Coordinators.
8. Networking opportunities with professionals and organizations in the field should also be available as well as support and advisory services, access to updated knowledge, and an alignment with ethical and environmental values.
9. Higher Educational Institutions (HEIs) should have farm equipment and be engaged in more of practical activities than theory.
10. The HEIs that are agriculture based to provide high-quality education and training in organic agriculture.
11. Mainstreaming of organic agriculture into the HEIs curricula covering all the aspects of agriculture.

WE URGE THAT

- * That the Government through the FMA&RD should give organic agriculture more visibility within the ambit of NATIP that is due to lapse in 2027.
- * The present Division within the Ministry of Agriculture should embark on creating access to information materials on organic agriculture and Agro ecology.
- * That agriculture based students should be given more priority in accessing student loans and enjoying tuition free studies in the HEIs.
- * Organic Agriculture be taken as programme and its inclusion in the Higher Institution Curriculum and not be limited to only ND programme.
- * Organic agriculture is versatile and goes beyond crop production, further research should cover almost all areas in Agriculture, namely Crop Science, Soil Science, Horticulture/ Landscaping, Forest Resources and Wildlife Management, Animal Science, Food Technology, Aquaculture, Agricultural Engineering, etc.
- * Each tertiary institutions to have dedicated plots of not less than 5 hectares for Real Organic Agriculture Teaching and Research. This could serve as demonstration plots for interested persons.
- * As an academic organ for organic agriculture, there is the need for OAPTIN to be more proactive and interrogate most of the crop introduction and releases in the country through advocacy. We are all enjoined to openly express our displeasure to any move being made to import or introduce any genetically modified organism (GMO) produce or products into the nation's agricultural system.

APPRECIATING ORGANIZERS

- * Prof. A. S. Fasina, the Vice Chancellor of Federal University Oye Ekiti (FUOYE) and National Coordinator of OAPTIN, Prof. O.B. Kehinde, the Vice Chancellor of Federal University of Technology, Abeokuta.

COLLABORATORS

- * OAPTIN Board of Trustees.
- * The Interim OAPTIN Executive members.
- * Aare Afe Babalola, Founder of Afe Babalola University Ado Ekiti, (ABUAD)
- * Distinguished participants and visitors from all over Nigeria.

WE AGREE to meet at the University of Port Harcourt, Rivers State, Nigeria in 2025.



Prof. V. I. O. Olowe
OAPTIN Interim Nat. Coordinating Scientist



Prof. O. O. Olubode
LOC Chairman, ORGANICOYE2024

FROM FARM TO FORTUNE: CULTIVATING WEALTH & WELL-BEING THROUGH ORGANIC ANIMAL AGRICULTURE IN NIGERIA

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LEAD PAPER ADDRESS PRESENTED AT THE ANNUAL CONFERENCE OF
ORGANIC AGRICULTURE PROFESSIONALS IN TERTIARY INSTITUTIONS IN NIGERIA
(OAPTIN)

It is an honor to serve as one of the Lead Paper Presenters for this pivotal gathering of minds united with a common goal — to explore the transformative possibilities of organic agriculture not just for a sustainable future, but also as the basis for exciting new opportunities for wealth and creation.

The next days would throw up robust discussions, groundbreaking research, and innovative practices all speaking to an interdependent relationship between sustainability and economic prosperity. We shall therefore, in this forum, seek to leverage this synergy of collective wisdom to develop a new agricultural paradigm that esteems the health of our planet and its people. We shall hope to walk together in this interconnected web of components of organic agriculture, unravel its challenges, and celebrate its triumphs.”

STATE OF ORGANIC ANIMAL AGRICULTURE

The discussion around conventional animal agriculture often revolves around concerns such as animal welfare, environmental harm, and the sustainability of our food systems. In stark contrast, organic animal agriculture shines a light on an all-encompassing approach, focusing on ecosystem health, species-appropriate care, and responsible management of resources. It stands as a viable and sustainable path for the livestock sector, capable of lessening environmental impacts, enhancing the well-being of animals, and bolstering economic strength. The global landscape of organic animal agriculture is on an impressive upward trajectory. Countries like Germany, France, and the United States are setting benchmarks in organic production and consumption. Stories of success span the globe, from New Zealand's extensive organic dairy operations to the Netherlands' sustainable poultry practices, illustrating a varied yet cohesive portrait of achievement.

In Nigeria, the organic agriculture sector is on the rise, showing great promise. This growth is fueled by an increasing recognition of the health and environmental benefits associated with organic practices. Organic animal agriculture presents a practical and sustainable option for the livestock industry, with the potential to mitigate environmental issues, improve animal welfare, and enhance economic viability. The harmful effects of synthetic inputs such as synthetic amino acids, animal protein, growth-enhancing hormones, drugs, etc. used in conventional animal production have spurred a rising demand for organic products both locally and globally [1]. Although the market is still developing, the potential for growth remains substantial.

THE PRINCIPLES OF ORGANIC ANIMAL AGRICULTURE

- **Health & Nutrition:** Organic standards ensure animals receive a natural diet, free from GMOs, synthetic fertilizers, and pesticides, promoting overall health and robust immune systems. The product is healthier and tastier.
- **Ethical Treatment & Animal Welfare:** Organic farming practices demand sufficient living conditions, outdoor access, and humane treatment, leading to better animal behavior and reduced stress.
- **Environmental Sustainability:** The role of organic animal agriculture in sustainability is pivotal, emphasizing biodiversity conservation and ecological balance, with a notable reduction in carbon footprints and methane emissions from organic farms. In addition, organic agriculture contributes to mitigating the greenhouse effect and global warming through its ability to sequester carbon in the

soil. Also, excess nitrogen excretion and minerals such as phosphorus are abated. A good environment is also created and sustained when the wastes from the farm are recircled back to the farm in the form of organic fertilizer to crop farmers and feed ingredients to livestock.

- **Economic Viability and Social Responsibility:** Despite challenges such as scalability and higher production costs, the organic sector offers significant economic benefits, including a consumer willingness to pay a premium for organic products. The commitment to social responsibility and community engagement is demonstrated through initiatives like the Organic Farmers Welfare Program (OFWP).

LINKING ORGANIC ANIMAL AGRICULTURE TO WEALTH CREATION

Besides, there has always been a high valuation for products obtained from organic agriculture, ensuring better margins for the producing community. For instance, studies have shown that organic dairy farming can be more than 20% better in profitability than the conventional practice [2]. It also positively impacts the local communities by creating jobs and developing local markets.

IMPACT ON HEALTH AND WELL-BEING

a) Impact on consumers health

Organic animal products are not only good for the environment but are also healthier. It was found that organic milk and meat contain about 50% more omega-3 fatty acids compared to conventionally produced products [3]. Omega-3 has a positive impact on heart health, cognitive function, and overall well-being. In general, this shift to healthier products greatly contributes to public health. In his study [4] on the health implications of organic agriculture pointed out that products from organically reared animals are free from harmful synthetic hormones and antibiotics. It linked the consumption of organic animal products to lower incidences of health issues including antibiotic-resistant infections and hormone-related disorders.

b) Impact on the health of the farmer

Additionally, [4] highlighted that farmers engaged in organic animal agriculture are less exposed to harmful chemicals, leading to better overall health and reduced medical expenses.

SUSTAINABILITY AND THE ENVIRONMENT

Animal agriculture has been central to the maintenance of biodiversity, enhanced soil health, and lessened the degree of carbon being released into the atmosphere. This is, for instance, with organic farming practices that increase the sequestration of soil carbon, which is pivotal in the mitigation of climate change [5]. According to [6], it was observed similarly that the application of organic farming including that of animal agriculture has led to reducing soil erosion and leaching of nutrients; which eventually increases soil fertility and structure. It also helps to reduce high health risks often occasioned by environmental contamination through anthropogenic contribution. Of importance is the ability to plow back some farm wastes which could have been an environmental menace to increase and sustain food security.

CHALLENGES OF ORGANIC ANIMAL FARMING

Organic farming is an agricultural process that includes organic fertilizers (e.g.- bone meal, green manure, compost manure), pesticides, livestock food additives, growth regulators, and genetically modified organisms. However, Organic Farming has some challenges. These include-

High cost: One of the major disadvantages associated with organic farming is the high costs involved in the process [7]. Because there is no use of pesticides the crops grown are far more vulnerable to pests and disease. Farming can be a lot more labour intensive and the cost of organic feed is much higher than non-organic feed. These costs are passed on to the consumer making organic food more expensive to buy than conventionally produced food. Whilst many people are more than willing to pay more for their food because it is organic, during times of hardship and recession people are less likely to buy organic when they can get the same food for a cheaper price [8].

Poor Marketing: Since food is produced in small quantities, the distribution and marketing of food are not as efficient.

Requirement of adequate knowledge: This is a special process. Thus, organic farmers need to have sufficient skills required for it. They should have adequate knowledge of localized soil systems, ecology, meteorology, and other factors responsible for crop growth. If the farmer does not have enough knowledge and skill, they will be unable to save the crop from [9].

Easily susceptible to disease: Organic crops are prone to disease. Because of this, the pace of production may slow down [10].

Lack of Subsidy: Farmers not only have to face the issue of bad crops, but they also have to face the loss of the subsidy they get to other farmers. Crop disease and bad weather conditions make them lose their land and livelihood.

Organic Pesticides and Other Chemicals: Organic farmers use low-concentration organic pesticides and chemicals. They are harmless but can be toxic to crops if used frequently [11].

STRATEGIES FOR WEALTH AND WELL-BEING THROUGH ORGANIC ANIMAL AGRICULTURE

The organic animal agriculture sub-sector stands a chance to be a significant arm of the organic agricultural system in Nigeria. The following strategies should lead to the elimination of the constraints and capitalization of opportunities in the subsector for enhanced wealth creation, sustainability, and well-being.

A) Strengthening of Organic Input Supply Chain

i) Promotion of Local Organic Inputs' Production: Encouragement and support in the production of organic inputs, such as organic feeds, repellents for natural pests, and soil enhancers, possibly through the mechanism of subsidies, technical assistance, and training programs [12].

ii) Create Input Supply Networks: Develop and nurture networks and cooperatives to ensure the supply of inputs in time and at cost-effective prices to organic farmers.

B) Enhancing Market Access and Value Addition

i) Developing organic value chains: Special value chains should be developed for organic products where at every step from the production to distribution level, organic value is developed.

ii) Organic Market Linkage: Getting organic farmers linked with markets, local or international; it may be chains of retail, trade to organic food fairs, or e-promotions.

C) Education, Training, and Awareness

i) Farmer's Education Programs - Execution of wide-ranging education programs for farmers on organic animal husbandry, sustainable farming practices, and business management. Knowledge is the fundamental transition to the maintenance of organic practices in farming. This can be achieved through the production of pamphlets written in local languages and the organization of workshops for traditional farmers. The use of herbs to mitigate some disease outbreaks and morbidity should be emphasized. Farmers should be trained on how to cultivate the herb plants and from there develop their business plans vis-a-vis creating jobs and employment opportunities. Here the services of extension agents should be given a high premium [13].

ii) Consumer Awareness Campaigns: Organize consumer awareness campaigns to enumerate the benefits accruable from the uptake of organic produce. An informed consumer base can drive demand and ensure a stable market for organic products.

D) Technology Integration and Innovation

i) Adoption of Sustainable Technologies: Adoption of technologies that help in increasing the productivity of organic farming. This will include sustainable water management systems, use of renewable sources of energy, and recycling of organic wastes.

ii) Innovation in Organic Practices: Encourage innovation in organic animal agronomy through support to research and development. Majorly, basic and adaptable research should be funded by the government and well-to-do individuals. This will ensure that the organic inputs are tested and that farmers are convinced to use the tested inputs. This would result in better management practices, superior quality products, reduced costs, and so forth.

E) Policy Support and Institutional Framework

i) Policy environment: Advocacy and contribution towards the policy space supportive of organic agriculture, including those related to land use, organic certification, subsidies for organic inputs, and research in organic farming cannot be underscored. Arising from the health benefit of organic agriculture, policy borne out of sincerity to enhance engagement in organic agriculture and consumption of animal products from it should be put in place. This policy must ensure that the products from organic animal agriculture are affordable by the masses.

ii) Strengthen Institutional Support for organic farming, including but not limited to agricultural extension services, bodies for certification of organic food and farming inputs, and farmer cooperatives is imperative. Products supplied by organic animal agriculture must be standardized to meet international market requirements. Many individuals are expected to be engaged along the value chain of production and marketing. This will have a profound impact on job and wealth creation among the youth and women.

F) Community Engagement and Social Capital

Inclusive community development: The initiative to develop organic farming will be all-inclusive in the process of eliciting local communities' involvement in making decisions. The initiative could enhance the building of social capital, making the entire community come on board in support and thus making the organic practice sustainable. This will have a positive impact on retirees and women seeking job opportunities.

ii) The second set of people targeted are the youths, in the sense that such policies will encourage organic farming as a modern viable, and sustainable career option for the youth. Training and startup support can attract the youth towards organic farming which ensures that this industry will have a growing and sustaining future.

This is a reason why it calls for an all-round effort from the government, private sector, farmers, and the community. The country's agricultural land will be transformed into a viable and sustainable sector, potentially becoming one that will have to contribute significantly to national wealth, health, and the overall well-being of the nation.

CONCLUSION

It is dawning on us that what organic animal agriculture has cut through in Nigeria is not just an agricultural trend but a transformational movement aptly set to redefine paradigms of farming, health, and environmental stewardship. The road from the farm to a fortune via organic agriculture comes paved with immense prospects and potential benefits for the country's farming community and the nation at large.

With consumers becoming more health-conscious both locally and internationally, coupled with global market access that is widening, this is a window of opportunity for Nigeria to tap into the organic market space. However, the full potential of this can be realized if only this potential is properly harnessed through the embracing of technological innovations and ensuring education and training of the farmers to be able to produce not just in quantity but with quality and organically.

Still, more important will be the supportive policies that play a pivotal role and the effectiveness of a public-private partnership that can never be overemphasized. Hence, an all-inclusive synergistic approach involving all stakeholders must, therefore, be paramount in dealing with the prevailing challenges to build sound infrastructure conducive to the growth and sustainability of organic animal agriculture.

In light of these reflections, the call to action for policymakers, farmers, investors, and consumers is clear. It's the right time to invest, support, and participate in the revolution of organic agriculture. It is an organic revolution— a revolution that promises not just wealth and prosperity but also health and sustainability for generations to come. This is so because the future of organic animal agriculture in Nigeria is not only a promise but a kind of actuality possible to be translated through our collective wills, commitments, and shared visions of a greener, healthier, and prosperous society.

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EFFECTS OF FERTILIZER SOURCE AND STAKING ON ORGANOLEPTIC PROPERTIES OF CUCUMBER

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ABSTRACT

Cucumber is a significant vegetable that is used for variety of purposes. The experiment was carried out between June and September 2023 at the Federal Polytechnic Ilaro, Nigeria to determine the effects of fertilizer source, staking and variety on organoleptic properties of cucumber. The experimental site was cleared and tilled mechanically. The plot was marked and pegged into plot size of 3m×3m and margin of 1m between the three replicates. 10t/ha poultry manure rate and 3g/plant of N. P. K 15:15:15 was applied based on treatment except for the control. The sensory evaluation was done using 30 respondents to access the organoleptic qualities. The data for the primary source were collected using sensory assessment sheet with a nine-point hedonic scale. The results showed that the effects of fertilizer, staking and variety were significant on almost all the organoleptic properties of cucumber. Staked African giant cucumber treated with organic fertilizer were better in terms of texture, colour and aroma (unstaked) while untreated fruit gave the highest taste value followed by organic, this report will be confirmed in the next planting season. Staked Tokyo treated with organic fertilizer was better in terms of taste while inorganic had the best in appearance and texture, this might be attributed to the fact that inorganic fertilizer releases its nutrient rapidly. Staking also had significant effect on the colour, appearance, taste, aroma, and texture. In conclusion, Staked African giant treated with 10 t/ha poultry manure had more acceptable sensory properties when compared to Tokyo.

Keywords: Aroma, Fertilizer Organoleptic, Stake, Variety

INTRODUCTION

Cucumber belongs to the Cucurbitaceae family made of 118 genera and 825 species, other crops in the same family includes watermelon, musk melon, squash and pumpkin (1). It can be cultivated in the subtropical and tropical environments. Growing in popularity throughout most of Nigeria is the cultivation of cucumbers, presumably due to their high nutritional and financial worth (2). The crop offers numerous health benefits when consumed fresh, such as significant anti-inflammatory, antioxidant, and anti-cancer properties (3). One of the key components to a great cucumber crop cultivation is fertilizer (4).

Fertilizers are materials that provide one or more plant nutrients to the soil when they are introduced, it may be inorganic or organic (4). Organic fertilizer is mostly made up of plant and animal residues (5,4), while inorganic fertilizers are chemical compounds produced in factories. Staking has a significant impact on the quality of cucumber fruit. The reason behind staking of cucumber fruit is that when climbing crops, such as cucumbers, are left on the ground, their fruit and shoots may eventually rot (6). Cucumber is an important vegetable with a lot of uses (7, 8), hence there is need to consider fertilizer effect on different sensory attributes of cucumber, to evaluate consumer's acceptability. The study was aimed at determining the effect of fertilizer source, staking and variety on organoleptic properties of cucumber.

MATERIALS AND METHODS

The field experiment was carried out at The Federal Polytechnic Ilaro, Ogun State, Nigeria (latitude 6°53'N, longitude 2°58'E), between June and September, 2023. Cucumber F1 seed (Tokyo and African giant) was obtained from Lagos, Kuch -99 agricultural and seeds limited. The poultry manure was obtained from The Federal Polytechnic Ilaro, Nigeria. The Directorate of Agrobusiness and Agropreneur (layer unit). 10t/ha poultry manure (organic) and N.P.K 15:15:15 (inorganic) was applied per plot based on the treatment except for control. The experimental site was cleared and tilled mechanically. The plot was marked and pegged into plot size of 3m×3m and margin of 1m between the three replicates. All necessary cultural operation was carried out.

Participants in the descriptive research were from The Federal Polytechnic Ilaro, Ogun State. Students of the department of Agricultural Technology participated in the quantitative research. A total of 30 respondents were used in this study and the data for the primary source were collected using sensory assessment sheet with a nine-point hedonic scale. To access the organoleptic qualities, panelists were told to taste, assess the aroma, and examine the appearance. Samples of cucumbers were rated according to their aroma, texture, taste, appearance, and colour. Analysis of variance One-Way (ANOVA) was used to determine statistically significant difference between the samples.

The result of the analysis of variance (ANOVA) conducted showed that there was significant difference ($p \leq 0.05$) in the appearance of cucumber across Sample A-E (African Giant Variety). Staked cucumber fruit, treated with inorganic fertilizer gave the highest mean value of $8.86 \pm 1.25de$ while Unstaked cucumber fruit treated with inorganic fertilizer gave the lowest mean value of appearance ($7.93 \pm 1.92abcd$) (Table 1.1). For Taste it was significant ($p \leq 0.05$) across the samples, Untreated cucumber fruit gave the highest mean value of $8.20 \pm 1.91bc$ followed by Organic staked ($7.86 \pm 1.81ab$) while Staked cucumber fruit treated with inorganic fertilizer gave the lowest ($7.80 \pm 1.32bcd$) (Table 1.1). There was significant difference in the texture, colour (Sample A&E) and Aroma. For Texture and Colour respectively. Staked cucumber treated with Organic fertilizer gave the highest mean value of $8.40 \pm 1.42c, 8.20 \pm 1.76b$ while Control gave the lowest mean value of $6.20 \pm 2.48a, 6.93 \pm 1.79a$. For Aroma, unstaked cucumber fruit with Organic manure gave the highest mean value ($8.26 \pm 2.01cd$) and control gave the lowest mean value of $8.26 \pm 2.01cd$ (Table 1.1).

The result of the analysis of variance (ANOVA) conducted showed that there was significant difference ($p \leq 0.05$) in the appearance of cucumber across Sample F-J (Tokyo Variety). Staked cucumber fruit, treated with inorganic fertilizer gave the highest mean value of appearance ($9.06 \pm 1.14e$) followed by organic staked ($8.66 \pm 1.42de$), while Unstaked cucumber fruit treated with inorganic fertilizer gave the lowest ($7.06 \pm 1.72a$) (Table 1.2). For taste, there was significant difference ($p \leq 0.05$), Staked cucumber fruit, treated with Organic fertilizer gave the highest mean value of ($9.20 \pm 1.44de$) while unstaked treated with inorganic fertilizer gave the lowest mean value of ($8.06 \pm 1.77bc$) For texture, it was significant ($p \leq 0.05$) while colour was not significant except Sample J. (Table 1.2). For Aroma, Sample F, H and I were similar and sample L and N were also similar.

DISCUSSION

This study accessed the acceptability and comparative analysis of cucumber treated with fertilizer sources (organic and inorganic), variety (African giant and Tokyo) and staking in order to determine the differences in the sensory qualities, in terms of appearance, texture, taste, aroma and colour. It was observed that all the varieties were acceptable. Also, it was revealed that staked African giant cucumber treated with organic fertilizer were better in terms of texture, colour and aroma (unstaked) this corroborates with the findings of Djoufack et al., 2023(9) who observed the best scores in sensory quality of carrot treated with 10t/ha poultry manure. Parwada et al., 2021(10) also reported that infant spinach's sensory properties were reportedly improved by the use of organic manures. In terms of taste, untreated fruits gave the highest taste value followed by organic, this report will be confirmed in the next planting season. Staked Tokyo treated with Organic fertilizer was the best in terms of taste while inorganic had the best in appearance and texture, this might attributed to the fact that inorganic fertilizers releases its nutrient rapidly. It was also noted that staking improved the cucumber's appearance, color, taste, texture, and aroma.

These observations are consistent with studies conducted by Okonmah (2011) (11) and Hardy et al., (2002) (12), which found that staking improved the color of cucumbers, decreased the incidence of yellow bellies, increased fruit yield, prevented disease and pest infestation, and increased the percentage of marketable fruits.

CONCLUSION

In conclusion, the two varieties had acceptable sensory properties in terms of appearance, taste, texture, colour and aroma. Although, Staked African giant treated with 10t/ha poultry manure had more (texture, colour and aroma) acceptable sensory properties when compared to Tokyo.

Representation of Sample varieties:

Sample	VARIETY
A	Organic Fertilizer, Staked (African giant)
B	Organic Fertilizer, No staking (African giant)
C	Inorganic staking. (African giant)
D	Inorganic No staking (African giant)
E	Control (African giant)
F	Inorganic Fertilizer, staking (Tokyo),
G	Organic Fertilizer, staking (Tokyo)
H	Organic Fertilizer, No staking (Tokyo)
I	Inorganic Fertilizer, No staking (Tokyo)
J	Control, Fertilizer. (Tokyo)

Table 1: African Giant; Sensory attribute of Cucumber as affected by Variety, Fertilizer, Staking

Treatment	Appearance	Taste	Texture	Colour	Aroma
Mean (A)	8.40±1.69 ^{cde}	7.86±1.81 ^{ab}	8.40±1.42 ^c	8.20±1.76 ^b	8.13±1.56 ^{bc} d
B	8.00±1.48 ^{g bcd}	7.80±1.76 ^{ab}	7.66±1.97 ^{bc}	8.00±2.03 ^{ab}	8.26±2.01 ^{cd}
C	8.86±1.25 ^{de}	7.80±1.32 ^{bc} d	7.73±1.55 ^{bc}	7.80±1.76 ^{ab}	7.06±1.72 ^{ab}
D	7.93±1.92 ^{abc} d	7.20±1.62 ^a	7.76±2.27 ^{ab}	7.60±1.69 ^{ab}	7.06±1.87 ^{ab}
E	8.80±1.62 ^{de}	8.20±1.91 ^{bc}	6.20±2.48 ^a	6.93±1.79 ^a	6.66±2.36 ^a

Table 2: Tokyo; Sensory attribute of Cucumber as affected by Variety, Fertilizer and Staking

Treatment	Appearance	Taste	Texture	Colour	Aroma
Mean(F)	9.06±1.14 ^e	8.80±1.44 ^{cde}	8.53±1.73 ^c	8.00±1.96 ^{ab}	7.93±1.85 ^{bcd}
G	8.66±1.42 ^{de}	9.20±1.44 ^{de}	7.53±1.71 ^{bc}	7.73±2.08 ^{ab}	7.20±1.62 ^{abc}
H	7.66±2.03 ^{abc}	8.46±1.71 ^{bcd}	7.40±1.67 ^{bc}	7.93±1.52 ^{ab}	7.86±2.02 ^{bcd}
I	7.06±1.72 ^a	8.06±1.77 ^{bc}	7.73±2.39 ^{bc}	7.80±2.05 ^{ab}	7.33±2.18 ^{abc}
J	7.40±1.90 ^{ab}	8.20±1.68 ^{bc}	8.00±1.81 ^{bc}	8.26±1.72 ^b	8.33±1.74 ^{cd}

Source: Extracted from XL Stat Output, version 5.03.

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EFFECTS OF WEED CONTROL METHODS ON FRUIT YIELD IN OKRA (*Abelmoschus esculentus* [L.] MOENCH) IN DERIVED SAVANNAH AGROECOLOGY

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ABSTRACT

Mulching offers enormous advantages in vegetable production, the practice has, however, not been extensively investigated under local conditions. Effects of organic mulching materials on weed flora and okra var. (NHAe47-4) productivity were evaluated at the Teaching and Research Farm, Federal University Oye Ekiti, Ekiti State, during the 2020 planting season. Four organic mulching materials (OMM) tested for their efficacies on weed control included; sawdust (T1), wood shavings (T2), grass straw (T3), and *Tithonia diversifolia* straw (T4), applied at 5 tons ha⁻¹ followed by one supplementary hoe-weeding (SHW) at 6 weeks after planting (WAP), 2 HWs at 3 and 6 WAP (T5) plus unweedy check (T6). The results showed that T5 produced maximum number of okra fruits /plant (11.6), total fruit weight/plant (501.7g) and fruit yield/ plot (3.54kg) while T6 had 4.13 fruits/plant, 77.1g for fruit weight/plant and 0.51kg for fruits yield/plot. Prevalent annual weed flora with high relative abundance at 6WAP included; *Tithonia diversifolia*, *Euphorbia heterophylla*, *Amaranthus spinosus* and *Digitaria horizontalis* plus three perennial sedges such as *Cyperus rotundus*, *Cyperus esculentus* and *Mariscus alternifolius* including *Adropogon tectorum* the only giant grass. In conclusion, it was observed that T5 produced the heaviest yield and yield components of okra followed by T3 and T4, therefore, increasing the rates of organic materials used for the last two treatments could enhance the productivity of the crop.

Keywords: weed control, organic mulches, weed flora, Okra, yield

INTRODUCTION

The adoption of herbicides for weed control had negative impact of the herbicidal spray drifts on the environment and human health. This has culminated in the advocacy for non-chemical weed control method in crop production [7]. Okra (*Abelmoschus esculentus* (L.) Moench) is a vegetable grown for its young leaves and fruits exclusively consumed by different households and ethnic groups worldwide. On the average, fresh okra fruits contain 6.4g (carbohydrate), 1.9 g (protein), 1.2g (fibre), 0.7g (minerals) and 0.2g (fat) per 100g edible portion and (energy value) 4550 kcal/kg [5]. The crop is mostly grown as a companion crop, interplant or intercropped with maize, cassava, yam, cocoyam, tomato and garden egg by small holder farmers in Nigeria, a farming system noted for numerous production constraints (2). Among other challenges, weed interference appears to be the most deleterious and underestimated biological pest with enormous crop yield losses [4]. Previous literatures, [8], attributed yield reductions of about 34%, 18% and 16% in traditional crops due to weeds, vertebrate pests and plant pathogens respectively. In okra production, [10], indicated that losses in fruit yield caused by weed menace ranged from 54 to 91%. Arising from these observations, [8], opined that effective weed control method with timely weed removal is vital to the quality of marketable produce and high yields.

In Nigeria, several weed control options including; crop rotation, use of cover crops, green manure, mulching with organic or inorganic materials, application of animal faecal matter and use of allelopathic plants explored in organic agriculture have been reported with good results [5]. The present study was conducted to evaluate effects of different organic mulching materials on weed flora composition and fruit yields of okra in a derived savanna environment.

MATERIALS AND METHODS

Experimental Procedures

Field trial was conducted at the Teaching and Research Farm, Federal University Oye Ekiti, Ikole campus, Ekiti State, during the early season of 2020. The experimental site was ploughed once, stumped, raked and leveled manually at two weeks interval.

Composite soil samples of the experimental field were collected for physico-chemical analysis. A randomized complete block design with three replications was adopted for the study. Each plot measured 2.4m x 3m, and was demarcated by 1m and 0.5m alleys between blocks and plots respectively. Each replicate consisted of six plots, and a total of 18 plots served as experimental unit. Three seeds of okra variety (NHAe47-4) were planted manually at a spacing of 60 cm x 40 cm between plants and within plant rows, and thinned to two plants per stand at 2WAP giving plant population density of 208, 333. Weed control treatments comprised four organic mulching materials viz; sawdust (T1), wood shavings (T2), grass straw (T3) and *Tithonia diversifolia* straw (T4), each of which was applied at 5 tons ha⁻¹ followed by one supplemented hoe-weeding at 6 weeks after planting (WAP), 2hoe-weedings at 3 and 6WAP (T5) and the unweeded control (T6).

Agronomic practices such as seed treatment using fungicide (Furadan) at 8 g per 10 kg seeds and poultry manure applied at 10 tons ha⁻¹ recommended for okra was distributed evenly over the experimental unit. Mulching treatments were applied to the appropriate plots at 3WAP, and hoe-weeded once at 6WAP. A quadrant of 0.5m² dimension thrown twice within the diagonals of each plot was used for collection of weed samples prior to application of weed control treatments. Hand weeding treatment was carried out using a short handle West African hoe. Weeding operations preceded data collection on weed flora composition and okra yields at harvest.

RESULTS AND DISCUSSION

Weed flora composition from the experimental area at 6 WAP showed a cumulative of 24 weed species comprising broadleaved, grass and sedge having 17, 4 and 3 species per category respectively, Table 1. Of the 9 plant families encountered, *Asteraceae* with 20.8% recorded the highest weed flora composition and *Poaceae* 16.5% followed by *Euphorbiaceae*, *Leguminosae* and *Cyperaceae* having 12.5% plant population per family. The unweeded plots produced the highest weed flora comparable with sawdust and wood shaving treatments at 6WAP. During the period, annual broadleaved weeds including; *Amaranthus spinosus*, *Euphorbia heterophylla*, *Digitaria horizontalis* and *Talinum triangulare* predominated the fields. In addition, *Calopogonium mucunoides*, *Mimosa pudica* and *Solanum torvum* were most frequent perennials in T6, but none of T1 and T2 combined with supplementary hoe-weeding was as effective as T5, T4 and T3 in controlling weeds. In respective of weed control treatments, plots with high clay soil content had more of *Cyperus* spp. and *Adropogon tectorum* due to poor drainage than plots with sandy loam texture. The prevalence of annual broad-leaved weeds over narrow species from the experimental field agree with [10], who reported similar occurrence in the savanna agro-ecology caused by rich soil seed bank, frequent soil disturbance and adequate rainfalls.

Two hoe-weedings at 3 and 6 WAP at the yield data (Table 2) produced maximum number of fruits/plant (11.6) compared with the unweeded T6 with the least (4.13) similar to sawdust and wood shaving treatments. Although all the treatments revealed insignificant response for fruit weight/plant (g) and fruit yield/plot (kg) (Table 2), the higher number of fruits/plant in plots hoe-weeded twice aligned with [9] and [10], who suggested that timely weeding operations prevented early weed competition and provided a conducive environment for nutrient availability for crop growth and development. The okra variety which showed differential response to the weed control management for fruit number indicated that some treatments enhanced fruit number/plant. Insignificant response of the vegetable for pod yield/plant and pod yield/plot as affected by the weed control treatments suggest that treatments (T1 to T5) did not influence fruit yield (Table 2). The higher moisture stress and competition for nutrient suffered by plants subjected to T6 may be responsible for poor okra productivity.

CONCLUSION

The present study has revealed that mulching with T3 and T4 gave okra fruit yields higher than T1 and T2, but slightly lower than T5 treatment.

To overcome the production challenges posed by manual hoe-weeding in organic farming, increasing the rates of organic materials used in T3 and T4 may have positive impact on okra productivity.

Table 1: Effects of Organic Mulching Materials on Weed Flora Composition at 6WAP

Weed categories / families		Weed species	Growth habit
Broadleaved	(%)		
<i>Asteraceae</i>	20.8	<i>Celosia argentea</i> (L.)	ABL
		<i>Tridax procumbens</i> (Linn.)	ABL
		<i>Tithonia diversifolia</i> (Hemsl.) A. Gray	PBL
		<i>Biden pilosa</i> (L.)	ABL
		<i>Acanthospermum hispidum</i> DC	ABL
<i>Euphorbiaceae</i>	12.5	<i>Synedrella nodiflora</i> (L.)	ABL
		<i>Euphorbia heterophylla</i> (Linn.)	ABL
		<i>Euphorbia hirta</i>	ABL
		<i>Phyllanthus nurii</i>	ABL
<i>Leguminosae</i>	12.5	<i>Senna hirsuta</i> (Linn) Irwin.	ABL
		<i>Calopogonium mucunoides</i> (L.)	ABL
		<i>Mimosa pudica</i> (L)	PBL
<i>Malvaceae</i>	NN	<i>Corchorus olitorus</i> (L.)	ABL
<i>Portulacaceae</i>	NN	<i>Talinum triangulare</i> (Jacq.) Wild	PBL
		<i>Portulaca oleracea</i>	PBL
Grasses: <i>Poaceae</i>	16.7	<i>Andropogon tectorum</i> (L.)	PG
		<i>Chloris pilosa</i> (Linn.)	AGL
		<i>Digitaria horizontalis</i> (Jacq.)	AGL
Sedges: <i>Cyperaceae</i>	12.5	<i>Cyperus esculentus</i> (Linn)	PS
		<i>Cyperus tuberosum</i> (Thonn)	PS
		<i>Mariscus alternifolius</i> (Vahl)	PS

Legend: ABL = Annual broadleaved; Perennial broadleaved; AGL = Perennial Grass; Perennial Sedge; N = Negligible.

Table 2: Effects of Organic Mulching Materials on Okra Fruit Yields

Weed Control Treatments	Number of fruits/Plant	Pod weight/ plant (g)	Pod yield/plot (kg)
T1	5.8b	218.6	2.48
T2	6.2b	224.8	2.43
T3	8.4b	380.6	2.86
T4	9.5b	381.9	2.92
T5	11.6a	501.7	3.54
T6	4.1b	77.5	0.51
LSD (0.05)	3.05	NS	NS

Means followed by the same letters along the column are not significantly different ($P \leq 0.05$). Legend: T1 = Sawdust, T2 = Wood shavings, T3 = Grass straw, T4 = *Tithonia diversifolia* straw, T5 = 2 Hoe-weeding at 3 and 6 WAP and T6 = Control

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NUTRITIONAL QUALITY ASSESSMENT OF ORGANICALLY GROWN CORCHORUS OLITORIOUS

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ABSTRACT

Jute mallow (*Corchorus olitorius*) is a popular indigenous vegetable crop with antibacterial properties useful in the treatment of numerous diseases and having the potential to alleviate malnutrition. Considering its richness, it is necessary to check for any possible changes in the nutrient of the soup made from organically grown jute mallow soup. A study was conducted at the Hospitality and Tourism Management, Federal University Oye-Ekiti to determine the nutritional qualities, organoleptic properties of organically grown jute mallow soup. A group of 30 panelists were considered for the organoleptic test and questionnaires were administered to them. The samples were analyzed in the laboratory to determine the nutritional qualities. The result showed that most of the panelists (96.7%) liked to eat jute mallow soup while those that eat it frequently were 35%. Most of the respondents (44%) buy from the market while others did from the farm gate. About 50% of the panelists rated organically raised products' overall acceptability as extremely. The organically raised products had high content of ash, calcium, iron, vitamin A and DPPH value. In conclusion, the study revealed that organically grown jute mallow had great preference among panelists and the nutritional contents were highly favoured.

Keywords: Jute mallow, organically grown products, nutritional content, organoleptic properties

INTRODUCTION

Corchorus olitorius, often known as jute mallow or Egyptian spinach, has been a part of traditional meals in many cultures for ages. It is known locally in Nigeria's Yoruba dialect as *Ewedu*. While sometimes overlooked in modern cuisine, its nutritional profile and health benefits make it a strong contender for a spot on everyone's plate. *Corchorus olitorius* thrives on well-drained, loamy soil with a pH ranging from slightly acidic to neutral (6.0 to 7.0). Soil rich in organic matter stimulates vigorous development and improves nutrient uptake by plants. *Corchorus* is a warm-season crop that thrives in tropical and subtropical environments. The ideal temperature range for germination and growth is between 25°C and 35°C (77°F to 95°F).

Corchorus olitorius contains critical vitamins and minerals that are necessary for good health. According to a study published in the Journal of Food Composition and Analysis, *Corchorus* leaves are high in vitamin C, a powerful antioxidant required for immunological function and collagen formation^[1]. Furthermore, these leaves are high in vitamin A, which promotes visual health and immunological function^[2]. Aside from vitamins, *Corchorus* leaves provide vital elements such as calcium, iron, and magnesium. A study published in the Journal of Agricultural and Food Chemistry underlines the large iron concentration in *Corchorus* leaves, making it a helpful addition to treat iron deficiency anemia, especially in locations where availability to iron-rich foods is limited.

The nutritional value of *Corchorus olitorius* results in a slew of health benefits. One major advantage is its possible application in diabetes management. According to a study published in the International Journal of Diabetes in Developing Countries, *Corchorus* leaves have hypoglycemic qualities that aid in blood sugar regulation and insulin sensitivity^[3]. Furthermore, *Corchorus* is known for its anti-inflammatory qualities. According to a study published in the Journal of Medicinal Food, the bioactive chemicals contained in *Corchorus* leaves have significant anti-inflammatory properties that may help alleviate the symptoms of inflammatory illnesses such as arthritis and inflammatory bowel disease. Beyond its nutritional and therapeutic properties, *Corchorus* leaves have culinary diversity. *Corchorus* leaves are commonly used in soups, stews, and

salads, adding a distinct flavor and texture to the dish. The mucilaginous structure of *Cochorus* leaves thickens soups and stews, improving their consistency and mouth feel. Furthermore, *Cochorus* leaves can be included into smoothies and juices to add a nutritious boost to beverages. Its moderate flavor profile makes it versatile in culinary preparations, allowing chefs and home cooks alike to experiment with new recipes and cooking techniques.

MATERIALS AND METHODS

Jute mallow was obtained from the Teaching and Research Farm, Federal University Oye Ekiti, while the other sample of the Jute Mallow used to compare the sample from the School Farm was bought from the local market within the town. Both of the vegetables were rinsed with water and cooked with equal amounts of water, bicarbonate, locust bean, seasoning cubes, and salt. After the preparation of the *Cochorus* leaf to make the soup, both Organically Grown Jute Mallow and the Jute Mallow bought from the market were subjected to organoleptic testing; the nutritional properties were also investigated. Proximate composition determination: Moisture content, total ash, fat, carbohydrate, sodium, calcium, potassium, copper, magnesium, iron, manganese, zinc, phosphorus and DPPH content of the organically grown *Cochorus* and the *Cochorus* bought from the market were determined using the standard methods of Association of Official Analytical Chemist (2015)^[1] and Spectrometry was also carried out.

$\text{CHO \%} = 100 - (\% \text{Moisture} + \% \text{Crude fat} + \% \text{Total ash} + \% \text{Crude fibre} + \% \text{Crude protein})$

Mineral compositions determination: Calcium, magnesium, iron, copper and zinc were determined using atomic absorption spectrophotometer (AAS Model SP9). Sodium and potassium were determined using flame emission photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK) with NaCl and KCl as the standards^[1]. Phosphorus was determined using Vanado-molybdate method.

Sensory analyses were conducted at the Hospitality and Tourism Management Restaurant, Federal University Oye Ekiti, Nigeria. Members of the Panel included Students and Staff at the Ikole Campus of the University. Both samples were coded as “A” and “B” and the Panelists were individually given an opportunity to taste the prepared soups (both sample A and B). Water at room temperature was provided for mouth rinsing in between successive evaluation. Questionnaires were provided to the Panelist to fill in their assessments. Sample attributes (colour, texture, taste, aroma, etc.) were rated on a nine-point scoring scale, where a = dislike extremely and i = like extremely. Descriptive statistics was employed. Data were analyzed using Statistical Package for Social Sciences (SPSS) version 16 at $p \leq 0.05$.

RESULTS AND DISCUSSION

Result showed that majority (96.7%) of the panelist like to eat jute mallow soup and 35% also claimed that they eat it frequently. Most (44%) of the respondents buys from market. 78.3% of the panelist rated texture of the soup from organically grown jute mallow as like extremely, 53.3% rated taste as like extremely, 43.3% rated aroma as like extremely, 53.3% rated appearance as like extremely while 50% of the panelist rated soup from organically grown jute mallow overall acceptability as like extremely while 12% of the panelist rated the one made from market source as like extremely. Soup from organically grown jute mallow has lesser moisture than that bought from market, soup from organically grown *Corchorus olitorius* has higher content of ash, calcium, iron, vitamin A compared to the one market bought and DPPH value is also higher than that of market source. The study revealed that soup made from organically grown was more preferred to the one brought from market, implying that if people get a source for organically grown jute mallow they would definitely go for it. Also, the nutritional contents of soup from organically grown jute mallow were more favourable. Another very compelling argument in favour of organic vegetables is the absence of synthetic pesticides, herbicides, and fertilizers commonly used in conventional farming.

These chemicals not only pose a threat to human health but also wreak havoc on ecosystems and biodiversity. By choosing organically grown vegetables, individuals can minimize their exposure to harmful chemicals, thereby safe guarding their health and well-being. Organic farming practices prioritize sustainability by embracing principles that minimize environmental impact and promote ecosystem health. Unlike conventional farming, which relies heavily on synthetic inputs and monoculture cropping systems, organic agriculture emphasizes biodiversity, crop rotation, and natural pest management techniques. These practices not only conserve soil fertility and water resources but also mitigate greenhouse gas emissions, making organic farming a more environmentally sustainable choice^[4]. By supporting organic agriculture, consumers contribute to the preservation of biodiversity, soil health, and overall ecological balance.

CONCLUSION

It is evidence that organically grown vegetables have emerged as champions in the realm of nutrition. This is in line with studies that have consistently shown that organically grown produce tends to have higher levels of essential nutrients compared to their conventionally grown counterparts. Furthermore, organic farming practices promote soil health, fostering a nutrient-rich environment that enhances the uptake of minerals by plants, thereby enriching the nutritional profile of organically grown vegetables. The case for organically grown vegetables transcends mere nutritional superiority; it embodies a holistic approach to food production that prioritizes human health, environmental sustainability, and ethical stewardship. By opting for organic produce, individuals empower themselves to make informed choices that resonate with their values and aspirations for a healthier planet. As we navigate an era of unprecedented environmental challenges and growing health concerns, embracing organic agriculture emerges as a tangible solution that holds promise for future generations.

Table 1: Sensory evaluation table expressed in percentage

		LE	LVE	LM	LS	NLND	DS	DM	DVM	DE
Texture	Organically	78.3	18.3	3.3	-	-	-	-	-	-
	Bought from market	25.0	30.0	23.3	21.7	-	-	-	-	-
Taste	Organically	53.3	31.7	11.7	3.3	-	-	-	-	-
	Bought from market	16.7	13.3	36.7	25	6.7	-	1.7	-	-
Aroma	Organically	43.3	45.0	10.0	1.7	-	-	-	-	-
	Bought from market	11.7	38.3	21.7	18.3	8.3	-	1.7	-	-
Appearance	Organically	53.3	36.7	10.0	-	-	-	-	-	-
	Bought from market	6.7	46.7	30.0	16.7	-	-	-	-	-
Overall Acceptability	Organically	50.0	33.3	16.7	-	-	-	-	-	-
	Bought from market	12.0	38.0	33.3	16.7	-	-	-	-	-

Note: Like extremely = LE , Like very much = LVE , Like moderately = LM , Like slightly = LS , Neither like nor dislike = NLND , Dislike slightly = DS , Dislike moderately = DM , Dislike very much = DVM , Dislike extremely = DE

Table 2: Nutritional qualities of the *Corchorus olitorius*

PARAMETERS	Organically grown	Market procured
MOISTURE(%)	22.190	24.530
ASH(%)	2.247	2.162
FAT(%)	8.520	9.185
FIBRE(%)	20.938	24.250
PROTEIN(%)	16.750	18.530
CHO(%)	29.374	21.373
CALCIUM(mg/100g)	90.800	83.600
IRON(mg/100g)	3.956	3.171
VITAMIN A(IU/100g)	1.788	1.513
VITAMIN B3(%)	1.340	2.062
VITAMIN B9(µg/100g)	195.220	202.152
VITAMIN C(mg/100g)	8.538	10.295
DPPH(%)	91.160	86.580

Source: College of sciences research and extension unit ABUAD.

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EFFECTS OF POULTRY MANURE ON THE GROWTH PERFORMANCE OF MORINGA OLEIFERA

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ABSTRACT

Among the important herbs and medicinal plants in popularity due to recent discoveries of its usefulness to mankind is *Moringa oleifera* resulting in rapid interest in the plant requiring research into improvement in production practices. Experiment was conducted at the Federal College of Forest Resources Management, Maiduguri in 2022 to determine the effects of organic (poultry manure) fertilizer on the growth performances of *Moringa oleifera*. The experiment consisted of three treatments in which poultry manure was applied at three levels of 0, 10g and 15g, and designated as treatment 1, 2 and 3 respectively in five replicates respectively. The experimental design was Completely Randomized Design (CRD). Growth parameters measured included: number of leaves per plant, plant height (cm) and stem girth (cm). Data collected were subjected to ANOVA using Duncan Multiple Range Test (DMRT) to separate the means. Result of the analysis shows that 15g of poultry manure applied to the plants at week 10 produced more leaves (140 leaves), the tallest plant (56.4cm) and highest stem girth (1.78cm) when compared to 10g poultry manure and control plants. Researchers conclude that vegetative growth of *Moringa oleifera* was best supported by the application of 15g poultry manure compared to control treatment.

Keywords: Poultry manure, *Moringa oleifera* and growth parameters

INTRODUCTION

Moringa oleifera has gained a lot of popularity due to recent discoveries of its usefulness to mankind, resulting in rapid interest in the plant [1]. *Moringa Oleifera* belongs to the monogeneric family of shrubs and trees, called *Moringaceae*. The tree originated from Agra and Qudh in Northwestern region of India, South of the Himalayan Mountain. The tree has spread to almost all tropical belt because it is drought-resistant [2]. There is an increasing national and international interest in the planting of *Moringa oleifera* as a non-timber tree species because of its nutritional, medicinal and economic value [3]. Organic materials serve not only as sources of plant nutrients but also as soil conditioners by improving soil physical properties, as evidenced by increased water infiltration, water holding capacity, aeration and permeability, soil aggregation and rooting depth, and by decreased soil crusting, bulk density and erosion [4]. Usually, when organic wastes of acceptable quality are returned to agricultural soils on regular basis, they contribute greatly to the overall maintenance of soil fertility and productivity and reduce the need for mineral fertilizer. Consequently, this study was conducted to compare the growth response of *Moringa oleifera* to among three treatment levels of poultry manure.

MATERIALS AND METHODS

Experimental Procedures:

A pot experiment was carried out in 2022 at Maiduguri, Nigeria according to the method described by [5]. The area has a bimodal rainfall pattern with a rainy season between April and August and a shorter rainy season from September to early Novembers. The experiment was arranged in a Complete Randomized Design (CRD) with five replicates. Topsoil was filled into each of the fifteen polythene bags. One seed was planted into each of the polythene bags at a depth of 3cm, the soil was affirmed and watered immediately for proper plant establishment. Each seedling received 400 ml of water twice daily until they were 17 days old when the treatments began. All the seedlings were subjected to the same watering regime throughout the experimental period. Three levels of poultry manure namely: 0g, 10g and 15g levels were compared, using the first treatment as the control. *Moringa oleifera* growth was assessed by the number of leaves per plant, plant height (cm) and stem girth (mm).

RESULTS

The average number of leaves per plant tended to increase across all treatments over the weeks irrespective of the level of poultry manure applied (Table 1).

Application of poultry manure increased the height of *Moringa* plant over the weeks (Table 2). Tallest plant of 56.40 cm at week 10 was produced by 15g poultry manure while the shortest plant of 39.38cm was produced by control plant. The differences in height yield between poultry manure and control plant is statistically significant ($p < 0.05$) using Duncan multiple range.

The stem girth tends to increase as growth progressed irrespective of the level of poultry manure applied (table 3). The highest stem girth value of 1.78 cm at week 10 was observed in plant that received 15g of poultry manure while the lowest stem girth value of 0.91 cm was observed at week 4 in control plant. There is no significant differences ($p < 0.05$) between the stem girth observed in poultry manure and that of control plant ($p < 0.05$).

DISCUSSION

The application of organic manures to soil provides potential benefits including improving the fertility, structure, water holding capacity of soil, increasing soil organic matter and reducing the amount of synthetic fertilizer needed for crop production [6]. The effect of compost and other organic amendment on crop growth and development may be as the result of the interaction between the nutrients present and plant growth hormones, as compost and co-compost has been found to contain auxins, gibberellins and cytokinin [7]. The highest plant obtained from plant treated with 15g poultry manure in this research at week 4 (44.72 cm) and week 8 (54.35 cm) where lower than that obtained from compost + topsoil (50.6 cm) at week 4, rice husk + topsoil (94.4cm) at week 8 as reported by [8] but higher than that of poultry manure (42.6 cm) as reported [5]. The highest stem girth (1.56 cm) produced at week 8 from the plant treated with 15g poultry manure in this research is lower than that of compost + topsoil (1.76 cm), poultry manure + topsoil (1.60 cm), rice husk + top soil (1.84cm) [7] but higher than that of top soil only (1.36 cm) [7]. It is important to note that, at week 10, plant treated with 15g of poultry manure recorded the highest stem height and the highest stem girth. This indicates that, stem height growth goes with the growth in stem girth. The highest number of leaves (121) produced from plant treated with 15g poultry manure at week 10 in this research is lower than that of compost + topsoil (307) and poultry manure + topsoil (179) [8].

CONCLUSION

In conclusion, the poultry manure application rates had effects on *Moringa oleifera* growth in terms of stem height, stem girth and number of leaves. Poultry manure application rate of 15 g gave the highest growth rate of *Moringa oleifera*, hence could be adopted by resource poor small holder *Moringa oleifera* farmers in the country where the manure is readily available.

Table1: Effects of poultry manure level on leaf count of *Moringa oleifera* plant

Treatments (g)	Weeks			
	4	6	8	10
C	54 ^c	71 ^c	94 ^c	109 ^c
T ₁	63 ^a	93 ^a	116 ^a	140 ^a
T ₂	59 ^b	85 ^b	110 ^b	122 ^b

Note: C: control, T₂: poultry manure =10g, T₁: poultry manure =15g, ^{a,b,c}, means within a column with different superscripts are significantly different ($P < 0.05$)

Table2: Effects of poultry manure level on plant height (cm) of *Moringa Oleifera* plant

Treatments (g)	weeks			
	4	6	8	10
T ₁	44.72 ^a	49.40 ^a	54.35 ^a	56.40 ^a
T ₂	43.80 ^b	47.60 ^b	52.00 ^b	53.59 ^b
C	39.38 ^c	42.80 ^c	47.60 ^c	49.20 ^c

Note: C: control, T₂: poultry manure =10g, T₁: poultry manure =15g, ^{a,b,c}, means within a column with different superscripts are significantly different (P <0.05)

Table 3: Effects of poultry manure level on stem girth (cm) of *Moringa oleifera* plant

Treatments (g)	weeks			
	4	6	8	10
T ₁	0.92 ^b	1.24 ^a	1.56 ^a	1.78 ^a
T ₂	0.90 ^b	1.22 ^a	1.44 ^a	1.76 ^a
C	0.91 ^b	1.22 ^a	1.08 ^a	1.76 ^a

Note: C: control, T₂: poultry manure =10g, T₁: poultry manure =15g, ^{a,b,c}, means within a column with different superscripts are significantly different (P <0.05)

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NUTRIENT COMPOSITION OF COOKIES MADE FROM WHEAT, PLANTAIN PEEL AND GINGER COMPOSITE FLOUR

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ABSTRACT

Cookies are one of the confectionary food products consumed in Nigeria especially among children, however, the unavailability of wheat flour due to harsh growing condition for growing wheat plant has been a major economic and political issue necessitating substitution studies. Experiment conducted at the Federal University Oye-Ekiti considered cookies baked from a composite flour blend consisting of flours from Wheat, Unripe plantain and Ginger using whole wheat flour as control. The substitution evaluated three mixtures of 100% wheat (WFO), 90% wheat, 5% unripe plantain flour, 5% ginger flour (WUG), and 80% wheat, 10% unripe plantain flour, 10% ginger flour (WGU). The flours were analyzed for proximate composition and mineral contents. The cookies were also subjected to sensory analysis. The results of the proximate composition showed that the substitution using WGU was higher in protein compared to the whole wheat flour. Sensory evaluation showed the whole wheat cookie was more acceptable compared to the experimental cookies with WGU being the most preferred of the two.

Keywords: Composite flour, Sensory analysis, Wheat substitution, Ginger, Unripe plantain

INTRODUCTION

Cookies are baked treats which are small sweet, crispy or cake-like pastry often made with wheat flour, sugar, water and fat. Cookies are one of the confectionary food products consumed in Nigeria especially among children. Wheat Flour is the key ingredient in cookie production but the harsh climatic conditions in the tropical region is not conducive for the growth of the wheat plant thus the availability of wheat flour has been a major economic and political issue. Wheat flour can be substituted when mixed with another type of flour produced from either roots, tubers or legumes. According to the FAO, over 2.3 million metric tons of plantain are produced in Nigeria annually. However, about 35% - 60% post-harvest losses had been reported and attributed to lack of storage facilities and inappropriate technologies for food processing [3]. This research was aimed to examine the nutritional changes on substitution of Wheat flour with unripe plantain peel (*Musa paradisiaca L.*) and ginger (*Zingiber officinale*) flours in cookie production.

MATERIALS AND METHODS

Experiments were conducted at the Federal University Oye-Ekiti, Ekiti State, Nigeria. Wheat flour (*Triticum spp.*), Unripe Plantain Peel (*Musa paradisiaca L.*) and Ginger (*Zingiber officinale*) used for this research study were purchased from Oja - Oba market in Akure, Ondo State, Nigeria. Unripe plantain peel Flour was produced using the methods of Akubor and Ukwuru [2] with slight modifications. Matured unripe plantain fruits were washed in flowing tap water, hand peeled and separated into pulp and peel. The peel was then dried at 40°C for 48 h in a hot air oven. Fresh ginger roots were sorted, soaked in water for 3 to 4 minutes and then washed under running water to remove the dirt completely. They were then peeled and thinly sliced into small pieces using a sharp knife, and oven dried at 60°C for 72 hrs. Dried plantain peels and ginger were milled separately, sieved and stored for further use. Wheat, unripe plantain peel and ginger flours were blended as shown in Table 1. The resulting composite blends were kept in air tight containers until needed for production of cookies and analysis. To produce the cookies the dry ingredients (100g flour, 40g butter, 40g sugar, 40g powdered milk, a pinch of salt, 1 egg, and milk flavor) were thoroughly mixed in a bowl by hand for 3mins. The batter was rolled on a clean and smooth surface with a rolling pin and cut into various shapes with a cutter. The cookies were placed on baking trays leaving spaces between them and baked at 180°C for 10 mins in the oven.

The baked cookies were allowed to cool at ambient temperature, packaged in polyethylene bags and stored at 23°C till needed. Proximate composition and mineral contents were determined by the AOAC methods of analysis [1].

RESULTS AND DISCUSSION

The result of the proximate composition of the cookie samples are presented in Table 2. The results show sample WUG had the lowest moisture content (1.18%) and sample WGU had the highest (3.44%). Low moisture content of the wheat flour would enhance its storage stability. The moisture content of all flour was within the acceptable limit of not more than 10% for long term storage of flour [4].

The results also show that crude fiber was highest in the control sample WFO (22.65%) and was lowest in sample WGU. Crude fibre helps in bowel movement and the prevention of a host of diseases.

For protein content, sample WGU had protein contents higher than that of the control sample WFO. This may be attributed to the higher substitution rate with unripe plantain peel flour.

The results of the mineral composition of the flour blends are shown in Table 3. Sodium was not detected and Phosphorus was the most abundant element in the flour blends. There was a significant difference ($p \leq 0.05$) between the control sample (100% wheat) and the flour blends. Potassium content ranged between 1.94mg/100g and 5.62mg/100g with the least value recorded for 100% wheat flour (WFO) (1.94mg/100g) and the highest value for 80% wheat, 10% unripe plantain peel and 10% ginger flour blend (WGU) (5.62mg/100g). Potassium protects against arterial hypertension [7]. Also, potassium is required to maintain osmotic balance of the body fluids, the pH of the body, to regulate muscle and nerve irritability, control glucose absorption, and enhance normal retention of protein during growth [5]. WUG had the highest calcium content. Calcium constitutes a large proportion of the bone, human blood and extracellular fluid. It is necessary for the normal functioning of cardiac muscles, milk coagulation and blood clotting, and the regulation of cell permeability [6].

The mean sensory scores of the cookies produced from the flour blends are as displayed (Table 4). Levels of flour substitution showed significant differences ($p \leq 0.05$) in all the sensory attributes evaluated except texture. For overall acceptability, cookies produced from 100% wheat flour (WFO) were most preferred but cookies from 80% wheat, 10% unripe plantain peel, 10% ginger (WGU) were the more preferred of the two experimental cookies.

CONCLUSION

The inclusion of unripe plantain peel flour and ginger powder to the production of cookie was of an acceptable quality. Unripe plantain peel flour could be added to bread up to 10% without any significance adverse effect regarding the quality, nutritional composition and uniformity. The WUG samples that have varying mineral contents contained the highest mineral levels. In conclusion, cookie sample WUG was the best of the experimental blends due to its higher nutritional content and consumer preference.

Table 1: Composite flour blend formulations used for the production of cookies

Treatments	Wheat flour (%)	Unripe plantain peel flour (%)	Ginger flour (%)
WFO	100	0	0
WUG	90	5	5
WGU	80	10	10

Notes: Values with the same superscript across columns indicate no significant difference at $p \leq 0.05$

WFO – 100% wheat, WUG– 90% wheat, 5% unripe plantain flour, 5% ginger flour, WGU 80% wheat, 10% unripe plantain flour, 10% ginger flour

Table 2: Proximate Composition (mg/100g) of Wheat, Unripe Plantain Peel and Ginger Flour Blends

Treatments	M.C	ASH	FIBRE	FAT	PROTEIN	CHO
WFO	1.79±0.01 ^b	2.94±0.08 ^a	22.65±0.15 ^a	33.90±0.20 ^b	8.19±0.04 ^b	30.72±0.78 ^c
WUG	1.19±0.00 ^c	2.55±0.25 ^b	11.40±0.20 ^b	35.55±0.35 ^a	7.25±0.07 ^c	42.10±0.93 ^b
WGU	3.44±0.06 ^a	2.21±0.03 ^b	1.30±0.20 ^c	26.65±0.25 ^c	9.66±0.36 ^a	57.47±2.08 ^a

Notes: Values with the same superscript across columns indicate no significant difference at $p \leq 0.05$

WFO – 100% wheat, WUG – 90% wheat, 5% unripe plantain flour, 5% ginger flour, WGU – 80% wheat, 10% unripe plantain flour, 10% ginger flour

Table 3: Table showing mineral composition (mg/100g) of the wheat, unripe plantain peel and ginger flour blends

Elements	WFO	WUG	WGU
K	1.94±0.04 ^c	3.27±0.01 ^b	5.62±0.06 ^a
Ca	2.55±0.02 ^c	3.75±0.04 ^a	3.75±0.04 ^a
P	3.90±0.06 ^c	5.06±0.01 ^a	4.77±0.04 ^b
Fe	1.51±0.04 ^b	1.76±0.03 ^a	1.60±0.10 ^{ab}

Notes: Values with the same superscript across rows indicate no significant difference at $p \leq 0.05$, WFO – 100% wheat, WUG – 90% wheat, 5% unripe plantain flour, 5% ginger flour, WGU – 80% wheat, 10% unripe plantain flour, 10% ginger flour

Table 4 : Sensory evaluation result of the cookies produced

reatments	Flavour	Colour	Taste	Texture	Aroma	Overall Acceptability
WFO	7.60±0.69 ^a	8.10±1.10 ^a	8.30±0.95 ^a	6.20±1.03 ^a	8.30±0.67 ^a	8.00±0.67 ^a
WUG	6.10±1.85 ^{ab}	5.40±2.01 ^b	5.60±1.27 ^b	5.60±1.96 ^a	6.20±1.32 ^b	6.20±1.32 ^b
WGU	5.70±1.57 ^b	4.50±2.27 ^b	5.80±1.39 ^b	6.70±1.49 ^a	6.40±0.84 ^b	6.40±0.69 ^b

Notes: Values with the same superscript across columns indicate no significant difference at $p \leq 0.05$

WFO – 100% wheat, WUG – 90% wheat, 5% unripe plantain flour, 5% ginger flour, WGU – 80% wheat, 10% unripe plantain flour, 10% ginger flour

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OPTIMIZATION AND PROXIMATE COMPOSITION OF WHEAT, UNRIPE PLANTAIN, AMARANTH GRAIN AND TIGERNUT FLOUR BLENDS

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ABSTRACT

Bread, a common dietary staple, not only acts as an excellent energy source and nutrient carrier but also serves as a suitable vehicle for delivering phenolic antioxidants and fiber polysaccharides. This study conducted at the Federal University Oye- Ekiti, Nigeria explores the proximate composition of flour blends consisting of wheat, amaranth, unripe plantain, and Tiger nut. Utilizing locally available ingredients holds promise for enriching the nutritional content of staple foods. Proximate composition parameters—moisture, protein, fat, carbohydrate, and dietary fiber—were analyzed for the 16 generated runs. The ranges of values for moisture, fat, fiber, ash, protein, carbohydrates, and energy for the flour samples varied between 1.93 in Run 7 and 3.00 in Run 3, 9.11 in Run 2 and 15.32 in Run 8, 1.24 in Run 8 and 3.11 in Run 14, 2.11 in Run 4 and 3.41 in Run 7, 9.62 in Run 7 and 13.64 in Run 9, 66.01 to 72.34g/100g, and 1699 to 18520kcal/100g, respectively. The optimal blend, selected by response surface methodology for high protein and fiber content, comprised 40% wheat, 20% unripe plantain, 30% amaranth grain, and 10% Tiger nut rice. In conclusion, substituting wheat flour with amaranth, unripe plantain, and Tiger nut offers a cost-effective solution, enhancing nutritional value while potentially aiding in blood sugar control due to the resistant starch content in unripe plantain.

Keywords: Flour, blends, wheat, amaranth, unripe plantain, tiger nut

INTRODUCTION

Functional foods, introduced in Japan in the mid-1980s, offer benefits beyond regular nutrition and seamlessly integrate into daily diets (5). Bread, a common dietary staple, not only acts as an excellent energy source and nutrient carrier but also serves as a suitable vehicle for delivering phenolic antioxidants and fiber polysaccharides (9). Wheat, a globally vital cereal crop, is a significant source of energy, protein, and dietary fiber, with gluten proteins playing a crucial role in driving global demand for processed foods (11). Categorizations like "clean" or "brown" with gluten and "soft" or "weak" with low gluten impact wheat's applications. Wheat flour, constituting approximately 71% complex carbohydrates, plays a pivotal role in human nutrition. Plantain, a tropical fruit and staple in Central and West Africa, significantly contributes to local nutrition, particularly in Nigeria. With diverse ripeness stages and cooking methods, plantain serves as a staple with anti-ulcerogenic, antimicrobial, and analgesic properties (4). Processed into flour or chips, plantains offer dietary options, including potential use for obese individuals. Rich in minerals and vitamins, plantains, especially as chips, are popular snacks in Nigeria. Amaranths, a major leaf vegetable crop, holds therapeutic value for cardiovascular diseases and cancer prevention due to its high phytosterol content. Amaranth's high dietary fiber and natural antioxidants make it valuable for food products, and its historical use in traditional medicine underscores its significance.

Tiger nut, a globally cultivated plant known for its edible tubers or tiger nuts, is rich in proteins, starches, and nutrients (1). Used in snacks and beverages, tiger nuts have widespread appeal. The dependence on imported wheat flour burdens the Nigerian economy and non-wheat-producing countries, leading to high baked product costs. The dominance of wheat flour in the baking industry n proteins playing a crucial role in driving global demand for processed foods (11). Categorizations like "clean" or "brown" with gluten and "soft" or "weak" with low gluten impact wheat's applications. Wheat flour, constituting approximately 71% complex carbohydrates, plays a pivotal role in human nutrition. Plantain, a tropical fruit and staple in Central and West Africa, significantly contributes to local nutrition, particularly in Nigeria. With diverse ripeness stages and cooking methods, plantain serves as a staple with anti-ulcerogenic, antimicrobial, and analgesic properties

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The abundant production of amaranths, unripe plantain, and tiger nut in Nigeria makes them viable substitutes, lowering costs and enhancing nutritional value. Including unripe plantain flour, rich in resistant starch, may contribute to better blood sugar control, potentially reducing the risk of diabetes (2). This research aimed to optimize the composite flour blends and determine their proximate composition.

MATERIALS AND METHODS

Experimental Procedures

Wheat, Unripe plantain, Amaranth and Tiger nut was purchased from Ikole central market, Ekiti State, Nigeria. Other equipment used during processing such as bowl, sieve, baking pans, baking tray were also purchased from Ikole central market. All other reagents used were of analytical grade.

The preparation of unripe plantain flour involved washing and manually peeling matured unripe plantain fruits. The pulp was sliced into uniform pieces, dipped in sodium metabisulphite solution, and dried at 80°C for 24 hours. The dried slices were milled, sieved, and stored in an airtight container (6). For amaranth flour, grains were cleaned, washed, and dried at 80°C for 24 hours. The dried grains were milled, sieved through a 425µm mesh, and stored in a polythene bag at room temperature [10]. Tiger nut flour was prepared by sorting, washing, and drying the grains, followed by milling and sieving through a 425µm mesh. The resulting flour was sealed in polyethylene bags and stored at room temperature [10]. Determination of Proximate Composition was done for Moisture, crude fat, crude protein, Total ash, crude fibre was determined using standard methods.

RESULTS AND DISCUSSION

The proximate composition of the composite flour had Moisture content ranged from 1.93g/100g to 3.12g/100g across different runs, indicating low moisture consistent with dry flour samples (Table 1). This aligns with findings by [8; 9], suggesting extended shelf life against microbial activities. The fat content varied between 9.119g/100g and 14.343g/100g, with the higher fat content attributed to the incorporation of Tiger nut flour. Tiger nuts are rich in lipids (22.14–44.92%), serving as a source of edible oils with monounsaturated fatty acids. The high fat content suggests potential benefits for transporting fat-soluble vitamins and preventing excessive water loss. Crude fiber content ranged from 1.22g/100g to 3.22g/100g, showing an increase with the substitution of wheat-plantain-amaranth-Tiger nut flour blend.

Mature green plantain, amaranth, and Tiger nut are known for their fiber richness, enhancing gastrointestinal tract function and reducing obesity and diabetes risk. Sample 3, with higher dietary

content met the recommended 25% Recommended Daily Intake (RDI) for adults (>14 g/100 g). Inclusion of mature green plantain and amaranth flour enhances nutritional value, promoting growth and tissue repair. Sample 9, with higher protein content, may support growth and development.

Comparable results were reported in multigrain bread by (5) with amaranth flour. Ash content, representing mineral content, was highest in sample 11 (3.44), indicating potential richness in minerals. Tiger nut and unripe plantain are known sources of dietary fiber, minerals, vitamins, and antioxidants. Carbohydrate content ranged from 66.10% to 72.34%, with the higher values suggesting a rich carbohydrate source. Carbohydrates are crucial for energy, especially for infants and adults engaged in activities for growth and development. The highest gross energy value (1837.7 kcal/100 g) was observed in samples 15 and 16, suggesting that the composite flour from wheat, mature green plantain, amaranth, and Tiger nut flour may provide ample calories for daily activities. These samples may be suitable for athletes requiring increased energy for daily exercises.

CONCLUSION

The exploration of composite flour blends incorporating wheat, unripe plantain, amaranth, and tiger nut presents a promising avenue for developing a nutritionally enriched alternative. The amalgamation of these diverse ingredients results in a flour blend that addresses fundamental dietary needs. Wheat, a primary component, contributes substantial energy, protein, and complex carbohydrates, with gluten enhancing structural versatility for various food applications. Unripe plantain, rich in resistant starch, adds to energy reserves and supports blood sugar control, catering to health-conscious consumers. Amaranth, a therapeutic leafy vegetable, boosts the nutritional profile with high dietary fiber and natural antioxidants, promoting overall well-being and disease prevention. Tiger nut, renowned for its rich protein, starch, and nutrient content, introduces distinctive flavor and enhances the flour's protein content, appealing to those seeking diverse and nutrient-dense alternatives. Together, this synergistic combination addresses the limitations of traditional wheat flour, aligning with the global trend towards healthier dietary choices.

Table 1: Proximate composition (g/100g) and Energy value (kcal/100g) of composite flour

Run	Wheat	unripe plantain	Amaranth	Tiger nut	Moisture	Fat	Fibre	Ash	Protein	carbohydrate	Energy value
1	45	20	20	15	2.114	10.085	2.005	3.109	10.937	71.752	1757.75
2	41.25	21.25	21.25	16.25	3.12	9.119	3.112	3.322	12.252	69.089	1767.57
3	45	25	20	10	3.006	12.451	3.221	2.418	12.254	69.662	1833.06
4	45	20	25	10	2.993	11.085	1.952	2.117	11.815	70.049	1699.23
5	40	25	20	15	2.015	11.72	2.024	1.943	8.752	73.545	1753.7
6	40	20	30	10	1.945	13.114	1.982	3.228	13.126	66.01	1815.92
7	50	20	20	10	1.932	11.263	2.223	3.412	9.624	71.545	1722.1
8	40	30	20	10	2.994	15.316	1.242	3.116	11.376	65.957	1935.33
9	40	25	25	10	1.973	14.409	1.229	3.119	13.568	65.707	1846.87
10	42.5	22.5	22.5	12.5	2.931	10.002	2.099	3.014	9.632	72.347	1746
11	40	30	20	10	2.994	15.316	1.242	3.116	11.376	65.957	1868.3
12	50	20	20	10	1.932	11.263	2.223	3.412	9.624	71.545	1722.1
13	40	20	25	15	1.932	14.321	2.897	2.897	10.935	67.555	1850.54
14	41.25	21.25	26.25	11.25	3.12	9.119	3.112	3.322	12.252	69.089	1701.56
15	40	20	20	20	2.874	14.343	3.003	2.117	10.067	67.607	1837.7
16	40	20	20	20	2.874	14.343	3.01	2.117	10.067	67.607	1837.7

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NUTRITIONAL EVALUATION OF SEED, PULP AND PEEL OF AFRICAN STAR APPLE (*Chrysophyllum albidum*) FRUIT

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ABSTRACT

Fruits have been shown to be one of the best sources of dietary fiber with lots of vitamins and minerals. The nutritional composition of the dried seed, dried pulp and dried peel of African Star Apple were analyzed. The three morphological parts of the fruit analyzed included the dried pulp, dried seed and dried peel which were grounded and analyzed for their nutritional properties. The results for the nutritional properties showed that the dried seed contained 97.40% dry matter, 9.10% Crude Protein, 401.00% Energy having higher values than the dried pulp and dried peel respectively. The dried seed is richer in Carbohydrate content (79.00%) and Vitamin E (79.92%) than the dried pulp and dried peel. The dried pulp contained Vitamin C (35.10%), had higher moisture content (16.50%) and Fat Content (5.80%) than the dried seed and dried peel. The dried peel was seen to have the highest crude fiber content (8.10%) than the dried seed and dried pulp. In conclusion, the nutritional composition showed that the dried seed, dried pulp and dried peel possess the required nutritional benefits needed for consumers' healthy living.

Keywords: Nutritional, Functional, Peel, Pulp and African Star Apple

INTRODUCTION

African Star Apple (*Chrysophyllum albidum*), is a forest fruit tree belonging to the family *Sapotaceae*. The fruit is seasonal (December – April) and has immense economic potential, especially following the report that jams obtained from the fruit-pulp could compete with raspberry jams and jellies while the oil from the seed has been used for diverse purposes (3). Fruits have been shown to be one of the best sources of dietary fiber with lots of vitamins especially C, E and A as well as minerals. Frequent consumption of fruits and vegetables has been associated with a lowered risk of diabetes, hypertension, coronary heart disease, cancer, and stroke (1). Fruits give carbohydrates in the form of soluble sugars, cellulose and starch (2) and serve as source of nutrient, appetizer and supplement for food in a world faced with problem of food scarcity. Fruits are therefore said to constitute important parts of a balanced diet as they are natural sources of food nutrients needed by man and animals.

Its rich sources of natural antioxidants have been established to promote health by acting against oxidative stress related diseases such as diabetics, cancer and coronary heart diseases (4,5). The fruit-pulp has been reported to contain significant amount of ascorbic acid (6), vitamins, iron and food flavors (7), fat (8), carbohydrate and mineral elements (6,9). The fruit-peel has been shown to be a rich source of fiber and mineral (10) while the seed shell pericarp has been reported to be a good source of carbohydrate and minerals (11). The fleshy and juicy fruits are popularly eaten (12). The fruit pulp and flesh surrounding the seed is usually eaten while the seed and the peel are thrown away as they are seen not to have any nutritional benefits to the human body (13). The milky juice that comes out of it when squeezed or sucked is not only satisfying like the chewable skin (14). It boasts a myriad of health benefits and is thus used as a natural medicine for a number of health issues, ranging from fighting indigestion to acting as a natural anti-oxidant (5). It acts as a good source of vitamin C which strongly helps in strengthening the human immune system.

MATERIALS AND METHODS

The fruits of African star apple (*Chrysophyllum albidum*) were purchased from Omi-Adio market in Ibadan, Oyo State, Nigeria. All the reagents were of analytical grade. The ripe African star apple fruits were sorted and washed. The fruits were cut into two halves using a knife and the pulp and seeds were removed manually with the aid of a spatula. The seed, pulp and peel skin were oven dried at 60°C for 18 h and used for other determinations. Chemical analyses were performed on each of the samples in triplicate using standard methods of (15).

RESULTS AND DISCUSSION

The results of the Chemical composition of the dried African Star Apple seeds, pulp and peel or skin are presented in Table 1. The dried seed contains more Dry matter (97.40%), Crude protein (9.10%), Energy (401.00%) and rich in Carbohydrate (79.00%) and Vitamin E (74.92%) while the dried pulp is rich in Vitamin C (35.10%) and has the highest Moisture content (16.50%) and Fat content (5.80%) (Table 1). However, the dried peel has the highest Ash content (5.10%) and crude fiber (8.10%). This means that consumption of dried seed of African Star Apple will provide the consumers with Energy, Carbohydrate and Vitamin E and hence consumers do not need to throw away the seeds as it also contains nutrients needed by the body for daily activities. The consumption of the dried pulp is rich in Vitamin C, which is an essential nutrient involved in the repair of tissue, protection against immune system deficiencies and also provision of antioxidant for the body which will remove potentially damaging oxidizing agents in consumers and helps to protect the cells in consumers against the effects of free radicals. Vitamin C also helps in curing colds and preventing scurvy. The dried pulp is more prone to deterioration as a result of the high moisture content than the dried seed and dried peel. The dried peel, which has the highest crude fiber content, will help consumers with weight loss by reducing the appetite of the consumers and preventing over eating. Also, consumption of the dried peel with high fiber content can reduce serum cholesterol level, colon, breast cancer and hypertension. It will also enhance glucose tolerance and increase insulin sensitivity. Similar results were obtained from the works of (16) and (17).

CONCLUSION

The result of the chemical composition of African Star Apple dried seeds, dried pulp and dried peel or skin revealed that they contain necessary nutrients needed by the body and will still provide the body with the required nutrients just as the fresh African Star Apple seeds, pulp and peel. Also, drying of the fresh African Star Apple does not affect the nutritional composition of the fruit and drying serves as a way of preservation of the fruit during the seasonal period to prevent deterioration and creates availability of the fruit during the off-season period.

Table 1: Proximate and Vitamin composition of Dried African Star Apple Seeds, Pulp and Peel

PARAMETERS	DRIED SEED	DRIED PULP	DRIED PEEL
Dry Matter (%)	97.40 ^a ± 0.02	83.90 ^c ± 0.08	93.50 ^b ± 0.07
Moisture Content (%)	2.60 ^c ± 0.01	16.50 ^a ± 0.02	6.50 ^b ± 0.00
Ash Content (%)	1.20 ^c ± 0.01	3.20 ^b ± 0.01	5.10 ^a ± 0.05
Crude Fat (%)	5.40 ^a ± 0.01	5.80 ^a ± 0.03	2.10 ^b ± 0.08
Crude Fiber (%)	2.70 ^c ± 0.02	3.80 ^b ± 0.04	8.10 ^a ± 0.00
Crude Protein (%)	9.10 ^a ± 0.04	8.05 ^b ± 0.02	7.00 ^c ± 0.03
Carbohydrate (%)	79.00 ^a ± 0.00	62.65 ^c ± 0.04	71.20 ^b ± 0.08
Energy (Kcal)	401.00 ^a ± 0.47	335.00 ^b ± 0.82	331.70 ^c ± 0.05
Vitamin C (mg/100g)	3.25 ^c ± 0.00	35.10 ^a ± 0.05	4.70 ^b ± 0.02
Vitamin E	74.92 ^a ± 0.08	23.59 ^c ± 0.01	35.73 ^b ± 0.06

Values are mean ± S.D. Means with different superscript along a row are significantly different at $p < 0.05$

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SOCIABILITY AND THE PHOTOTACTIC RESPONSE OF JUVENILE AFRICAN CATFISH (*Clarias gariepinus*)

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ABSTRACT

This study conducted at the Ikole campus of Federal University, Oye-Ekiti, Ekiti State investigated the sociability and phototactic responses of *Clarias gariepinus* juveniles with an average weight of 23 g and a standard length of 9 cm. Sociability tests were conducted in a dichotomous chamber, two smaller rectangular tanks with mesh sides were placed in each compartment to allow interaction. One tank contained 10 conspecifics, while the other was empty. Subsequently, a test fish was placed in the middle of the rectangular tank and sociability trait was observed for 300 seconds. Phototactic tests were conducted using a similarly divided tank, with one compartment darkened and the other illuminated, and the time spent by fish in light and dark compartments were recorded for 300 seconds. Results indicated a significant preference for group living (av. 184.35) over solitude (av. 115.58s; $t = -3.5613$, $df = 59$, $p = 0.0007$) in the sociability test. In addition, the phototactic response revealed a preference for the light compartment (av. 191.55) over the dark (av. 108.867s; $t = -5.0241$, $df = 59$, $p = 0.0001$). Present study contributes to the understanding of *C. gariepinus* behaviour, emphasizing sociability preferences and phototactic responses which are crucial for their welfare and effective aquaculture management. The observed sociability aligns with group living advantages, while the phototactic behaviour emphasizes an adaptation strategy. In conclusion, *C. gariepinus* performed optimally under a balanced photoperiod environment with adequate light intensity and conspecific presence for *C. gariepinus* welfare in aquaculture.

Keywords: Aquaculture, Fish Behaviour, Clarias gariepinus, Phototactic, Sociability.

INTRODUCTION

Sociability, the tendency to associate with others of the same species, is a key aspect of social behaviour found in many different animals [1]. Sociability is referred to as the relative tendency or disposition to be sociable or associate with one's fellows. It denotes the predisposition to be sociable and engage with fellow individuals, influencing their behaviour in various contexts, such as group dynamics and proximity. Consistent individual differences in sociability have been identified in different animals [2, 3, 4, 5], conferring advantages like predator protection, efficient group foraging, mating opportunities and altruism [6], thereby enhancing population fitness.

Fish, in particular, utilize environmental cues like light, sound, water flow, and temperature to govern their behaviour, impacting aspects such as diet and growth [7, 8]. Fish behavioural responses to light are instrumental in aquaculture and marine fisheries, as well as in techniques like light trapping and fish repelling to enhance flow efficiency in construction projects like fishways and transportation systems [9, 10]

The phenomenon of fish phototaxis, where fish exhibit movement toward or away from a light source, is a typical response to light stimulation, influencing their behaviour [11]. According to [12], light becomes a critical factor for fish survival, enabling appropriate metabolic reactions. Fish utilize retinal and extraretinal photoreceptors to perceive light intensity and spectral variations [13, 14]. Despite existing studies shedding light on various behavioural aspects, a comprehensive exploration integrating sociability and phototactic responses in fish, particularly juvenile *Clarias gariepinus*, remains scarce. This research aims to fill this gap, providing a holistic understanding of this critical behavioural aspect of the fish and offering valuable insights for both academic research and practical applications in aquaculture management.

The African catfish, *Clarias gariepinus*, emerges as a pivotal species with economic importance in aquaculture and ecological significance in freshwater ecosystems. As a species widely cultured for its high-quality flesh and adaptability to diverse environments, investigating the behavioural dynamics of *C. gariepinus* is crucial for enhancing aquaculture practices.

There is a growing interest in understanding and improving the welfare of cultured fish from both ethical and production perspectives. Understanding its sociability, in terms of group preference, and its phototactic response may be valuable to the welfare of cultured *Clarias gariepinus*. Therefore, this research seeks to examine the sociability trait and the phototactic response of juvenile *Clarias gariepinus*.

MATERIALS AND METHODS

Collection and conditioning of test organisms

A total number of 70 *Clarias gariepinus* juveniles with a mean weight of 23 g and a standard length of 9 cm were obtained from a reputable fish farm in Ado, Ekiti state; and transported to the Fisheries and Aquaculture wet laboratory at the Ikole campus of Federal University, Oye-Ekiti, Ekiti State. To ensure a smooth transition and optimal conditions for the fish, a two-week acclimatization phase was implemented. During this period, the fish were introduced to a spacious plastic tank filled with pristine water. Prioritizing their comfort and well-being, the fish were provided with a commercial feed of 35% crude protein throughout the acclimatization period and water quality parameters were monitored to ensure ideal conditions for their well-being and success of the experiment. After the acclimatization phase, each fish underwent precise weighing using Mettler top loading balance, marking the initiation of the experiment to assess their behaviour and development.

Behavioural tests

Sociability test

The sociability test was conducted in a dichotomous chamber. The rectangular tank was divided into two equal compartments (30 cm x 15 cm x 17 cm) using external lines. The rectangular tank was filled with 60L of water to a depth of 17cm. Two smaller rectangular tanks (4 cm x 12 cm), each were placed with mesh on all four sides, on the extreme sides of the two compartments. The meshed smaller rectangular tanks allowed the test fish to see into the tank and enabled the transfer of pheromones. 10 conspecifics were introduced into one of the smaller tanks, while the other smaller tank remained empty. Subsequently, a test fish was placed in the middle of the rectangular tank and allowed to acclimate for sixty seconds.

The experiment lasted 300 seconds, during which the recording focused on the time the test fish spent in proximity to either of the smaller mesh rectangular tanks [15]. To minimize any potential tank effects, the side on which the mesh tank holding the 10 conspecifics was alternated throughout the experimental trials and was carried out in duplicate. After the completion of each test, careful return of the fish to their respective home tanks was ensured.

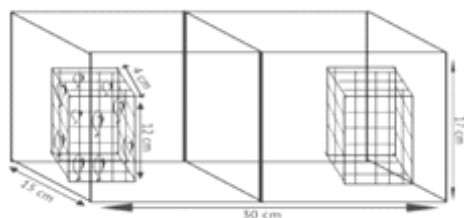


Figure 1: Diagrammatic representation of sociability test

Phototactic Test

A rectangular tank (45 cm x 25 cm x 27 cm) was divided into two equal compartments (45 cm x 25 cm x 27 cm) using external lines. One compartment was covered with black material to ensure darkness, while the other part was illuminated using a bulb. In this controlled environment, a test fish was placed in the middle of the rectangular tank and it was allowed to acclimate for 60 seconds.

During the experiment, the amount of time the test fish spent within either the dark or illuminated compartment was recorded. This data collection process was conducted for 300 seconds in duplicate, in order to capture the fish's response to the contrasting environments [16]. After each test, careful and immediate return of the fish to their designated home tank was ensured, while prioritizing their well-being throughout the procedure.

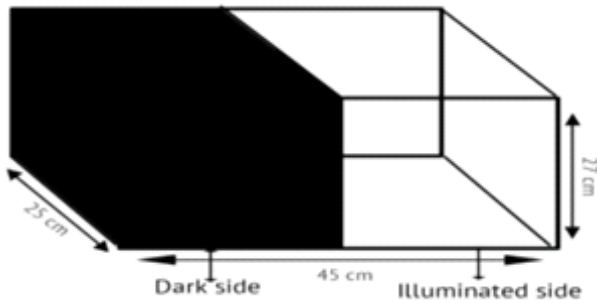


Figure 2: Diagrammatic representation of phototactic response test.

Statistical Analysis of Data

Data on sociability (preference for being in a group or being solitary) and phototactic response (preference for being in the dark or light) were analyzed using paired t-test procedures, using the R statistical package version 4.2.2.

RESULTS

Sociability test

The mean time the test fish spent in the group compartment (mean = 184.35s) was significantly higher than the time spent in the empty compartment (paired t-test: mean = 115.58s; $t = -3.5613$, $df = 59$, $p = 0.0007$).

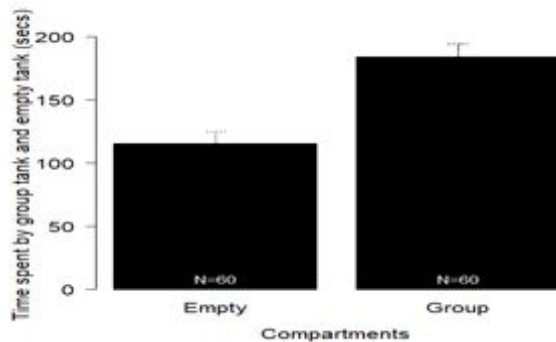


Figure 3: Sociability in *Clarias gariepinus* juveniles showing the preference to be solitary (empty compartment) or be with conspecific (group).

Phototactic response test

The mean time the test fish in the light compartment (mean = 191.55s) was significantly higher than the time spent in the dark compartment (paired t-test: mean = 108.867s; $t = -5.0241$, $df = 59$, $p = 0.0001$).

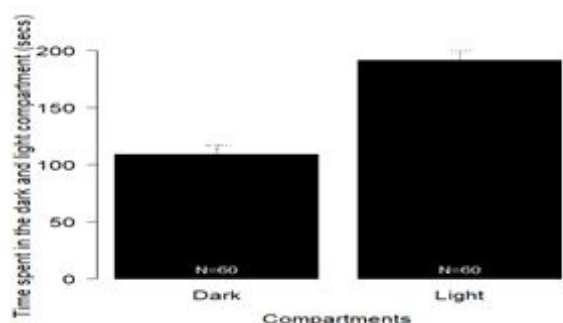


Figure 4: Phototactic response in *Clarias gariepinus* juveniles showing the preference for dark or light compartments.

DISCUSSION

In terms of the sociability response of *Clarias gariepinus*, it was observed that the test fish spent significantly more time in the group compartment compared to the empty compartment. This suggests that the fish have a preference for social interaction or being in the presence of other fish of their species. This observation aligns with the study of [16], who posited that non-isolated fish spent more time eating and went more often to the water surface to get food than isolated fish in their study on the effect of group composition on the welfare of *C. gariepinus* [16]. Their study also suggested that solitary African catfish showed lower feeding response leading to reduced feed intake and poorer growth than non-isolated fish. The observed sociability of juvenile *C. gariepinus* bears a resemblance to the group behaviours found in many species across the animal kingdom. Group living often provides a range of advantages, such as heightened predator avoidance, collective vigilance, shared information transfer about food, potential threats, and increased likelihood of reproductive success [17]. In essence, the propensity for sociability among these juvenile catfish showcases a vital survival strategy, where group dynamics contribute to individual fitness and overall population resilience.

In present study, *C. gariepinus* juveniles spent more time in the light than in the dark. This response to light supports the notion that the fish exhibits phototactic behaviour, meaning that they are attracted to or preferred lighted over dark environment. This is in line with a study on *C. gariepinus* by [18] where juveniles were found to be more active and aggressive at high light intensity than at low light intensity. However, continuous exposure to light has been shown to be detrimental to the overall well-being of *C. gariepinus* juveniles [19]. [20] also found that continuous light had a significant impact on mortality and welfare status of the juveniles of *C. gariepinus*. In a similar vein, [21] observed that exposing fingerlings and juveniles to continuous darkness resulted in increased mean weight gain (MWG), survival rate, specific growth rate (SGR), and feed conversion ratio (FCR) without inducing physiological stress; and further suggested that employing a 24-hour darkness photoperiod regime is beneficial for cultivating fingerlings and juveniles of *C. gariepinus*, offering a promising approach to enhance fish production in the aquaculture sector.

CONCLUSION

The study on the sociability and phototactic responses of juvenile African catfish (*Clarias gariepinus*) investigated their behaviour in a controlled environment. The sociability test revealed a significant preference for group living over solitude, indicating the fish's inclination towards social interaction. Also, the phototactic response test showed a preference for light compartments, indicating the fish's attraction to illuminated environments. Therefore, it is recommended that this particular species should be maintained in balanced photoperiod environments where there is adequate light intensity and conspecifics.

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THE POTENTIALS OF ORGANIC BIOFERTILIZERS ON CROP GROWTH RATE, PARTITIONING COEFFICIENT, AND DRY MATTER YIELD OF TWO COWPEA (*Vigna unguiculata* L.Walp) VARIETIES

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ABSTRACT

The use of organic biofertilizers has emerged as a promising strategy to achieve sustainable agriculture and their importance requires the need to explore the optimal dosage and application methods to maximize their potential benefits on crop growth and yield. This study conducted at the Teaching and Research Farm, Federal Polytechnic, Ado-Ekiti, Nigeria aims to evaluate the potential effects of different organic bio fertilizers on Crop growth rate, Partitioning coefficient, and Dry matter yield of two cowpea varieties, Oloyin Brown and IT89KD-288. The organic bio fertilizers used in the experiment included Super Gro (SPG), Biostract (BT), SPG + BT, and a control group. The 2x4 factorial design was arranged in the randomized complete block design (RCBD) and carried out in the late rainy season. The results demonstrated that organic bio fertilizers significantly influenced the growth rate, partitioning coefficient, and dry matter yield of the two tested cowpea varieties. The result of the study revealed that Oloyin Brown had a significantly higher value for CGR for all the treatments over the improved variety. Conversely, the partitioning coefficient was significantly higher for the improved cowpea variety over the indigenous variety while dry matter yield was better for the improved variety under the treatment combination. In conclusion, the findings suggest that organic bio fertilizers possess the potential to enhance the growth and productivity of cowpea crops, thereby promoting sustainable agricultural practices.

Keywords: cowpea, organic bio fertilizers, Crop growth rate, partitioning coefficient, dry matter yield

INTRODUCTION

Cowpea (*Vigna unguiculata*) is an essential leguminous crop cultivated worldwide due to its economic and nutritional value [4, 6]. In recent years, conventional chemical fertilizers have gained popularity due to their rapid effects on plant growth and yield. However, the excessive use of chemical fertilizers has raised environmental and health concerns, necessitating a shift towards sustainable agricultural practices like the use of organic bio fertilizers [1, 5]. Organic bio fertilizers offer an eco-friendly alternative by harnessing the potential of beneficial microorganisms to enhance nutrient availability and uptake by plants [3, 8]. The use of organic biofertilizers has emerged as a promising strategy to achieve sustainable agriculture while reducing the dependency on chemical inputs. Organic biofertilizers are proven to enhance soil health, nutrient availability, and plant growth through the biological processes they induce. The conventional use of synthetic fertilizers has led to environmental degradation and reduced soil fertility over time [7, 8]. Organic biofertilizers offer a sustainable alternative, but their effects on cowpea growth rate, partitioning coefficient, and dry matter yield are not well understood.[2]. This study will provide valuable insights into the potential benefits of using organic biofertilizers on cowpea crops. The findings can help farmers enhance crop productivity while reducing environmental impacts associated with conventional farming practices. Therefore, the objectives of this research are (i) To evaluate the impact of organic biofertilizers on cowpea growth rate. (ii) To assess the partitioning coefficient of nutrients in cowpea plants treated with organic biofertilizers. (iii) To determine the effect of organic biofertilizers on the dry matter yield of cowpea.

MATERIALS AND METHODS

The experiment was conducted in the Teaching and Research Farm of the Department of Agricultural Technology of the Federal Polytechnic, Ado-Ekiti in August, 2023. The experiment was conducted to evaluate the potentials of different organic biofertilizers on crop growth rate, partitioning coefficient and dry matter yield of cowpea. The study area experiences rainfall and sunshine with an annual rainfall of about 2000 mm -3000 mm and a temperature of between 25°c to

30°C. This encourages fast growth of crops and other vegetables which cannot tolerate frost condition.

The experiment was a 2x4 factorial combination arranged in a randomized complete block design. It involves two cowpea varieties, improved (IT89KD-288) and an indigenous variety (Oloyin Brown). Other treatments include; Super Gro Biofertilizer (SPG) applied at 10ml per plot, Boostract Biofertilizer applied at 10ml per plot, (BTB) Combination of (SPG + (BTB) applied at the same rate and untreated check as Control (CLT). There were 8 treatments replicated 4 times to make a total of 32 pots. Two seeds each of the tested cowpea varieties were planted on a seed bed measuring 2 m x 2 m in a plot of 20 m x 10 m.

Planting was carried out in August, 2023 and weeding was done every fourth night while pest was controlled with the use of Cypermethrine insecticide applied every fourth night for a period of 8 weeks. Treatments were applied at the rate of 10ml per plot a week after germination. Null hypothesis: There is no significant difference in the growth rate, partitioning coefficient, and dry matter yield of two cowpea varieties treated with organic bio fertilizers compared to untreated control. Alternative hypothesis: There is a significant difference in the growth rate, partitioning coefficient, and dry matter yield of two cowpea varieties treated with organic bio fertilizers compared to untreated control.

The parameters evaluated included days to first flowering, days to first podding, pod length, number of seed per pod, pod weight and pod yield. Crop Growth Rate (CGR), was calculated throughout the entire crop duration. The CGR was calculated as $CGR = T/DH$, where T=Total Biomass, DH is number of days to maturity. The Pod Growth Rate (PGR) was estimated as $PGR = Y/RD$, Where Y is the pod or fruit yield and RD is reproductive duration. The Partitioning coefficient (P_r) was estimated as the ratio of pod growth rate to crop growth rate. [2, 11]

Data collected were subjected to analysis of variance, standard deviation and standard error to estimate the reliability of the sampled data while the treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability with the aid of Gestate Discovery Software.

The days to first flowering were significantly shorter with application of biofertilizers while the improved cowpea variety gave superior attributes over the indigenous cowpea variety (Table 1). Similarly, days to first podding were significantly shorter with combination of biofertilizers over the control. IT98K-288 had significantly higher value for number of pod (14.2), number of seed (13.6), pod length (22.2cm) and pod yield (509.6kg/ha) over other treatments. This was closely followed by application with Super Gro alone with the least value recorded for the control. The CGR was significantly higher for Oloyin Brown under the application of Boostract organic fertilizer (4.36 g/mg/day) (Table 2). This was closely followed by their combination for Oloyin Brown (4.08 g/mg/day while Super Gro for Oloyin Brown gave (4.0 g/mg/day) for IT89KD-288 for the control (1.93 g/mg/day). The Oloyin Brown had a significantly higher value for CGR for all the treatments over the improved cowpea variety. Conversely, the partitioning coefficient (P_r) was significantly higher for the improved cowpea variety over the indigenous variety. For instance, SPG had P_r of (12.5), BTB had P_r of (11.68), while their combination for IT89K-288 was (9.86) with the least P_r for Oloyin Brown recorded for the control (3.64).

DISCUSSION

Several studies have investigated the effects of organic bio fertilizers on crop growth and yield. For example, [10] found that the application of organic bio fertilizers significantly increased the growth rate and dry matter yield of wheat plants. Similarly, [9] reported that organic bio fertilizers improved the partitioning coefficient of nitrogen in rice plants, leading to higher grain yield. Moreover, a further study by [10, 7] demonstrated that organic bio fertilizers enhanced the growth rate and dry matter yield of tomato plants compared to chemical fertilizers [10].

These findings suggest that organic bio fertilizers have the potential to improve the growth and yield of a variety of crops. The dry matter partitioning coefficient (P_R) reflects the distribution and accumulation of dry matter in crop organs. This distribution of harvestable organs was significantly better for IT89K-288 over Oloyin Brown. The positive influence of organic bio fertilizer on cowpea dry matter production and partitioning was in accordance with what has been reported previously on its ability to enhance proper physiological processes in crop plants [9, 11]. The higher dry matter production by the combination of organic biofertilizers on cowpea could have resulted from availability of nutrients, which consequently enhanced plant metabolic processes. Interestingly, the combination of both fertilizers resulted in a CGR of 4.08 for Oloyin Brown and a partitioning coefficient of 9.86 for IT89K-288 suggesting a more efficient allocation of biomass thus, indicating that a relatively smaller proportion of the biomass was allocated to the desired plant parts. This might affect the yield and quality of the crop, as a high CGR alone does not necessarily guarantee improved productivity if the partitioning is inefficient [2, 11]. Comparing all the treatments to the control, it is evident that all fertilizers had a positive impact on CGR. This demonstrates the potential benefits of using organic bio fertilizers in promoting crop growth. However, the specific effects on partitioning coefficient varied among the treatments. Optimizing the partitioning coefficient is crucial for achieving desired crop yield and quality. Thus, it is important to carefully choose and combine fertilizers that can achieve both high CGR and efficient biomass distribution.

CONCLUSION

The application of different rates of bio fertilizers has been found to significantly affect the growth rate and partitioning coefficient of cowpea, leading to improved crop productivity. Further research is needed to optimize the application rates of different bio fertilizers for maximum benefit in cowpea cultivation. There is the need to explore the optimal dosage and application methods of organic biofertilizers to maximize their potential benefits on crop growth and yield. In addition, the long-term effects of organic bio fertilizers on soil properties and plant growth should be investigated to ensure sustainable crop production.

Table 1: Effect of biofertilizers on yield and yield characters of two cowpea varieties

Treatments	Varieties	Days to first flowering	Days to first podding	Number of pods/plant	Number of seed/pod	Pod length (cm)	Shoot biomass (g)	Pod yield (kg/ha)
IB	IT89KD -288	35.0 ^c	45.0 ^c	11.9 ^b	12.0 ^a	15.9 ^c	147.0 ^b	417.8 ^c
	Oloyin Brown	40.0 ^b	50.0 ^b	8.0 ^d	10.9 ^b	13.0 ^d	284.9 ^a	324.7 ^d
	IT89KD -288	35.0 ^c	45.0 ^d	12.6 ^b	12.7 ^a	16.6 ^c	157.5 ^b	406.6 ^c
	Oloyin Brown	40.0 ^b	50.0 ^b	10.4 ^c	9.4 ^b	14.3 ^d	289.3 ^a	312.4 ^d
	IT89KD -288	35.0 ^c	45.0 ^c	14.2 ^a	13.6 ^a	22.2 ^a	149.1 ^b	509.6 ^a
	Oloyin Brown	40.0 ^b	50.0 ^b	12.5 ^b	11.8 ^a	18.7 ^b	290.4 ^a	401.0 ^b
	IT89KD -288	40.0 ^b	50.0 ^b	8.3 ^d	8.0 ^b	13.5 ^d	146.6 ^b	213.8 ^c
	Oloyin Brown	45.0 ^a	55.0 ^a	7.1 ^d	6.3 ^c	11.8 ^e	279.8 ^a	201.3 ^c
		36.25	48.12	10.87	10.88	15.12	247.13	362.37
		15.59	2.50	2.39	2.28	3.62	65.99	98.15
BTB		5.52	0.88	0.85	0.81	1.28	23.36	34.76
		0.43	0.05	0.22	0.21	0.23	0.27	0.27

Values with the same superscript along the same columns are not significantly different at 5% probability level. SPG

-Super Gro. BTB -Boostract

Table 2: Effect of biofertilizers on crop growth rate, partitioning coefficient and dry matter yield of two cowpea varieties

Treatment	Variety	TB	DH	CGR (g/mg/day)	PGR (g/mg/day)	Partitioning Coefficient (P _R)
SPG	IT89KD-288	147.0 ^b	66.0 ^c	2.23 ^b	27.9 ^a	12.5 ^a
	Oloyin Brown	285.0 ^a	71.0 ^b	4.01 ^a	23.2 ^b	5.79 ^d
BTB	IT89KD-288	158.0 ^b	68.0 ^c	2.32 ^b	27.1 ^a	11.68 ^a
	Oloyin Brown	289.0 ^a	66.0 ^c	4.36 ^a	20.8 ^b	4.78 ^{cd}
SPG+BTB	IT89KD-288	149.0 ^b	71.0 ^b	2.09 ^b	20.6 ^b	9.86 ^b
	Oloyin Brown	290.0 ^a	71.0 ^b	4.08 ^a	26.7 ^a	6.54 ^{cd}
CTL	IT89KD-288	147.0 ^b	76.0 ^a	1.93 ^b	14.2 ^c	7.36 ^{cd}
	Oloyin Brown	280.0 ^a	76.0 ^a	3.68 ^a	13.4 ^c	3.64 ^d
Mean		222.65	70.37	3.16	21.88	7.38
SD		59.17	3.71	0.86	4.73	3.43
SE±		20.93	1.34	0.31	2.02	1.21
CV (%)		26.56	6.28	27.28	26.18	46.49

Means carrying the same superscript along the same columns are not significantly different at 5% probability level. TB-Total Biomass. DH-Number of days to maturity. CGR-Crop Growth Rate. PGR-Pod Growth Rate. SPG-Super Gro. BTB-Boostract.

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UTILIZATION OF DRIED CITRUS FRUITS PEEL AN AGRICULTURAL WASTE FOR THE CONTROL OF *Callosobruchus maculatus* INFESTATION IN STORED *Vigna unguiculata* SEEDS

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ABSTRACT

Despite cowpea grains potential benefits in human nutrition, smallholder farmers in developing countries faced serious challenges in protecting their harvested cowpeas from insect pest infestation during storage. A study was conducted to evaluate the effect of dried citrus fruit peel powder on the control of cowpea beetles (*Callosobruchus maculatus*) on stored cowpea (*Vigna unguiculata*) seeds. The experiment comprised of four treatments namely; 10g *Citrus Sinensis*, *C. limon*, *C. aurantifolia* peel powder and a control replicated six (6) times in a Completely Randomized Design. The results revealed that all the citrus fruit peel powders had significant insecticidal effects against *C. maculatus* compared with the untreated (control) with *C. aurantifolia* leading the observed exposure hours. Also, there was a significant difference ($P < 0.05$) in the progeny emergence among the treatments. There was significantly ($P < 0.05$) reduced progeny emergence in treated grains compared to untreated grains. Although *C. aurantifolia* peel powder had the least progeny emergence, all treated seeds had lower percentages compared to untreated grains. The percentage grain damage indicated that there was a significant increase in grain damage in untreated grain compared to seeds treated with citrus fruit peel powders and on the percentage germination, In conclusion, all the citrus fruit peel powders exhibited moderate toxic action against the cowpea beetle and can be recommended to resource-poor farmers as a substitute for synthetic insecticide.

Keywords: *Citrus Sinensis*, *Citrus limon*, *Citrus aurantifolia*, peel powder, progeny emergence, synthetic insecticide

INTRODUCTION

Cowpea (*Vigna unguiculata*) being a cheap source of dietary proteins, is a major source of food in Africa and different regions of the world. In Nigeria it accounts for about 60% of the protein intake [1] and can complement the protein deficiency of the predominantly carbohydrate-based diet of many African communities [2]. Despite cowpea grains potential benefits in human nutrition, smallholder farmers in developing countries faced serious challenges in protecting their harvested cowpeas from insect pest infestation during storage [3]. *Callosobruchus maculatus* (F.) is a cosmopolitan insect pest of stored cowpea and other grain legumes causing qualitative and quantitative losses as well as impair seed germination [4], hence the management of the insect pest infestation and their activities will surely go a long way in guarantee self-sufficiency and food security, thus reducing the world food crisis [5]. Presently, the control of *C. maculatus* and other stored product insects is habitually based on the application of synthetic insecticides and fumigants. However, increasing public awareness about the risks associated with the use of synthetic insecticides and fumigants on human health and the environment encourages the search for new insect pest management tactics [6]. Therefore, this study was conceived to determine the insecticidal potentials of *Citrus sinensis*, *Citrus aurantifolia* and *Citrus limon* dried peel powder for the protection of stored cowpea seed against *C. maculatus* infestation.

MATERIALS AND METHODS

Experimental Location: The research was carried out at the Entomology Laboratory, Federal College of Agriculture Ishiagu, Ebonyi state, Nigeria (Latitude 05.46°N and Longitude 07.41°E), with an annual rainfall between 1300mm to 1600mm and prevailing temperature of 29°C and average humidity of 65%.

Experimental Procedures: Cowpea seeds already infested with *C. maculatus* was sourced from traders of food commodity in Eke market, Ishiagu, to serve as substrate to culture the beetles which was reared on cowpea seeds (*V. unguiculata*) in the laboratory. About One hundred (100) beetles isolated from the infested cowpea seeds were introduced into two (2) different plastic containers previously washed, sterilized and dried containing batches of about one thousand (1000) seeds covered with a polythene net fastened tightly with a rubber band to prevent insect escape and allow for aeration. The cowpea seed-beetles' mixtures were kept in the laboratory for 4 days to allow mating and oviposition to occur after which the parent beetles were removed. The rearing was given sufficient time (25-30 days) until new adult insects emerged.

Sweet orange (*Citrus sinensis*), lime (*C. aurantifolia*) and lemon (*C. limon*) were procured from fruit dealers at Eke market Ishiagu. The citrus fruits were washed with clean water, peeled and air dried for 10 days at room temperature (28°C) under the shade. After drying, the peel was milled using an electric blender (Model BLG-400) and the powder was sieved repeatedly through a 1 mm² perforation mesh to obtain the fine powder.

Experimental Design/Treatments: About 50 g of sterilized cowpea seeds each were introduced into the twenty-four (24) plastic containers, arranged in a Completely Randomized Design and replicated six (6) times. The cowpeas were admixed with 10 g of *C. sinensis*, *C. aurantifolia* and *C. limon* and shaken thoroughly to ensure that the powders cover the cowpea surface uniformly. Thereafter, 10 unsexed adult beetles were introduced into each of the twenty-four (24) containers and kept on the laboratory workbench for observation. A control experiment with no powder treatment was equally setup.

Data Collection: Mortality of adult insect was monitored at 24, 48 and 72 hours after treatment. A beetle was considered dead, if it did not move any of the appendages when a needle was used to touch them, then dead beetles were counted and recorded. The percentage of insect mortality was calculated as Number of dead beetles per plastic/total number of beetles introduced x 100. The number of emerged adult beetles and emergent exit holes was counted and recorded per container at the end of the experiment. This was used to determine the percentage of damaged seeds by dividing the number of damaged seeds by a total number of seeds and multiplying by 100%.

At the end of the experiment twenty seeds were selected from each treatment and sown. The number of germinated seeds was counted. Percentage germination of seeds per treatment was determined using the percentage formula: number of germinated seeds/ total number of seed sown x 100.

Data collected were subjected to one-way analysis of variance (ANOVA) to compare differences in treatment means and significant treatment means were separated using Fisher's least significant differences at ($P < 0.05$). Prior to analysis, data on percentage mortality and seed germination were arc sine transformed while data on progeny emergency and grain damage were square root transformed.

RESULTS

There were significant differences ($P < 0.05$) observed in the mortality of *C. maculatus* on stored cowpeas treated with dried citrus fruit peel powders at 24hrs, 48hrs and 72 h exposure time (Table 1). Across the exposure time, *C. aurantifolia* peel powder recorded the highest percentage mortality followed by *C. limon* and *C. sinensis* respectively, while untreated grains had the least percentage mortality. However, the values obtained showed that three (3) citrus species peels were more effective causing high mortality rate on *C. maculatus* across the exposure hours.

The mean progeny emergence of *C. maculatus* from cowpea seeds treated with some dried citrus fruit peel powders showed a significant difference ($P < 0.05$) among the treatments. The untreated (control) recorded the highest mean progeny emergence (2.60), followed by *C. sinensis* and *C. limon* which both recorded (2.30) progeny emergence. The lowest value of 1.60 was recorded in

cowpea treated with *C. aurantifolia* peel powder. The mean Percentage damages of grain treated with dried citrus fruit peel powders revealed a significant ($P < 0.05$) damaged seeds (18.30%) compared to the significant suppressed damaged seeds among the treatment groups in mean percentage of damaged seeds recorded in *C. limon* (6.90%) and *C. sinensis* (6.00%) respectively (Table 2). The lowest percentage damaged seed (4.30%) was recorded with *C. aurantifolia*.

There was no significant difference ($P > 0.05$) between the percentage of seed germination of infested cowpea seed treated with *C. sinensis* and *C. aurantifolia* after 40 days of storage (Table 2). While cowpea seeds treated with *C. limon* with 32.00% and control (10.00%) were significantly different ($P < 0.05$) compared to other treatments.

DISCUSSION

Post-harvest insect pest management is indispensable practice in extending the shelf life of stored produce without appreciable quality and quantity loss [7]. The results gotten from this study showed that citrus peel powders are effective as stored cowpea grains protectant against *C. maculatus* infestation in exerting significant adult mortality, suppressed progeny emergence and seed damage. The study clearly showed that mortality significantly varies between the powders, with mortality highest recorded in decreasing order in *C. aurantifolia*, *C. limon* and *C. sinensis* respectively and increases with exposure time. The lethal effect of these powders might be due to its toxic phytochemical constituents which negatively affected the insect survival on treated grains. In addition, the powder could also block the insect spiracle leading to choking it to death. This aligned with the discoveries of Adesina and Ofuya [8] and Adeboye et al [9].

The reduction in progeny emergence recorded in this study could be as a result of presence of some bioactive compound preset in the citrus powders which might act as oviposition deterrence and/or ovicidal potential leading to inhibition of progeny emergence. Njoroge *et al.* [10] reported that, insecticidal activity of citrus peel powders may probably be due to the presence of limonene, myrcene, apinene, linalool, octanal and decanal. Adesina and Ofuya [8] opined the possibility of *C. maculatus* eggs in contact with toxic secondary metabolites in *S. afzelii* powder might cause higher egg mortalities and ultimately suppressed adult emergence. The significant difference observed in the progeny emergence of *C. maculatus* in treated cowpea seeds might be due the varied level of limonene composition in different citrus fruits peels.

This corroborates the results of Njoroge *et al.* [10] and Mansour *et al.* [11] who stated that limonene composition is responsible for a range of pesticidal activities exhibited by citrus plants. The significant reduction in percentage seed damaged of treated cowpea seeds may be as a result of the ability of the citrus peel powders to inhibit oviposition and progeny emergence rate of *C. maculatus* in the stored cowpea. Adesina and Ofuya [8] postulated that lower percentage adult emergence from the treated grains translated to lower seed damage. While untreated seeds recorded significantly highest progeny emergence and subject the grains to unrestricted feeding developmental and metabolic activities of the insect larvae within the stored cowpea [6]. The efficacy of the citrus peel powders in suppressing seed damage is in tandem with the outcomes of Belmain and Stevenson [12] who also reported effective use of *C. sinensis* powder against legume pests.

In the present study, citrus powders did not hinder the germinative capability of the treated cowpea seeds compared to the untreated seeds. This confirmed previous research that botanicals protect stored seeds against insect infestation and do not destructively affect seed germination [13].

CONCLUSION

Based on toxicity effect of the citrus peel powder in exerting high mortality, progeny inhibitory effects and suppression of grain damages, citrus peel powder might be a suitable plant-based pesticide as substitute against synthetic insecticides and fumigants for effective control tactic of cowpea beetles in storages among resource-poor rural farmers. Further study is necessary to determine the powders mode of action.

Table 1: Mean Percentage mortality of *C. maculatus* treated with some dried citrus fruit peel powders on stored cowpea at 24, 48 and 72 hours.

Treatments	Mean Percentage adult mortality		
	24hours	48hours	72hours
<i>Citrus sinensis</i> 10g	20.00	35.00	69.50
<i>Citrus limon</i> 10g	25.00	45.00	75.00
<i>Citrus aurantifolia</i> 10g	30.00	70.33	95.00
Control	0.00	2.00	5.00
LSD	0.09	0.21	1.24

LSD= least significant difference

Table 2: Mean Progeny emergence of *C. maculatus* treated with some dried citrus fruit peel powders on stored cowpea at forty (40) days of storage

Treatments	Mean Progeny Emergence	Mean damages	Grain	Mean seed germination (%)
<i>Citrus sinensis</i>	6.00	4.60		60.00
<i>Citrus limon</i>	6.90	3.60		32.00
<i>Citrus aurantifolia</i>	4.30	6.00		60.00
Control	18.30	15.00		10.00
LSD	2.20	0.53		1.20

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INFLUENCE OF BAMBOO AND NEEM BIOCHARS ON YIELD ATTRIBUTES AND NUTRITIONAL CONTENT OF SWEET CORN (*Zea mays saccharata* Sturt)

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ABSTRACT

The experiment was carried out to evaluate the yield and nutritional content of sweet corn (*Zea mays saccharata* Sturt.) on soil amended with neem and bamboo biochars in the Ikorodu agroecological area of Lagos state. Four treatments were used: 0t/ha control (no biochar), 10 t/ha neem biochar, 10 t/ha bamboo biochar, and 5t/ha bamboo + 5 t/ha neem biochars arranged in Randomized Complete Block Design (RCBD) with three replications. Parameters taken were cob length, cob weight, ear weight, dehusked weight, weight of marketable yield, and weight of non-marketable yield and nutritional contents. Results showed that the biochar application significantly affected the yield attributes with 5 t/ha bamboo + 5 t/ha neem biochar producing the best result. However, a non-significant biochar application effect was observed in nutritional composition. Further study is required to evaluate the effect of tother variable rates and application time interval before planting.

Keywords: Biochar, cob weight, marketable yield, nutritional content.

INTRODUCTION

Sweet corn (*Zea mays* L. *saccharata* Sturt.) is a hybrid of maize with a high sugar content. It is an increasingly popular agricultural crop and is in demand because of its sweet taste when consumed. The decline in the production of sweet corn is mostly due to poor soil fertility and efforts to improve same is through the application of inorganic fertilizer [1], its extensive use leads to soil degradation, thus the focus shift to organic fertilizers.

Organic material such as biochar may serve as a better choice for soil amendment because its source is biological and it may be directly applied to soils with little pre-treatment. Biochar is fine particles of permeable substance when utilized as a soil amendment to lessen CO₂ from the air. In agricultural soils, biochar gives natural surroundings to soil microorganisms. Over the long haul, biochar does not upset the carbon-nitrogen balance; however, it can retain and make water and supplements more accessible to plants [2].

In recent times, it has been reported that biochar obtained from the carbonization of organic wastes can be a substitute that not only influences the appropriation of soil carbon but also modifies its physicochemical and biological properties [3, 4]. Hence, this study was designed to evaluate the efficacy of the biochars either alone or combined on the yield and nutritional content of sweet corn.

MATERIALS AND METHOD

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four treatments with three replications on a 165 m² area of land at the Teaching and Research Farms of Lagos State Polytechnic, Ikorodu, Nigeria. The treatments consisted of 10 t/ha sole application of bamboo biochar, 10 t/ha sole application of neem biochar, 5 t/ha bamboo + 5 t/ha neem applied to the experimental plot two weeks before planting and a control experiment (no biochar application). Neem (*Azadirachta indica* A.) and bamboo (*Bambusa vulgaris* (L.) (Poaceae)) plant materials were sourced within the Polytechnic community and biochar was obtained by pyrolysis under high-temperature and low-oxygen conditions. Sweet corn seed was obtained from a reputable source, (SOLAK) Ibadan, Oyo State Nigeria. Planting was done in situ by dibbling method at two seeds per hole at a spacing of 0.75 x 0.25 m and later thinned to one vigorous seedling two weeks after planting. Manual weeding was carried out on a fortnight basis with the use of hoe and cutlass to prevent weed infestation.

At maturity maize, cobs were harvested and the following data were collected following standard experimental procedures: (i) Number of marketable yields done by counting the number of non-damaged ears on each row, (ii) Weight of marketable yield (kg): This was done after harvest by weighing to the nearest kilogram on the weighing scale to ascertain the non-damaged dehusked cobs weight, (iii) Number of non-marketable yields: This was by counting the damaged ear after harvest, (iv) Weight of non-marketable yield (kg): This was carried out by weighing to the nearest kilogram using a digital balance weighing scale to ascertain dehusked cob weight, and (v) Cob width (cm) by using a veneer caliper to measure the widest part of the ear. The crude protein, carbohydrate content, crude fiber, total soluble solids, and starch content of harvested maize grains were subjected to standard routine laboratory analysis procedures to determine their nutritional composition [5].

Data collected on yield attributes and nutritional composition was subjected to analysis of variance (ANOVA) using PROC GLM in SAS version 9.3. Treatment means were separated using a Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Effects of bamboo and neem biochars on sweet corn yield attributes

The yield of sweet corn was not significantly ($p < 0.05\%$) different in cob length, dehusked weight, ear weight, and non-marketable yield across the treatments (Table 1). While significant ($p < 0.05\%$) difference was observed in cob weight and marketable yield of the sweet corn. Cob length harvested from control (50.05 cm) recorded the longest cob and sole application of 10 t/ha neem biochar and 5 t/ha of both biochar mixture recorded the shortest cobs (42.71 cm). Significant heaviest cob weight was obtained from the control plot (125.54 kg) and the sole application of neem biochar recorded the lightest cob weight (65.94 kg). The heaviest dehusked weight (1.53 kg) was observed from 5 + 5 t/ha neem and bamboo biochar and was not significantly different from the lowest weight observed from maize harvested from 10 t/ha sole application of neem biochar. A non-significant heaviest weight of the ear was obtained from 5 + 5 t/ha neem and bamboo biochar (2.35 kg) with 10 t/ha sole application of bamboo (1.85 kg) being the lightest weight. The mixture of both biochars also recorded the highest significant marketable weight (1.67 kg) and control being the lowest (1.01 kg). However, a non-significant marketable weight was recorded between the sole application of neem and bamboo biochar application. Non-marketable weight revealed that maize in control treatment had the highest non-significant weight (0.93 kg) compared to 5 + 5 t/ha neem and bamboo biochar which recorded the lowest weight (0.59 kg). This study negates some reports indicating that crop yield statistically increased if soils were amended with wood biochar at 10 - 60 t/ha [6, 7]. The non-significant effect observed between biochar application and control treatments might be due to the slow release of nutrients present in biochar for crop uptake.

Effects of bamboo and neem biochars on sweet corn nutritional composition

The biochar treatments applied to sweet corn were not significantly ($p < 0.05\%$) different with regards to the nutritional content across the treatments which indicated that there is no real effectiveness observed (Table 2). Numerically, 10 t/ha neem biochar and the control had the maximum values for the selected nutritional contents of the sweet corn while the bamboo and the combination had the lowest recorded values. Reasons for all of these could have resulted from bird pest attacks on the matured ear at the experimental site which might have altered the nutritional content of the sweet corn and perhaps the low rates recommendation of the biochar application. This could also be due to the slow release of the nutrients in the biochar, making them readily available for crop use.

CONCLUSION

In conclusion, the application of 5 + 5 t/ha neem and bamboo biochar performed better than the sole application of neem and bamboo biochar in terms of yield attributes and sweet corn grains nutrient composition. Hence, farmers can adopt 5 + 5 t/ha combination of neem and bamboo biochars for

growing sweet corn. However, further research is recommended with a focus on other variable rates of biochar and time interval between biochar application and planting.

Table 1: Effect of biochar fertilizers on yield attributes

Treatments (Biochar)	Cob Length	Cob Weight	Dehusked Weight	Ear Weight	Marketable Weight	Non- marketable
Neem (10t/ha)	42.71	65.94b	1.22	1.99	1.14ab	0.82
Bamboo (10t/ha)	45.03	131.13a	1.36	1.85	1.08ab	0.77
Neem (5t/ha) + Bamboo (5t/ha)	42.71	118.99ab	1.53	2.35	1.67a	0.59
Control	50.05	125.54ab	1.43	2.06	1.01b	0.93
LSD ($P \leq 0.05$)	ns	*	ns	ns	*	ns

Table 2: Effect of Bamboo and Neem biochar fertilizers on the nutritional content of sweet corn

Treatments (Biochar)	Crude Fibre content (g/100g)	Crude Protein content (g/100g)	Carbohydrate content (g/100g)	Total Soluble Solids (%)	Starch content (%)
Neem (10t/ha)	2.27	3.13	15.68	12.57	9.87
Bamboo (10t/ha)	2.44	3.35	16.67	13.45	9.45
Neem (5t/ha) + Bamboo (5t/ha)	2.28	3.11	15.78	10.20	8.22
Control	2.48	3.39	17.15	12.12	9.90
LSD ($P \leq 0.05$)	ns	ns	ns	ns	ns

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ORGANOMINERAL IMPACT OF FERTILIZERS ON THE GROWTH AND YIELD OF CAYENNE PEPPER (*Capsicum frutescens* L.)

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ABSTRACT

The need to improve the soil fertility with organic and inorganic fertilizer for optimum crop yield becomes a necessity because of depletion of nutrient in the soil resulting from continuous use of land over time. An experiment was conducted at Federal college of Agriculture Akure, Ondo State to determine the effects of organic and inorganic fertilizers on the growth and yield of cayenne (*Capsicum frutescens*). Cayenne pepper seed was planted in nursery and after 8 weeks, the seedlings were transplanted to the field. The treatments used include poultry manure, pig manure, wood ash, N.P.K 15 15 15 and control. The treatments were applied one week after transplanting using ring method for poultry manure, pig manure and wood ash, while N.P.K was applied using side placement method pocket form. Growth and yield parameters measured were plant height, number of fruits per plot, weight of fruit, length of fruit and girth of fruit. Data collected were subjected to analysis of variance (ANOVA). Results showed that poultry manure produced better growth in terms of plant height, as well as better yield in terms of number of fruits, whereas N.P.K produced better growth in term of better yield of weight, length and girth of fruit. However, poultry manure which is an organic fertilizer, and which had the highest yield in terms of number of fruits is recommended for cayenne pepper production for optimum yield.

Keywords: Organo-mineral, fertilizer, manure, wood ash and Cayenne pepper

INTRODUCTION

Pepper (*Capsicum spp.*) is a popular vegetable valued around the world for the colour, flavor, spice and nutritional value it contributes to many meals [3]. Pepper is an indispensable soup ingredient cherished as condiment in stews in Nigeria. It is among top 5% of the important vegetables consumed in the country [5]. In Nigeria, *Capsicum* used to be a cash crop for exportation and local consumption in various local and international dishes [5]. Cayenne pepper requires a high level of mineral nutrients in the growing medium for effective performance. The nutrients essential for pepper include nitrogen, phosphorus and potassium among others [4].

Despite the increasing relevance of cayenne pepper, its production still faces varieties of challenges ranging from low yields obtained in farmers' fields because of declining soil fertility due to continuous cropping and disregard for soil amendment materials. As a result of these, farmers use the land that has been earlier cultivated which led to depreciation in soil nutrient. Improvement of soil fertility with use of chemical fertilizer poses challenges such as high cost of purchase and destruction of soil properties on continuous use. There is need to look for alternative source of organic fertilizer which is available at low cost as well as supplying needed nutrient for the growth of pepper. Pepper, on the other hand, faced challenges of getting their seedling established from nursery, attack by insect pest in the nursery, transplanting to permanent side among others. The aim of the study was to determine the effect of organic fertilizer on the growth and yield parameters of cayenne pepper, determine the effect of organic fertilizer on the soil properties after harvest.

MATERIALS AND METHODS

Experimental Procedures:

The experiment was carried out at the Teaching and Research Farm, Federal college of Agriculture Akure, Ondo State. The annual rainfall of location of the study ranges from 1100 mm – 1500 mm per annum, the relative humidity is 85%, the temperature ranges from 25°C - 30°C, the longitude is 5.2684°E while the latitude is 7.2779°N.

The experimental design used was a Randomized Complete Block Design (RCBD) with five treatments replicated six times. Treatment used include pig manure, poultry manure, wood ash,

NPK 15: 15: 15 and on a plot size of 4m x 3m and on a total research area of 26m x 37m = 962m². The demarcation was done using measuring tape, pegs, and hammer.

Data was collected every two weeks after treatment application. Three plants were selected from each plot for data collection. The data collected included Growth parameters, Yield parameters. The data collected will be subjected to analysis of variance (ANOVA) technique (Wahua, 1999). Significant mean will be separated using Duncan multiple range test (DMRT).

RESULTS

The result of the soil test showed that the pH value of the soil is 5.29 which mean that the soil was slightly acidic as shown in soil analysis. The content of sand (91.56%), Silt (1.43%) and clay (7.03) showed that the textural class of the soil was sandy soil. The organic matter (OM) and organic carbon (OC) content are 1.56% and 0.88% respectively. The exchangeable cations were low in status with the values of 66.90ppm for Na, 24.70 ppm for Ca and 63.10 ppm for Mg. The value for K (80.00 ppm) and Na (66.90pp) were low. The total N was 0.44% and available Fe and P were 1.64 ppm and 8.14 ppm, respectively.

The effects of organic and inorganic fertilizers on the plant height of cayenne pepper (Table 1) revealed that at week 2 after transplanting (2WAT), poultry manure had the highest plant height with the value of 33.061^a and the lowest was found with control with value of 24.778^b. Although, control had the lowest value compared to pig manure, N.P.K and Wood ash, but there was no significant difference between pig manure, N.P.K., Wood ash and control. At 4WAT, there were significant differences in the fertilizer application. Highest plant height was observed in poultry manure which has the value 48.994^a and the lowest was observed in control with the value of 33.71^c. There was slightly significant difference between N.P.K., Pig manure, Wood ash and which has 42.094^{ab}, 45.478^{ab}, and 38.949^{bc} respectively.

At 6WAT and 10WAT, it was observed that poultry manure and N.P.K performed better than pig manure, wood ash and control. There was no significant difference between poultry manure, N.P.K and pig manure as well as wood ash and control. Also, at 8WAT and W10AT, it was observed that there was no significant difference between poultry manure, pig manure and N.P.K. Poultry manure showed the highest height while the lowest plant height was seen in control.

The effects of organic and inorganic fertilizers on the yield of cayenne pepper (Table 2) revealed that fertilizers treatment influenced the number of fruits per plot. A highest number of fruit was recorded in poultry manure, while the lowest number was obtained in wood ash. Highest weight of fruit was recorded in N.P.K. while the lowest was obtained from control. Highest length of fruit was obtained from N.P.K., while the lowest was recorded in wood ash. Fruit girth was higher in N.P.K., while lowest fruit girth obtained in pig manure.

DISCUSSION

Results of the study revealed that organic and inorganic fertilizers affect the growth (plant height), and yield of cayenne pepper. It was revealed that soil added with poultry manure and pig manure highly increased in its acidity, while soil added with N.P.K., wood ash slightly increased the acidity of the soil. Application of organic and inorganic fertilizer increased the organic matter and organic carbon of the soil. This agreed with the report of [1], who reported that organic fertilization conditions the soil, supplies several macro- and micronutrients, improves and maintain soil fertility status and improves crop response to inorganic fertilization. The results revealed further that application of poultry manure enhanced the plant height of cayenne pepper. This agrees with the research of [1] who reported that organic fertilization conditions the soil, supplies several macro- and micronutrients, improves and maintain soil fertility status and improves crop response to inorganic fertilization. Also reported by [2], that plant height increased with application of poultry manure. Comparing organic fertilizer (poultry manure, pig manure) with inorganic fertilizer

(N.P.K.), it was observed that poultry manure had greater influence on plant height, number of leaves and stem girth [1].

CONCLUSION

In conclusion, the performances of the manure treated plants despite the slow mineralization nature were comparable to the plants with inorganic fertilizer. However, the inorganic fertilizers along with detrimental effects on the environment are becoming very expensive to purchase by small holding farmers, hence considering the multiple benefits of organic materials the adoption in farming practice should be encouraged among farmers due to the beneficial secondary benefits on soil properties as well as being favourable to the environment.

Table 1: Effects of Organic and Inorganic Fertilizers on Plant Height

TREATMENT	Week After Transplanting (WAT)				
	2	4	6	8	10
Poultry Manure	33.061 ^a	48.994 ^a	54.8056 ^a	59.5667 ^a	61.006 ^a
Pig Manure	28.294 ^a	42.094 ^b	49.2222 ^b	53.8278 ^b	55.672 ^b
N.P.K.	28.583 ^b	45.478 ^b	53.1944 ^a	58.8778 ^a	60.972 ^a
Wood Ash	27.4674 ^a	38.949 ^c	43.9596 ^a	47.8257 ^a	49.042 ^b
Control	24.778 ^b	33.7167 ^a	37.0222 ^b	39.6833 ^a	40.406 ^c

* Means that do not share a subscript are significantly different.

Table 2: Effects of Organic and Inorganic Fertilizers on Yield of Cayenne P

TREATMENT	Yield Parameters			
	Number of Fruit	Average Weight of Fruit (g)	Length of Fruit (cm)	Fruit Girth (mm)
Pig Manure	273 ^{ab}	9.94 ^{ab}	9.28 ^a	6.5 ^b
Poultry Manure	419 ^a	10.35 ^a	9.49 ^a	7.2 ^{ab}
Wood Ash	186 ^b	10.00 ^a	8.58 ^{ab}	6.9 ^{ab}
N.P.K	413 ^a	10.69 ^a	9.79 ^a	7.5 ^a
Control	196 ^b	9.71 ^{ab}	9.25 ^a	7.1 ^{ab}

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EFFECT OF CLIMATE CHANGE AND ORGANIC RESTORATIVE MEASURES ON FOOD SECURITY OF CATFISH FARMERS IN ONDO STATE, NIGERIA

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ABSTRACT

The main goal of organic agriculture as a sustainable production of food with little or no effect on the environment has not been achieved by conventional farming hence the need to encourage organic farming practice that is capable of providing solutions to the current environmental challenges among which is the change in climate and environmental hazards and also help to achieve maximal production of quality food sustainability. Two stage sampling techniques were employed in selecting the 231 catfish farmers for the study. Results revealed that food secure households were estimated to be 42.86% while 57.14% of the respondents were food insecure. Results revealed that household size, ($p < 0.10$), education ($p < 0.001$) experience, ($p < 0.05$) climate variable ($p < 0.05$) have relationship to the food insecurity status of catfish farmers. In conclusion, the study recommends the encouragement of programmes that educate the catfish farmers on effect of climate change, and impact of measures such as the organically restorative measures that erect embankments to reduce/prevent flood water, stocking favorable climate change resistant fish species to boosting catfish production through adaptive capacity, and stocking of fingerlings that is healthy among others.

Keyword: Climate Change, Organic Restorative Measures, Catfish farmers, Logistic Regression.

INTRODUCTION

Change in climate poses a menace to all aspects of human existence, not just the socioeconomic and agricultural development of any one country [1, 2, 3 & 4]. According to the Intergovernmental Panel on Climate Change (IPCC, 2007) [5], the definition of climate change is the average weather during a specific time period which is a statistical description of appropriate quantities over a range of instant periods, from months to thousands or millions of years, in terms of their mean and variability. Variability in total rainfall, temperature, air, and humidity are all detrimental to the aquaculture system's ability to produce. These problems have caused large productivity losses and increased socioeconomic and financial vulnerability among farmers. According to [6,7], the general decline in productivity and produce quality, which invariably endangers the condition of food security at both the national and household levels is recognized as climate change effect on catfish in Nigeria. Habitat degradation, overfishing, pollution, parasites, diseases, and more recently, due to the increased variability brought on by climate change have threatened fisheries resources. Climate unevenness and alteration, which have gotten worse in the latter third of the 20th century, [8], haven't gotten nearly as much attention as the other dangers.

Organic agriculture utilizes various combinations of plant and animal species in time and space for the sustainability of the ecosystem. Organic agriculture not only enables agriculture-influenced ecosystems to better adjust to the effects of climate change but also offers potential to reduce the emissions of agricultural greenhouse gases. The main GHGs include methane, nitrous oxide and carbon dioxide. In organic agriculture, soil fertility is maintained mainly through farm internal inputs (organic manures, legume production, wide crop rotations etc.); energy-demanding synthetic fertilizers and plant protection agents are rejected; and there is less or no use of fossil fuel. It is reported that organic agriculture could be a resilience system for adaptation to climate change. Organic agriculture helps to increase resilience of farming systems through better management of soil and water, promoting biodiversity and strengthening community knowledge systems.

Climate change will have serious impacts on world economic output, human life and the environment throughout the world. Increasing crop failures and livestock deaths are already imposing high economic losses and undermining food security. More frequent droughts and increasing water scarcity may devastate large parts of the tropics and undermine fish farming, irrigation and drinking water in entire communities of already poor and vulnerable people [9]. The increased frequency and extent of floods, droughts and land cutting has rendered the agriculture sector more vulnerable and reduced the productivity of land and of the potential for plant production. The case is much more severe in countries like Nigeria where people have inadequate knowledge, weak governance systems and fewer resources to respond. It should also be noted that the effectiveness of organically restorative measures in improving catfish production and food security is not well understood and documented. There is therefore the need to examine the effect of climate change and organic restorative measures on catfish farmers' food security in Ondo State, Nigeria.

Organic farming represents a deliberate attempt to make the best use of local natural resources and is an environmentally friendly system of farming. Organic farming is a production system that excludes the use of synthetically manufactured chemicals like fertilizers, pesticides, growth enhancers/regulators, food additives, fungicides, and herbicides. Organic farming practices include crop rotation, biological pest control, crop residues, cover crop, legumes, organic fertilizers, animal manures and green manures among others. Organic farming technology is frequently regarded as the solution to environmental problems that are related to agriculture as well as food safety. It usually has “zero impact on the environment” [5].

Organic farming practices has been shown to affects soil microbiological activity and chemical properties by increasing soil nutrient availability, microbial biomass and microbial activity, which represent a set of sensitive indicators of soil quality. In addition to other benefits especially as it relates to health and food safety, organic farming has been shown to be safer and healthy. It also results to increased levels of flavonoids when used for the production of fruits and vegetables and protects against cancer and other age-related diseases to lesser extent. Organic farming increases insect pollination and overall species richness. The major goal of organic farming activities is a sustainable production of food with little or no effect on the environment [6]. This goal and many others have not been achieved by conventional farming hence the need to encourage organic farming which is capable of providing solutions to the current environmental challenges like the change in climate and environmental hazards and also help to achieve maximal production of quality food sustainability. Food and Agriculture Organization (FAO) clearly states that organic agriculture promotes ecological resilience, improves biodiversity, healthy management of farm and surrounding environment and building community knowledge and strength.

This study therefore aims to fill this gap by analyzing the socioeconomics variables of catfish farmers and the climate change effects and organic restorative measures on the food security of catfish farmers in Ondo State, Nigeria, a major catfish producing State in the country Nigeria.

MATERIAL AND METHODS

Ondo State is the study area for this study. With coordinates of 5° 45' N 40151E, it has a about 14,793,723 square kilometre land area and 3,441,024 million people. There are 18 Local Government Areas (LGAs) in it. Its climate has two distinct seasons: the rainy season (April to October), and the dry season (November to March). It is located in the tropics. Additionally, it is a state that produces oil in Nigeria. Bitumen limestone, kaolin, glass sand, and granite are further minerals that can be found in the state in significant quantities, National Boundary Commission (NBC) of Nigeria [10]. The study employed two stage sampling technique. The first stage is the purposive selection of Ondo State. This is because it is noted for cat fish farming in Nigeria. By making use of the list of the registered fish farmers, a random selection of two hundred and thirty-one (231) cat fish farmers were selected for this study.

Both descriptive (such as percentages, means, and frequency tables) and inferential (Likert Scale, Food Security Index and Weighted Mean) analytical tools were employed in analyzing the data collection.

Measuring Food Security

In this study, the Food Security Index (FSI) as used by [11, 12, 13, 14 and 15] was adopted. The Food Security Index (FSI) calculates the per-capita food expenditure of households (including both cash and farm produce consumptions) in monetary (Naira) terms. If a household spends at least two-thirds of the income on the average on food expenditure of the sampled households, it is regarded to be food secure; otherwise, it is deemed to be food insecure. FSI is thus given as:

$$F_i = \frac{\text{per capita food expenditure for the } i\text{th households}}{\frac{2}{3} \text{ mean per capita food expenditure in all households}}$$

Where:

F_i = Food security index

When

$F_i \geq 1$ = food secure – ith – household

$F_i \leq 1$ = food insecure – ith – household

$F_i \geq 1$ = food secure ith household

$F_i \leq 1$ = food insecure ith household

The Logit Regression (LR) Model

Each predictor in a logistic regression is assigned a coefficient that expresses how much of an independent contribution it makes to the variation in the dependent variable. If the response is "food secure," the dependent variable Y takes a value of 1, and if it is "food insecure," it takes a value of 0. The formula for the logit equation is

$$P_i = \frac{e^{\beta x}}{1 + e^{\beta x}}$$

Where P_i = 1 (For food secure) and 0 for food insecure. Since Logistic regression calculates the probability of success (p) over the probability of failure (q), the results of the analysis are in the form of an odds ratio (p/q).

RESULTS AND DISCUSSION

Climatic effects and Organic Restorative Measures

The climate change indicators were rated with Likert-type rating scale questions of 4-points rated as Strongly Agreed; Agreed; Undecided and Strongly Disagreed, Strongly Disagreed, with a scale from 5 to 1 respectively. Included among others flooding, long period of harmattan season leading to increase in fish production, precipitation increase resulting to increase in production of fish, long period of hot season resulting to decrease in production of fish, long period of hot season resulting to decrease in production of fish, situation of drought resulting to decrease in production of fish, decrease in fish farming, and decrease in quality of fish. In ranking, situation of drought resulting to decrease in production of fish rank first, followed by clearing pond regularly, avoidance of leakage of pond and so on (Table 1)

The organic restorative measures employed by the respondents in the study area according to the Table were protection of pond from predators, eco-friendly design, protection from polluting substances, manage without growth hormone, stocking healthy fingerlings (use of resistant varieties – climate favoured), natural treatment, purchase of weather monitoring kits, antibiotic use in clinical cases where no other treatment works, usage of quality water sources (ocean and rivers), cultivated without genetic engineering and sourcing climate change information.

According to the Table, protection from predators, ecofriendly design, protection from polluting substances ranked accordingly, digging bore hole and/or wells for alternative water source at dry seasons ranked first followed by clearing pond regularly, avoidance leakage of pond and so on. This is in agreement with the study conducted by Atoma, *et al.*, on the multifunctionality and impacts of organic and conventional agriculture.

Fish farmers Food Security

Food security index which is per capita food expenditure for the *ith* household divided by 2/3 mean per capital food expenditure of all households was used to determine the food security status. Household with Food Security Index (FI) greater or equal to one was considered food secured. The result in Table 2 showed that, the monthly mean per capita food expenditure for the total household was ₦59,065.03 and the 2/3 mean per capital food expenditure for all the household was ₦39,375.35. Using ₦39,375.35 as the standard, 42.86% of the households was estimated to be food secure (Table 2) while 57.14% of the respondents were food insecure. This probably could be the adverse effects of climate on the cat fish production. This is contrary with the study of [16 and 17] who used 2/3 of average mean per capita expenditure on food as the food secured line and reported that the respondents studied were food secure.

Effects of climate change and Organic Restorative Measures on Cat Fish Farmers' Food Security

Result in Table 3 showed the factors contributing to rise in food insecurity among catfish farmers in the study area. Results revealed that household size, ($p < 0.10$) increases the food insecurity of catfish farmers in Ondo State (pooled). For each additional rise in the household size, the odds of being food secure decreases by 0.77 holding all other variables constant. Implication of this implies an increase in the size of the household reduces the likelihood for the household to become food secure. Increase in household size necessitates increase in household food expenditure, especially, in circumstances where many of the other household members do not generate any income but only depended on the household heads. This is consistent with [18] findings. In addition, education ($p < 0.001$) has the probability of decreasing food insecurity of respondents. Coefficient (0.857) of the education has a positive relationship with household's food insecurity status. The result suggests food security increases with years of formal education among male headed household heads in the study area. This might be due to the fact that in Nigeria, years of formal education are major criteria in wage determination. Moreover, human capacity and technical know-how which transit in advancing the productivity of such households and consequently their food security status are related to education. This is in support of the work carried out by [19]. The coefficient of the variable experience, ($p < 0.05$) reduces the probability of catfish farmers being food insecure suggesting that the more experience household (male and female) had on catfish farming the less the probability of food being food insecure and vice versa (reduces the odd of being food insecure). The coefficient climate variables (access to information on climate) of the respondents have a positive connection with household food security status. Indication of this reveals that households with climate information have higher probability of being food secure compare to those that did not have. The reason being that access to access to information enhances the chances of households having access to better information relevant to climate variability that has to do with catfish production and how to cope or mitigate against them organically as well as other incentives in production and these go to affect their output vis-à-vis their food security status.

CONCLUSION

In order to improve their level of food security, household heads should be encouraged to develop their capacity, for example, by receiving more training on the organic restorative measures that will increase their engagement in income-generating activities, educating the fish farmers about climate change and boosting adaptive capacity that can increase catfish production. Finally, the study recommends that introduction of sustainable fishing operations that will improve the quality of life for those at risk from the effects of climate change when designing and implementing policy

programmes by government and all necessary stakeholders should take organically restorative measures into consideration.

Table 1: Weighted Mean (Derived from Likert Scale)

Variable	N	SA(5)	A(4)	U(3)	D(2)	SD(1)	WMS	MS	RANK
Climatic effects									
Flooding	231	48	170	0	9	4	942	4.077922	4
Long period of harmattan season leading to increase in fish production	231	69	35	21	39	67	693	3	7
Precipitation increase resulting to increase in production of fish	231	124	24	36	2	45	873	3.779221	6
Long period of hot season resulting to decrease in production of fish	231	141	42	23	1	24	968	4.190476	3
Situation of drought resulting to decrease in production of fish	231	178	25	25	2	1	1070	4.632035	1
Decrease in fish farming	231	180	19	22	3	7	1055	4.5671	2
Decrease in quality of fish	231	121	40	33	7	30	908	3.930736	5
Organic Restorative Measures									
High quality water sources (stream and river)	231	91	139	0	0	1	1012	4.380952	9
Protection of pond from predators	231	165	64	1	1	0	1086	4.701299	1
Manage without synthetic appetizer and coloring	231	126	72	20	0	13	991	4.290043	13
Sourcing climate change information	231	113	92	24	1	1	1008	4.363636	11
Antibiotics is used in clinical cases where no other treatment works	231	113	109	4	2	3	1020	4.415584	8
Site protection from polluting substances	231	126	98	4	1	2	1038	4.493506	3
Use of organic fertilizer	231	102	119	3	2	4	1003	4.341991	12
Purchase of weather monitoring kits	231	128	92	1	2	7	1022	4.424242	7
Natural treatment	231	119	103	2	4	3	1024	4.4329	6
Managing without growth hormones	231	138	83	2	1	7	1037	4.489177	4
Cultivated without genetic engineering	231	124	80	21	2	4	1011	4.376623	10
Eco-friendly design	231	165	65	0	0	1	1086	4.701299	2
Ensuring better inlet and outlet	231	21	0	1	101	108	418	1.809524	14
Use of resistant varieties/stocking healthy fingerling/ climate favoured	231	121	106	1	0	2	1034	4.47619	5

Source: Field Survey, 2023, N = Number of observation, SA = Strongly Agree, Agree, U= Undecided, D= Disagree, SD = Strongly Disagree, WMS =

Weighted Mean Score, MS = Mean Score

Table 2: Distribution of the Respondents according to Food security Status

Food security status	Frequency	Percentage
Food secure	99	42.86
Food insecure	132	57.14
Total	231	100

Source: Field Survey, 2023

Table 3: Logistic Regression Result

Variables	Odd Ratio	Std. Err.	p-value
Fishing experience	0.917	0.0348	0.022**
Association	1.452	0.699	0.439
Labour	1.122	0.404	0.750
Climate indicator	1.113	1.549	0.039**
Education	0.857	0.045	0.003***
Age	0.991	0.027	0.733
Marital status	1.275	0.571	0.588
Household size	0.776	0.106	0.063*
Constant	28.54	67.16	0.154
Observation	231		
LR $\chi^2(8)$	22.49		
Prob > χ^2	0.0041		
Pseudo R^2	0.1634		

*, ** and *** Represents 10%, 5% and 1% significant levels respectively(Source: Field Survey, 2023)

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RESPONSE OF LETTUCE (*Lactuca sativa* L.) TO BIOCHAR AND INORGANIC FERTILIZER

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ABSTRACT

The excessive use of inorganic fertilizers is a major soil environmental problem. Study at Agricultural Teaching and Research Farms of Federal University Oye-Ekiti evaluated the influence of oil palm frond biochar (OFB) and NPK 15:15:15 fertilizer on growth and yield of lettuce (*Lactuca sativa* L.) for two planting cycles (PC). The pot experiment was laid in a complete randomized design (CRD) with treatments: control, 10-, 15- and 20-ton OFB ha⁻¹, 100, 150 and 200 kg N ha⁻¹, replicated thrice. Growth and yield data obtained were statistically analyzed and means separated by Tukey test of significant at $p \leq 0.05$. The planting cycle had significant effect on the measured parameters with 2nd cycle having statistically higher values compared to the 1st cycle except for fresh weight (FW) of lettuce while the parameters increased significantly with days after transplanting (DAT). Furthermore, 100 kg N ha⁻¹ gave significantly higher lettuce values but not from the OFB treatments except for leaf width (LW) and FW where 10-ton OFB ha⁻¹ respectively recorded 10.39 cm and 24.57 g plant⁻¹ that were not significantly better than the control. Positive significant relationships existed among the growth and yield parameters of lettuce and the PC except that PC was non-significant with FW and number of leaf (NOL) whereas nutrient source (NS) correlated with none. Hence, 15-ton ha⁻¹ oil palm frond biochar should be adopted for growing lettuce as it statistically compared with 100 kg N ha⁻¹ coupled with its potential advantageous residual effects on soil and environment.

Keywords: Fertilizer, Lettuce, Oil palm frond biochar (OFB), Planting cycle and Yield.

INTRODUCTION

Vegetables consumption is known to help combat, prevent and control cardiovascular diseases and cancers [1]. Specifically, Maiuolo *et al.* [2] revealed that lettuce (*Lactuca sativa* L.) is capable of treating common life-threatening diseases such as diabetes, cancer and Alzheimer's disease. Lettuce is loaded with phytochemicals that include carotenoids, vitamin B groups, glycosylated flavonoids, phenolic acids, tocopherols, ascorbic acid, and sesquiterpene lactones [3, 4], as well high level of antioxidants [5]. Moreover, the phenolic compounds have the capacity to promote lettuce shelf life.

Nevertheless, its production requires specific agronomic practices like any other crops for optimum performance [6]. Inorganic fertilizer application is one of the major contributors to soil pollution and degradation [7] whereas, organic fertilizers improve soil health and crop performance, given men the privilege to consume healthy farm produce [8]. Application of biochar to the less fertile and usually acidic tropical soils is found to increased crop yield by 25% [9] and increases soil pH [10] because of the alkaline nature. Affirmatively, Wangmo *et al.* [11] reported that biochar from rice husk influences soil physiochemical properties and chill pepper growth. Moreover, from all waste generated from oil palm tree, the frond and trunk has been found to have the highest biomass contribution [12] from the regular pruning for optimum palm oil production [13]. Thus, conserving oil palm fronds by converting into biochar is essential as it tends to easily release nutrient elements into the soil [12, 14]. Furthermore, slow pyrolysis has been the best of all the pyrolysis methods, as it retains higher amount of the nutrients, oil and fuel within materials [15]. Hence, this work assessed the potential influence of oil palm frond made biochar on the performance of lettuce.

MATERIALS AND METHODS

Description of the experimental procedure

The research was conducted at the Agricultural Teaching and Research Farms, Federal University Oye-Ekiti (Ikole Campus) located at coordinates 07° 48.137' N, 005° 29.526' E. A derived savanna zone of Ekiti State, Nigeria. The soils are mainly alfisols developed on basement complex rocks [16]. The oil palm fronds collected from the University's oil palm Plantation were converted to biochar through slow pyrolysis method [15] using Top Lit-up Draft pyrolyzer. The NPK 15-15-15

fertilizer and seed of lettuce were procured from reliable vendors. The composite surface soil sample used and the oil palm frond biochar (OFB) were analyzed based on standard laboratory procedures.

The screen house pot experiment was laid in a complete randomized design (CRD) and ran for 2-cycles. The treatment consists of control (0 kg N or ton OFB ha⁻¹), OFB₁ (10-ton OFB ha⁻¹), OFB₂ (15 ton OFB ha⁻¹), OFB₃ (20 ton OFB ha⁻¹), N₁ (100 kg N ha⁻¹ NPK 15-15-15), N₂ (150 kg N ha⁻¹ NPK 15-15-15), and N₃ (200 kg N ha⁻¹ NPK 15-15-15) and replicated thrice. The OFB treatments were applied 7 days before lettuce transplanting while NPK fertilizers were 7 days after. Raised lettuce seedlings of near uniformed size were transplanted into the pots. Weeding, watering and insecticide application were done as required.

At 40 days after transplanting (DAT), growth data on plant height (PH), number leaves (NOL), leaf length (LL), leave width (LW) were taken at 5 days interval and yield fresh weight (FW) at 55 DAT before terminating the experimental cycle. The potted soils were allowed to rest for 2 weeks before commencing the second cycle without re-applying the treatments. SPSS version 2.0 was used to analyze the data collected and means' separation and relationships established at 5% probability level ($p \leq 0.05$). The data collected were subjected to analysis of variance (ANOVA) using SPSS version 2.0 and Tukey's significance difference test was used to compare means among the various treatments at 5% probability level ($P \leq 0.05$). Relationships were also established between the Lettuce parameters and selected soil properties using Pearson correlation.

RESULTS AND DISCUSSION

Properties of the native soil and oil palm frond biochar (OFB)

The selected properties of the native soil (Nat-S) and oil palm frond biochar (OFB) presented in Table 1 showed that the Nat-S was strongly acidic (pH 5.36) while OFB was very strongly alkaline at pH 10.19 [17]. The pH levels suggests that OFB may have alkalizing effects on acidic soils, which affirmed the Salaam *et al.* [18] report on potential influence of biochar on soil pH, nutrient availability and microbial activity. Generally, the native soil was low in fertility having essential properties below the critical limits set by SSDS-USDA [17] with 0.67 and 0.70 g kg⁻¹ organic carbon and total nitrogen respectively and available phosphorus of 6.45 mg kg⁻¹ compared to the OFB with high organic carbon content (24.9 g kg⁻¹), total nitrogen (2.38 g kg⁻¹) and available phosphorus (365.25 mg kg⁻¹). Thus, exhibiting soil amendment potentials as similarly reported by Kan *et al.* [19]. The OFB had higher organic carbon content to enhance soil organic matter and sequester carbon [20]. Among others, the higher levels of total nitrogen and available phosphorus in OFB highlight its possible effectiveness in supplying essential nutrients to plants, hence improve crop productivity. It agrees with Oram *et al.* [21]. Also, Ilori *et al.* [22] affirmed that conversion of agricultural biomass through slow pyrolysis at temperature even below 500°C into biochar enhanced and conserved the P-availability. Higher levels of basic cations in OFB also suggest its potential for enhancing soil fertility. More so, base saturation, an important indicator of soil fertility, was found to be distinctly high in OFB (98.90%) compared to Nat-S (87.91%) and the higher base saturation value indicates potential soil acidity neutralizer [23]. Texturally, the Nat-S was loamy sand based on the proportions of clay, sand and silts (114.80, 845.20 and 40.00 g kg⁻¹ respectively).

Effect of planting cycles, days after planting and nutrient sources on plant growth and yield parameters

Results in Table 2 shows that PH, LW and LL values obtained in the first planting cycle were significantly lower (15.43, 8.92 and 14.49 cm, respectively) compared to the second cycle with exception of NOL. This reveals the residual effect and availability of nutrients from OFB on lettuce performance. Kong *et al.* [20] similarly reported that biochar from oil palm biomass allows nutrient retention that supports plant growth. A non-significantly higher fresh weight (30.67 g) in first planting cycle (PC) is traceable to reduction in the NOL (6.35) in the second PC. Considering the DAT, the growth parameters of lettuce progress significantly as the crop grows into maturity, buttressing the prolong effect of the nutrient sources.

Additionally, the measured lettuce parameters differed significant across the nutrient sources (NS), and agreed with [24] that oil palm biomass biochar positively influenced the growth of oil palm seedlings. Considering the yield of lettuce (FW), OFB had a commensurate increasing effect than control. Specifically, OFB₂ (10-ton ha⁻¹) compared considerably with the inorganic fertilizer (N₁, 100 kg N ha⁻¹). Bakar *et al.* [25], similarly reported increased rice growth and yield parameters in oil palm empty fruit bunch biochar (EFBB) amended soils.

Correlation between growth parameters of lettuce, planting cycle and nutrient sources

The FW significantly correlated and positively with the PH, LW, LL and NOL having correlation coefficient (r) of 0.613**, 0.605**, 0.628** and 0.387*, respectively. This suggests that an increase in FW is associated with an increase in other plant parts. Similarly, positive relationships were established among other lettuce parameters. This finding shows that lettuce yield performance depends majorly on the plant's growth parameters and therefore revealed the need for soil fertility improvements for efficient and sustainable production of lettuce. However, nutrient source exhibited non-significant relationships with growth and yield parameters of lettuce while planting cycle (PC) correlated significantly only with PH, LW and LL. An indication that nutrient source was not a major influencer to lettuce performance but the negative r- value was a pointer to the need for fertilization.

CONCLUSION

Conclusively, oil palm frond biochar (OFB) considerably demonstrate a significant contribution to the growth and yield performance of lettuce with higher rates significantly outperforming the higher N-fertilizer rates and generally outshined the control. The lettuce yield and growth variables significantly contribute to fresh weight of lettuce while 15-ton OFB ha⁻¹ is suggested for adoption for sustainable lettuce production.

Table 1. Properties of the native soil and oil palm frond biochar (OFB)

Properties	Nat-S	OFB
pH (H ₂ O)	5.36	10.19
Electrical conductivity (dS m ⁻¹)	0.002	0.03
Organic carbon (g kg ⁻¹)	0.67	24.90
Total nitrogen (g kg ⁻¹)	0.70	2.38
Available phosphorus (mg kg ⁻¹)	6.45	365.25
Exchangeable bases and acidity (cmol kg ⁻¹)		
Potassium	0.34	1.54
Sodium	0.12	0.57
Calcium	1.59	3.20
Magnesium	0.64	1.90
Exchangeable aluminum	0.11	0.04
Exchangeable hydrogen	0.26	0.04
Total exchangeable bases (cmol kg ⁻¹)	2.69	-
Effective cation exchangeable capacity (cmol kg ⁻¹)	3.06	7.29
Base Saturation (%)	87.91	98.90
Extractable micronutrients (mg kg ⁻¹)		
Copper	0.89	1.54
Iron	4.96	7.54
Manganese	3.90	6.51
Zinc	0.27	0.32
Particle size distribution (g kg ⁻¹)		
Clay	114.80	
Sand	845.20	
Silt	40.00	
Textural class	Loamy sand	

Nat- S = native soil, OFB= oil palm frond biochar.

Table 2. Effect of planting cycles, days after transplanting and nutrient sources on plant growth and yield parameters

Variables	PH (cm)	LW (cm)	NOL	LL (cm)	FW (g plant ⁻¹)
Planting cycle (PC)					
1	15.43	8.92	7.07	14.49	30.67
2	30.67	11.51	6.35	18.62	29.95
Std. error	0.30	0.19	0.10	0.29	2.52
$P \leq 0.05$	*	*	*	*	Ns
Days after transplanting (DAT)					
40	12.42d	6.64d	5.21d	11.51d	-
45	15.56c	9.15c	6.24c	14.58c	-
50	19.61b	11.59b	7.31b	18.26b	-
55	22.92a	13.48a	8.07a	21.86a	-
Nutrient sources (NS)					
Control	14.90d	8.94cd	6.08b	13.89c	20.44b
N ₁	19.83a	11.91a	6.67ab	18.94a	50.87a
N ₂	17.32bc	9.96bc	6.50ab	16.38b	29.55b
N ₃	15.12cd	8.18d	6.58b	13.47c	22.93b
OFB ₁	17.96ab	10.39bc	6.83ab	16.96ab	24.57b
OFB ₂	20.11a	11.41ab	7.21a	19.13a	33.34ab
OFB ₃	18.14ab	10.71ab	7.08a	17.12ab	30.46ab

N₁ = 100 kg N ha⁻¹, N₂ = 150 kg N ha⁻¹, N₃ = 200 kg N ha⁻¹, B₁ = 10-ton OFB ha⁻¹, B₂ = 15-ton OFB ha⁻¹, B₃ = 20-ton OFB ha⁻¹, PC = Planting cycle, DAT = Days after transplanting and NS = Nutrient source. Means in the same column with the same or without letters are not significantly different and ns = not significant.

Table 3. Correlation between growth parameters of lettuce, planting cycle and nutrient sources

	FW	PH	LW	LL	NOL	PC	NS
FW	1	0.613**	0.605**	0.628**	0.387*	-0.026	-0.052
PH		1	0.814**	0.998**	0.378*	0.605**	0.140
LW			1	0.812**	0.463**	0.377*	0.175
LL				1	0.372*	0.585**	0.133
NOL					1	0.238	0.238
PC						1	0.000
NS							1

FW = Fresh weight, PH = Plant heights, LW = Leaf width, NOL = Number of leaves, LL = Leaf length, PC = Planting cycle and NS = Nutrient source. ** and * = Correlation is significant at the 0.01 and 0.05 probability levels (2 - tailed).

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PROCESS OF PRODUCTION OF QUALITY AND ODOURLESS FUFU IN NIGERIA

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ABSTRACT

Fufu is an important fermented processed cassava product in Nigeria. Traditionally processing on a household scale are associated with delays in processing fresh roots, arduous nature and time taken for processing, variable quality of the end product, poor product shelf life and product with odour. The use of modern technology, automated and semi-automated machines, will ensure commercialization, reduce processing time and drudgery, increases shelf life of the products and the complete removal of undesirable flavour and odour. The Niji Foods experience showed that odourless and quality fufu products can be obtained from cassava roots using automated and semi-automated mechanical systems. Information about the unit's operations alongside the equipment and their principle of operation were reported.

Keywords: cassava, roots, fermentation, products, automation

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a starchy root crop that has ability to tolerate drought and produce a reasonable yield on all agricultural land [1]. World production was 184 million tonnes in 2002, rising to 230 million tonnes in 2008 [2,3]. Nigeria is the leading producer of cassava in the world with an annual production of about 45.72 million tonnes in 2006 [4,5,6,7]

The crop is a basic raw material for cassava flour mills, bakeries, fast food firms, restaurants, garri and starch processing firms [8,3,9]. Cassava processing is to reduce post-harvest losses, hydrocyanic acid potential, improves the shelf life of the products, improves and enhances the taste and flavour of cassava products and consequently to generates higher income [10,9]

The crop is processed into many food products such as *fufu*, *garri*, *lafun* and *kpukpuru*. Problem associated with locally processing is undesirable flavour of the product which led to the development of several other processing techniques suitable for odourless *fufu* [11,12,13]. This work was aimed at assessing the production process for production of odourless *fufu* cassava flour at Niji Foods, Ilero, Oyo state, Nigeria.

THE CASE STUDY OF NIJI FOODS

NIJI GROUP

Niji Group is a value-added conglomerate with about three decades of providing critical end-to-end solution to Africa's agriculture through investment in Agricultural Machineries and Equipment Manufacturing, Farming, Food processing, Agribusiness Education, Farm Mechanization and Hospitality. The subsidiaries are Niji Lukas, Niji Farms, Niji Foods, NISA, Ripples Hotel and Niji Tractors. Niji Foods produce value added yam flour and high-quality cassava starch, high quality garri, high quality cassava flour, high quality cassava peel mash and odourless fufu as shown in Figure 1. The varieties of cassava roots processed are TME 419, TME 581, TME 1632 and yellow cassava [14].



Figure 1: Niji Foods products

NIJI FOODS Production Process of Odourless Fufu

Cassava roots are processed into odourless Fufu at the integrated cassava processing plant. The integrated cassava processing plant is fully automated, with a **4:1** production scale. The processing unit has two sections which are the wet and dry section. The wet section comprises of sorting, peeling, washing, grating, pressing, pulverizing, soaking, pressing, pulverizing, milling, drying, and packaging while the dry section comprises of drying, milling and packaging. Freshly harvested roots of cassava of TME581 varieties are used to produce fufu. They were organically grown and because of its whiteness quality also.

Process involved in the Production of Odourless Fufu

A. Wet Section

Sorting: This is the area where the first point of quality section is done. The cassava roots are brought into the receiving area of the integrated cassava processing unit for sorting to obtain wholesome production roots for production.

Peeling and Washing: Freshly harvested cassava roots are peeled with the use of the automated peeling machine.

Inspection: The cassava roots that dropped from the automated peeling machine are inspected on the horizontal conveyor or the inspection table for defects. Cassava roots are dropped on the inclined conveyor to the grater.

Grating: Clean roots are grated using the motorized grater to obtain a mash. The sharpness of the extruding zone affects the efficiency of subsequent operations such as fermentation and detoxification, and some quality characteristics of the final product such as fineness [15].

Pressing/Dewatering: The grated cassava is bagged in 5-20kg for pressing and dewatering to reduce the water from the cassava mash thereby reducing the content of the hydrogen cyanide.

Fermentation/Soaking: The pressed cassava mash is poured inside big tank already filled with water for about 3-4days for fermentation. During this process the slurry sediments, starch clustered together and fibre floats in the container. The fiber on the water and starch are removed every day and mixed thoroughly again and then filled with water till the fourth day.

Pressing/Dewatering: The thick slurry obtained from removing supernatant liquid is packed into sacks and then dewatered using hydraulic press to reduce its moisture content to 38-40% moisture content.

Pulverising: The cake cassava mash formed from dewatering is mechanically reduced in size to produce fine granules using a pulverizer, the process is also known as granulation.

B. Dry Section

Drying: The granulated fufu mash is fed into the hopper and dried mechanically using a flash dryer to yield grits of about 10-12% moisture content.

Milling: The dried fufu are collected and milled using the hammer mill.

Packaging: After milling the odourless fufu is then packaged into (1, 5, 10, 50) kg sack and then stored properly with the shelf life of one year.

EQUIPMENT USED IN ODOURLESS FUFU PRODUCTION IN NIJI FOOD AND THEIR PRINCIPLE OF OPERATION

Processing machines in use were the DORNOW peeling machine, the mechanical grating machine, hydraulic press, flash dryer and the hammer mill.



Figure 3: Dornow peeling Machine



Figure 4: Niji Lukas Flash-dryer

CHALLENGES OF FUFU PRODUCTION

The challenges are availability of raw material, modern equipment and machineries, personnel with technical know-how, market for processed fufu, unstable energy supply and health challenges attributed to exposure to of cyanogen glucoside.

PROSPECTS OF FUFU PRODUCTION

Addressing problems associated with raw material: The perishability of fresh cassava should be a major concern of the processors. To overcome problems associated with fluctuations in supply and poor transport networks of fresh cassava, the low-cost cassava storage technique provides the opportunity of extending the shelf life of roots to 6-8 days. The technique would need validation under commercial conditions with the varieties used for fufu production.

Access to market and market information

There is high demand for fufu flour in Nigeria. Fufu is consumed mainly as human food and its consumption now transcend ethnic, religious, and social barriers; of particular interest is ECOWAS sub-region, Europe, and America. The national demand estimate for fufu as human food is more than 750,000 metric tons with current supply level less than 20% of the demand estimate.

CONCLUSIONS

There is decline in production of Fufu in Nigeria due to it offensive odour and limited shelf-life. The improved technology adopted produced dried but odourless fufu flour, increase the shelf life, make the product convenient for easy consumption and increase production.

RECOMMENDATIONS

There is the urgent need for the Federal Government of Nigeria to assist the Cassava farmers and farms through special interventions. This would make modern technology and machineries affordable for small-income farmers.

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NUTRITIONAL COMPOSITION OF PEANUT BURGER COATINGS FROM WHEAT, CARDABA BANANA (MUSA ABB) AND AFRICAN YAM BEAN (*Sphenostylis stenocarpa*) FLOUR BLENDS

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ABSTRACT

Peanuts regarded as one of the most popular snack foods and number one snack nut, due to its nutritional benefits. The research investigates the nutritional composition of using peanut coatings from blends of wheat, cardaba banana and African yam bean flour. Wheat, Cardaba banana and African yam beans flours were mixed in different combinations which were coded as BAB2 (80:5:15), BAB3 (80:15:5), BAB4 (60:15:25) and BAB5 (60:25:15) with sample BAB1 (100% wheat) as control. The results of the proximate composition showed an increase in protein content (10.18 - 13.10%) as the inclusion of Cardaba banana and African yam bean increase while the fibre and ash increased in samples BAB2 (1.38, 4.23%) and BAB3 (1.47, 4.92%) respectively. Moisture (9.75 - 9.45%), fat (10.41 - 8.51%) and carbohydrate (65.03 - 62.45%) content decreased. The energy content (394.53 - 379.39KJ/g) was relatively high indicating high utilizable energy from the coatings. Sample BAB2 showed the highest mineral contents among the substituted coatings in calcium (247.25mg/100g), iron (71.95mg/100g), magnesium (156.82mg/100g), sodium (109.29mg/100g) and phosphorus (132.21mg/100g). All the substituted sample coatings were acceptable as shown in the sensory results with sample BAB2 most preferred in appearance (7.25), texture (7.55), taste (7.80), colour (7.20), aroma (7.00) and overall acceptability (7.55). In conclusion, the use of Cardaba banana and African yam bean flour in peanut coat formulations showed similar nutritional quality and acceptability compared to the control sample BAB1 which can be explored in the food industries.

Keywords: Nutritional composition, Peanut coatings, Cardaba banana, African yam beans

INTRODUCTION

Peanuts are important food crop legumes usually consumed and also processed into peanut burgers, peanut butter, peanut snacks, peanut caramel bars, candy, chocolates, cakes, and other food products. Peanuts are an excellent source of plant-based protein high in biological value and containing about 25.80g by weight [1] and the fats are considered heart-healthy. Peanut burger is a very simple crunchy fried snack made by coating groundnut with wheat flour, eggs, sugar, and other ingredients [2]. Peanut burger coatings have been developed using vegetables, wheat, oats and cassava flours [2; 3].

African yam bean (*Sphenostylis stenocarpa*) is an underutilized legume and an important crop in many parts of sub-Saharan Africa, where it is cultivated for both food and feed purposes [4]. African yam bean is a good source of protein, carbohydrates and dietary fibre [5]. Wheat which is commonly used in the processing of peanut burger coats have been very expensive due to importation cost of wheat grains. This research aims to explore the nutritional profile from the utilization of less common crops of Cardaba banana and African yam beans as partial replacements for wheat in peanut burger coatings, thereby reducing the dependency on wheat crops in order to promote agricultural diversity which will be beneficial in a low-income country like Nigeria.

MATERIALS AND METHODS

Experimental Procedures

Wheat grains and Cardaba banana were purchased from Ikole market, Ekiti state while African yam beans were purchased from Oja-Oba market, Ado Ekiti, Ekiti state. The wheat grains were cleaned to remove any foreign materials, dried at 60°C for 10 min and milled in a Kenwood blender. The flour was then sieved using 425 µm [6]. Freshly harvested matured Cardaba banana was washed with clean water, peeled manually and sliced into small pieces. The slices were dried in a dehydrator at 70°C until they were completely dried and crispy. The dried Cardaba banana slices were milled using a mechanical grinder. The flour was sieved to ensure uniform particle size [7]. African yam bean seeds were cleaned thoroughly, soaked in clean water for 12 hours to soften the seeds, dehulled

and oven-dried at 55°C for 5 hours. The dried seeds were milled and the flour was packaged in airtight containers and stored [8].

The flours from wheat, Cardaba banana and African yam beans were blended to give five samples coded as BAB2 (80:5:15), BAB3 (80:15:5), BAB4 (60:15:25) and BAB5 (60:25:15) while sample BAB1 (100% wheat) served as control. Fresh peanuts were sorted, blanched at 100°C for 10 min, drained and air-dried at room temperature for 24 hours. The Egg (30.0 g) was whisked, sugar (20.0 g) was added and stirred, the solution was simultaneously sprinkled alongside with composite flour blends of wheat: cardaba banana: African yam bean flour (100 g) and salt (2.0 g) on the peanuts (100 g). The coated peanuts were deep fried, strained and packaged [2]. The fried peanut coats were detached from the peanuts and analysed for the determination of moisture, protein, fat, ash and crude fibre contents [9]. The carbohydrate content was estimated as the difference between 100 and the total sum of moisture, fat, protein, crude fibre and ash contents. The energy value was calculated from their fat, protein and carbohydrate using the formula;

$$\text{Energy value KJ/g} = (9 \times \text{Fat}) + (4 \times \text{Protein}) + (4 \times \text{Carbohydrate content})$$

Standard methods [9] were used for determining the mineral contents (calcium, magnesium, iron, sodium, zinc and potassium) of the fried coating blends using Atomic Absorption Spectrophotometer (Buck Scientific Atomic Absorption Emission Spectrophotometer, Model 205, Nowalk, Connecticut, USA). Phosphorous was determined using a flame Photometer. The sensory attributes of produced peanut burgers were evaluated by 20 panelists using a 9-point hedonic scale from like extremely (point 9) to dislike extremely (point 1) rating. Quality parameters evaluated were appearance, texture, taste, color, aroma and overall acceptability [10].

The results obtained were subjected to a One-way Analysis of Variance (ANOVA) and the means were separated using Duncan's multiple range test. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) Version 20.0 and significance was examined at 5% level of probability.

RESULTS AND DISCUSSION

The proximate content showed significant difference between samples at ($P \leq 0.05$) on each nutrient (Table 1). There was an increase in protein content (11.53-13.10%) of the composite coatings. There was commensurate increase in the protein content in the samples as the African yam bean flour was increased. The fibre and ash content in the 20% substitution samples BAB2 (1.38, 4.23%) and BAB3 (1.47, 4.92%) respectively also increased while the moisture (9.75 - 9.45%), fat (10.41 – 8.51%), carbohydrate (65.03 – 62.45%) and energy (394.53 – 379.39KJ/g) content decreased. There were no significant differences among samples in energy values ($P > 0.05$). The energy value observed indicates the levels of utilizable energy that can be derived from the peanut burger coatings.

The results of minerals content of peanut coatings are presented in Table 2. Sample BAB1 had the highest mineral content in all the parameters evaluated. Among the substituted sample coatings, sample BAB2 had the highest mineral content in calcium (247.25mg/100g), iron (71.95mg/100g), magnesium (156.82mg/100g), sodium (109.29mg/100g) and phosphorus (132.21mg/100g).

The sensory profile of peanut burgers for all the samples scored above point - 4 (dislike slightly) in all the parameters where sample BAB1 had the highest score in appearance 7(.40), texture (7.95), aroma (7.30) and overall acceptability (8.00) (Table 3). This could be due to familiarity of peanuts burger from wheat flour coatings. However, sample BAB2 had similar and high score with sample BAB1 in all sensory parameters evaluated. Among composite peanut burgers, sample BAB2 was most preferred in appearance (7.25), texture (7.55), taste (7.80), colour (7.20), aroma (7.00) and overall acceptability (7.55).

CONCLUSION

In conclusion the inclusion of Cardaba banana and African yam bean flour to wheat in peanut burger coatings increased the protein (12.98, 11.53%), fibre (1.38, 1.47%), ash (4.23, 4.92%) and potassium (156.23, 199.10mg/100g) content in samples BAB2 and BAB3 respectively. The energy value (3.79.39 – 394.53KJ/g) observed showed that the peanut burgers had similar energy content and will contribute to energy intake for daily activities. Sample BAB2 was the most preferred among the composite coatings in appearance, texture, taste, colour, aroma and overall acceptability. Hence the inclusion of Cardaba banana and African yam beans flour in peanut burger formulations can be beneficial towards improving the nutritional value of peanut burgers.

Table 1 : Percent proximate composition and energy values (KJ/g) of prepared peanut burger coats from different proportions of wheat, Cardaba banana and African yam beans.

Sample	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate	Energy value
3AB1	9.45 ± 0.13 ^c	10.18±0.01 ^d	10.41±0.07 ^a	1.25±0.00 ^c	3.68 ± 0.11 ^d	65.03±0.33 ^a	394.53
3AB2	9.15 ± 0.0 ^d	12.98±0.05 ^b	9.57 ± 0.07 ^b	1.38±0.00 ^b	4.23 ± 0.03 ^c	62.69±0.15 ^c	388.81
3AB3	9.38 ± 0.00 ^c	11.53±0.04 ^c	9.19 ± 0.19 ^c	1.47±0.01 ^a	4.92 ± 0.35 ^a	63.51±0.33 ^b	382.87
3AB4	9.65 ± 0.06 ^b	13.10±0.07 ^a	8.86 ± 0.09 ^d	1.21±0.01 ^c	4.73 ± 0.07 ^b	62.45±0.05 ^c	381.94
3AB5	9.75 ± 0.01 ^a	11.75±0.07 ^c	8.51 ± 0.06 ^c	1.23±0.01 ^c	4.80±0.05 ^{ab}	63.96±0.04 ^b	379.39

Note: BAB1 (100% wheat), BAB2 (80:5:15), BAB3 (80:15:5), BAB4 (60:15:25) and BAB5 (60:25:15) of mixtures of wheat, Cardaba banana and African yam beans

Table 2 : Mineral composition (mg/100g) of peanut burger coats from different proportions of wheat, cardaba banana and African yam beans flours.

Samples	Ca	Fe	Mg	Ph	Na	K
3AB1	309.05±0.43 ^a	86.17±0.26 ^a	207.59±1.46 ^a	136.98±1.86 ^a	133.77± 1.06 ^a	149.96± 0.74 ^d
3AB2	247.25±0.37 ^b	71.95±1.84 ^b	156.82± 1.27 ^b	132.21±0.38 ^b	109.29± 0.86 ^b	156.23±0.66 ^c
3AB3	187.46±1.43 ^c	34.86±1.34 ^c	139.69±1.92 ^c	127.28± 1.97 ^c	102.23±0.06 ^c	199.10± 1.41 ^a
3AB4	132.99±1.11 ^d	30.29±0.01 ^c	38.84±0.81 ^d	88.27± 1.80 ^d	61.09± 0.04 ^d	93.87± 0.13 ^e
3AB5	139.35±1.17 ^e	21.64±1.79 ^d	35.39±0.23 ^d	69.65± 0.70 ^e	56.50± 0.45 ^e	175.65± 1.46 ^b

Note: BAB1 (100% wheat), BAB2 (80:5:15), BAB3 (80:15:5), BAB4 (60:15:25) and BAB5 (60:25:15) of mixtures of wheat, Cardaba banana and African yam beans

Table 3 : Sensory properties of peanut burgers coated with different proportions of wheat, cardaba banana and African yam beans flours.

amples	Appearance	Texture	Taste	Color	Aroma	Overall acceptability
AB1	7.40 ± 1.09 ^a	7.95 ± 0.94 ^a	7.70 ± 1.08 ^a	7.10 ± 1.4 ^a	7.30 ± 0.86 ^a	8.00 ± 0.79 ^a
AB2	7.25 ± 1.53 ^a	7.55 ± 1.19 ^a	7.80 ± 0.89 ^a	7.20 ± 1.2 ^a	7.00 ± 0.86 ^a	7.55 ± 0.94 ^a
AB3	6.65 ± 1.87 ^b	5.45 ± 1.39 ^c	5.70 ± 1.66 ^c	6.25 ± 1.9 ^c	6.15 ± 1.39 ^c	6.30 ± 1.38 ^c
AB4	6.40 ± 1.09 ^b	6.10 ± 1.41 ^{bc}	6.30 ± 1.53 ^b	6.70 ± 1.6 ^b	6.50 ± 1.39 ^b	6.60 ± 1.43 ^b
AB5	6.50 ± 1.47 ^b	6.51 ± 1.39 ^b	6.45 ± 1.39 ^b	6.80 ± 1.2 ^b	6.65 ± 1.42 ^b	6.50 ± 1.43 ^b

Note: BAB1 (100% wheat), BAB2 (80:5:15), BAB3 (80:15:5), BAB4 (60:15:25) and BAB5 (60:25:15) of mixtures of wheat, Cardaba banana and African yam beans

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TITHONIA SOIL AMENDMENTS ON YIELD AND POSTHARVEST QUALITY OF PEPPER FRUITS (*Capsicum frutescens* (L.))

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ABSTRACT

Tithonia diversifolia is important as an effective source of nutrient to enhance soil fertility and improve chemical properties of the soil. Research was conducted at the Federal University Oye Ekiti, Ekiti State, Nigeria to assess the effect of different levels of *Tithonia diversifolia* biomass on growth, fruit yield, post-harvest quality and shelf life of pepper fruits. The treatments included *Tithonia diversifolia* at 0, 5, 10 and 15 t/ha and two varieties (V1 and V2) of *Capsicum frutescens* (L.) were planted. Results showed that variety 1 had significantly larger leaf area, longer stalk length, more leaves and heavier fruit yield compared to variety 2. Treatment with 15 tons/ha *Tithonia diversifolia* performed best and had the highest values for growth response and in fruit yield. The pepper in the refrigerator stored best for both varieties followed by evaporative coolant structure (pot-in-pot). In conclusion, the evaporative coolant structure can be adopted by pepper farmers to elongated shelf life and for storage as a good alternative to refrigerator storage.

Keywords: *Tithonia diversifolia*, pepper varieties, N.P.K fertilizer, postharvest, storage.

INTRODUCTION

Capsicum frutescens (L.) belongs to the family Solanaceae and cultivated worldwide. [1, 2]. The use of *Tithonia diversifolia* as an effective source of nutrient for annual crops has been reported for crop [3, 4]. This could be attributed to the addition of nutrient and probably phyto-chemicals from the leaves of *Tithonia diversifolia* to the soil. [5, 6, 7, 8]. Moreover, [9] showed that *Tithonia diversifolia* plant rapidly decomposes in soil when incorporated as an effective source of Nitrogen (N), Phosphorus (P) and Potassium (K) for crops. Green leaf of *Tithonia diversifolia* is high in nutrients with dry matter content averaging about 3.5% N, 0.37% P and 4.1% K [10, 11]. The use of *Tithonia diversifolia* led to increase in nitrogen, phosphorus, calcium, Potassium and magnesium essential for crop growth [12 and 13]. This research was aimed to determine the effect of different levels of *Tithonia diversifolia* biomass on growth, fruit yield, post-harvest quality and the effect of different storage methods on the shelf life of pepper fruits.

MATERIALS AND METHODS

Field experiment was conducted at the Teaching and Research Farm, Federal University Oye - Ekiti, (Ikole-Ekiti Campus), Ekiti State (Longitude 7 47° and Latitude 5 31°). The bed size was 2.5 m x 2.5 m per plot and 0.5 m between rows. Seedlings were transplanted at the spacing of 60 cm by 60 cm and depth of 5 cm. The experimental design was Randomized Complete Block Design (RCBD). The plant materials were chopped, weighed and incorporated into the soil. Treatments included *Tithonia diversifolia* at 0 t/ha (control), and application at 5, 10 and 15 t/ha and two pepper varieties (V1 - long size. 11.5cm and V2 - medium size. 6.5cm). Agronomic parameters measured included the plant height, number of leaves, number of branches, number of fruits per plant and fruit yield. All the data collected were subjected to Analysis of Variance (ANOVA) and means separated by Tukey (Honestly significant difference). At the post-harvest studies pepper fruits were stored under three storage conditions. open shelves in the laboratory (Ambient (21.9 C – 33.5 C; 58 - 62 % RH), portable model evaporative coolant structure E.C.S. (18 C – 20 C; 70 - 75 % RH) described by [14], and Refrigerator (4 C; 40 - 45 % RH). The degree of crispness or softness of pepper was observed using tensiometer at six days intervals to determine the level of firmness of pepper fruit. Firmness was also rated on a scale of 1-4. 1 = Not firm; 2 = slightly firm; 3 = Firm; 4 = very Firm [15]

The weight loss was calculated using the equation

$$\text{Weight loss} = \frac{W_1 - W_2}{\text{Original weight}} \times 100 \quad W_1 = \text{Initial weight, } W_2 = \text{Final weight} \dots\dots \text{Equation 1}$$

RESULTS AND DISCUSSION

The results showed that pepper with long size fruit 11.5cm (V1) had significantly higher growth rate and yield compared to medium size. 6.5cm (V2) (Table.1) indicating variations in the genetic components of the two varieties. Several studies [16 and 17] asserted that variation exists in the morphological traits of crops because of differences in genetic traits. Application of *Tithonia diversifolia* biomass at 15 t/ha gave highest performance for both (V1) and (V2). Report by [18] stated that nitrogen is required for the formation of chlorophyll and phosphorus for cell division and elongation. Similar vegetative growth in pepper had been reported [9, 19], as well a corresponding increase in vegetative parameters such as number of branches, number of leaves [20 and 21]. The firmness of pepper fruits stored in pot and refrigerator were not different across the days of storage for both varieties. (Table 3). Pepper fruits from *Tithonia diversifolia* biomass applied at 15 t/ha performed best with regards to fruit firmness across days of storage for the three-storage system (Table 3.) The fruit stored in the ECS were superior in their firmness because of the ability of the pot-in-pot to lengthen shelf life compared to ambient environment. It was reported by [22, 23] that low temperature and high relative humidity can be achieved using evaporative cooling system. Pepper fruits stored in refrigerator showed significantly lower weight loss and stored for 21 days compared to other storage structure. Fruits stored in the refrigerator had the least weight loss followed by ECS (15 days) and Ambient 6 days. The variation was due to exchange of gases between the fruit and the storage environment which is usually influenced by the surface/volume ratio (cm²/cm³) according to [24]. The study showed variety 2 had higher weight loss compared to V1. Thus, the genotypes V1 was susceptible to high rates of water loss due to lower quantities of total lipids in their membranes. The differences in weight loss of fruits under the storage environments tended to narrow down as the days of storage extend [25, 26, 27, 28 and 29].

Table 1: Effect of *Tithonia diversifolia* on Growth and yield of two pepper varieties

Treatments	Varieties	NL								
		8	10	12	8	10	12	8	10	12
T ₀	V ₁	37.63	41.27	42.17	4.00	8.00	10.00	29.00	33.00	33.00
	V ₂	37.70	40.93	41.03	3.00	6.00	7.00	30.00	30.00	30.00
	HSD 0.05	2.41	16.44	2.77	9.31	5.84	5.84	8.73	3.15	3.15
T ₁	V ₁	42.90	47.53	49.77	6.00	10.00	14.00	22.00	36.00	40.00
	V ₂	39.73	41.03	47.20	6.00	8.00	12.00	30.00	34.00	36.00
	HSD 0.05	2.41	16.44	2.77	9.31	5.84	5.84	8.73	3.15	3.15
T ₂	V ₁	37.20	47.70	47.77	7.00	9.00	15.00	36.00	37.00	37.00
	V ₂	43.57	54.53	54.57	6.00	8.00	12.00	30.00	37.00	37.00
	HSD 0.05	2.41	16.44	2.77	9.31	5.84	5.84	8.73	3.15	3.15
T ₃	V ₁	39.03	52.40	52.47	5.00	9.00	14.00	26.00	37.00	37.00
	V ₂	41.40	55.13	55.33	4.00	8.00	13.00	30.00	38.00	38.00
	HSD 0.05	2.41	16.44	2.77	9.31	5.84	5.84	8.73	3.15	3.15

Mean in a column with the same letter(s) are not significantly different according to Tukey Honestly Difference at (P = 0.05), V1= variety 1, V2= variety 2
T0= control plot, T1= *Tithonia diversifolia* biomass applied at 5 t/ha, T2= *Tithonia diversifolia* biomass applied at 10 t/ha, T3= *Tithonia diversifolia* biomass applied at 15 t/ha, PH= Plant height, NBr=Number of branches, WAS= Weeks after sowing

Table 2: Effect of different levels of *Tithonia diversifolia* on pepper fruit yield

Treatment	Variety	FRUIT DIMENSION						
		NF1	NF2	NF1 HARV	NF3 HARV	FL	FW	FFW
T0	V1	16.00	13.00	76.00	35.00	10.00	2.00	19.00
	V2	18.00	14.00	96.00	69.00	6.00	1.00	14.00
	HSD 0.05	6.24	2.13	19.15	20.12	1.42	0.18	0.00
T1	V1	28.00	21.00	95.00	71.00	12.00	2.00	21.00
	V2	30.00	25.00	110.00	90.00	8.00	1.00	15.00
	HSD 0.05	6.24	2.13	19.15	20.12	1.42	0.18	0.00
T2	V1	30.00	24.00	103.00	100.00	14.00	3.00	21.00
	V2	32.00	27.00	111.00	121.00	10.00	2.00	17.00
	HSD 0.05	6.24	2.13	19.15	20.12	1.42	0.18	0.00
T3	V1	33.00	21.00	111.00	86.00	13.00	3.00	21.00
	V2	37.00	25.00	121.00	109.00	11.00	2.00	17.00
	HSD 0.05	6.24	2.13	19.15	20.12	1.42	0.18	0.00

Mean in a column with the same letter(s) are not significantly different according to Tukey Honestly Difference at (P=0.05), V1= variety 1, V2= variety 2, T0= control plot, T1= *Tithonia diversifolia* biomass applied at 5t/ha, T2= *Tithonia diversifolia* biomass applied at 10t/ha, T3= *Tithonia diversifolia* biomass applied at 15t/ha, , NF 1= Number of first fruit set, NF2= Number of second fruit set, , FL=fruit length, FW= fruit width, FFW=fresh fruit weight

Table 3: Effect of *Tithonia diversifolia* firmness o pepper stored across three media

z	Varieties	ECS			RF			ABT			ECS			RF			ABT		
		6 DAS			12 DAS			18 DAS			24 DAS			30 DAS					
T ₀	V ₁	4	4	4	3	2	4	3	1	3	2	1	3	2	0	1			
	V ₂	3	4	4	3	2	4	2	1	4	2	1	4	2	0	2			
	HSD 0.05	0.99	0.99	0.99	1.07	1.14	0.96	0.72	1.08	1.13	0.72	0.87	0.73	1.08	0.00	0.73			
T ₁	V ₁	3	4	3	3	1	3	2	1	3	2	1	3	3	0	2			
	V ₂	4	4	4	3	2	4	3	2	4	3	1	4	3	0	2			
	HSD 0.05	0.99	0.99	0.99	1.07	1.14	0.96	0.72	1.08	1.13	0.72	0.87	0.73	1.08	0.00	0.73			
T ₂	V ₁	4	4	4	3	1	3	2	1	3	2	1	3	3	0	2			
	V ₂	3	4	4	3	2	4	2	2	4	2	1	4	2	0	2			
	HSD 0.05	0.99	0.99	0.99	1.07	1.14	0.96	0.72	1.08	1.13	0.72	0.87	0.73	1.08	0.00	0.73			
T ₃	V ₁	4	4	4	3	1	4	3	1	4	3	2	4	3	0	2			
	V ₂	4	4	4	3	2	4	2	2	4	2	1	4	2	0	2			
	HSD 0.05	0.99	0.99	0.99	1.07	1.14	0.96	0.72	1.08	1.13	0.72	0.87	0.73	1.08	0.00	0.73			

Mean in a column with the same letter(s) are not significantly different according to Tukey Honestly Difference at (P = 0.05), V1= variety 1, V2= variety 2, T0= control plot, T1=*Tithonia diversifolia* biomass applied at 5t/ha, T2=*Tithonia diversifolia* biomass applied at 10t/ha, T3= *Tithonia diversifolia* biomass applied at 15t/ha, ECS fruit firmness, RF= Refrigerator, ABT= Ambient, DAS= Days after storage. Firmness scale where 1 = Not firm; 2 = slightly firm; 3 = Firm; 4 = very Firm.

Table 4: Effect of *Tithonia diversifolia* on fruit weight of pepper stored across three media

Treatments	Varities	ECS	RF	ABT	ECS	RF	ABT	ECS	RF	ABT	ECS	RF	ABT	ECS	RF	ABT
		6DAS			12DAS			18DAS			24DAS			30DAS		
T ₀	V ₁	17.57	18.07	16.10	14.17	19.47	12.23	8.87	26.53	8.83	5.53	12.23	4.00	2.47	1.20	3.83
	V ₂	13.20	13.47	12.47	12.23	16.10	8.70	5.80	21.27	5.80	3.83	8.70	2.70	2.10	1.27	2.67
	HSD0.05	0.56	0.45	0.23	0.36	1.03	0.52	0.99	1.75	1.15	0.44	0.52	0.41	0.43	0.78	0.43
T ₁	V ₁	18.57	18.77	16.10	14.17	19.37	12.63	8.43	26.57	8.53	5.53	12.63	3.93	2.73	1.47	3.83
	V ₂	14.13	14.43	13.23	11.97	16.10	8.60	5.63	21.07	5.63	3.90	8.60	2.63	1.97	1.33	2.60
	HSD0.05	0.56	0.45	0.23	0.36	1.03	0.52	0.99	1.75	1.15	0.44	0.52	0.41	0.43	0.78	0.43
T ₂	V ₁	18.97	20.17	17.17	12.47	21.67	12.33	9.20	26.47	9.20	5.20	12.13	3.83	2.53	1.50	3.83
	V ₂	15.90	16.13	13.27	12.17	16.70	8.40	5.53	22.00	5.53	3.67	8.40	2.57	2.13	1.43	2.53
	HSD0.05	0.56	0.45	0.23	0.36	1.03	0.52	0.99	1.75	1.15	0.44	0.52	0.41	0.43	0.78	0.43
T ₃	V ₁	19.40	20.47	16.80	13.23	21.50	12.30	8.20	26.37	8.40	5.27	12.23	3.90	2.20	1.47	3.67
	V ₂	16.23	16.53	13.53	13.27	16.83	8.53	5.33	20.77	5.33	3.63	8.53	2.57	2.20	1.43	2.53
	HSD0.05	0.56	0.45	0.23	0.36	1.03	0.52	0.99	1.75	1.15	0.44	0.52	0.41	0.43	0.78	0.43

Main in a column with the same letter(s) are not significantly different according to

variety 1, V2=variety 2, T0= control plot, T1= *Tithonia diversifolia* biomass applied at 5t/ha, T2= *Tithonia diversifolia* biomass applied at 10t/ha, T3= *Tithonia diversifolia* biomass applied at 15t/ha, Ambient fruit weight, DAS= Days after storage

Tukey Honestly Difference at (P=0.05), VI=

ECS = Evaporative coolant, RF= Refrigerator, ABT=

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EVALUATION OF INDIGENOUS FARMING PRACTICES AMONG VEGETABLE FARMERS IN IKOLE LOCAL GOVERNMENT

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ABSTRACT

Agriculture is the main occupation of the people of Ekiti and provides income and employment for more than 75% of the population of Ekiti State. A study conducted at the Federal University Oye-Ekiti evaluated indigenous farming practices among vegetable farmers in Ikole local Government Area, Ekiti State. A multi-stage sampling procedure was used to select 120 indigenous vegetable farmers. The objectives of the study were to evaluate the level of deployment and effectiveness of identified organic-farming practices among vegetable farmers. The data were analysed using descriptive statistics such as frequency counts, mean and standard deviation. The mean age of the farmers was 46.24 ± 10.83 years with the majority (70.1%) being males. Majority (69.3%) of the farmers were married with an average household size of 6. About 50.2% of the respondents had secondary education. Watering ($x=4.91$), shifting cultivation ($x=4.86$) and Crop rotation ($x=4.81$) ranked first, second and third as most utilised indigenous farming practices for vegetable production. From the result of study, farmers perceived that the effectiveness of the identified indigenous vegetable farming practices was high. Crop rotation ($x=4.84$), proper tillage ($x=4.82$) and watering ($x=4.80$), ranked first, second and third on the farmers' perception scale. It was concluded that vegetable farmers in Ikole demonstrated a high level of utilisation of indigenous farming practices. It is recommended that capacity building workshops be facilitated by extension agents and NGOs to encourage the use of eco-friendly indigenous and organic practices for vegetable farming for high productivity in the area.

Keywords: Vegetables, farmers, knowledge, indigenous farm practices

INTRODUCTION

Each location has certain and peculiar indigenous vegetables to the area which is part of the food culture of the people over the ages. Therefore, indigenous vegetables are plant species consumed in specific locations as part of their traditional diets. The usage of these indigenous vegetables is based on traditional knowledge about the cultivation methods and meal preparation [1]. Indigenous vegetables are regarded as local vegetables which may either be found in some geographical areas but scarce in other areas. They are highly nutritious vegetables that have been abandoned either by the local farmers or the consumers. They are the species of vegetables which may be under-utilised in some areas but not so in some areas [2]. In many parts of Nigeria, indigenous leafy vegetables have been accepted as dietary constituents, generally forming a substantial portion of soups and stews. Indigenous vegetables possess the potentials to alleviate poverty, address nutritional deficiency and mitigate food insecurity because they are easy to cultivate, highly affordable, easily available and require minimum production inputs [3]. Some common indigenous vegetables include Ugwu (*Telfairia occidentalis*), water leaf (*Talinium triangulaire*), bitter leaf (*Vernonia amygdalina*), Green (*Amaranthus caudatus*) and ukazi (*Gnetum africanum*). Many indigenous leafy vegetables are collected in their natural growing habitats as wild species, while only few are cultivated for consumption [4].

Vegetable crops can be classified as fruit vegetables such as tomato, cucumber, watermelon, peas; root and tuber/root vegetables such as carrot, potato, sweet potato, radish, elephant foot yam; green leafy vegetables such as Amaranthus, celery, cabbage, curry leaf and bulb vegetables such as onion and garlic. Vegetables are important to food security and are mostly consumed with the local common staples. They contain essential minerals and vitamins that are essential to human health and strengthens resistance to diseases [5].

There has been need for increased awareness on the utilization of indigenous agricultural practices over conventional systems in Africa [6].

This has been attributed to increased use of agrochemicals for agricultural production that has negative implications for the environment and health of the consumers. [7] acknowledged that indigenous or local knowledge and related social and cultural practices are important for sustainable agricultural development. The authors opined that rather than replacing what people know with new, often expensive, unfamiliar, culturally and socially inappropriate and consequently locally unsustainable technologies, it is better to consider and understand what people know and, where appropriate, build upon this knowledge [7].

Mechanized farming is characterized by use of chemicals, and these chemicals such as pesticides are generally used to protect the plant- soil-animal ecology from various diseases. The use of chemicals has been reported to have environmental effects and health implications for consumers [8]. This is however different from the old system of crop production and management that incorporated indigenous agricultural methods devoid of chemicals and without environmental or health risk [9]. Due to these adverse effects, there is urgent need to develop agricultural innovations for ecological and sustainable food production [8].

Despite utilization of mechanized farming, there are still reports of inadequate production and supply of vegetable to meet consumers demand [10]. In the light of this scenario, this study was carried out to ascertain the level of utilization and effectiveness of indigenous vegetable management practices in the study area.

MATERIALS AND METHODS

The research was carried out in Ikole Local Government Area of Ekiti State, located in South-west Nigeria. The LGA is located on latitude 7°47'0"N and longitude 5°31'0"E in the Northwestern part of the state. A two-stage sampling procedure was used to select 120 indigenous vegetable farmers. The first stage involved the selection of five (5) communities from the Local Government Area (LGA) namely: Odo-oro, Ijesha-Isu, Ayedun, Osin and Oke-orin. At the second stage, twenty-four (24) indigenous vegetable farmers were randomly selected from each community making one hundred and twenty (120) respondents. Primary data were collected with the aid of a structured interview schedule. The data were analysed using descriptive statistics such as frequency, mean and standard deviation. The dependent variable of study was utilization of the indigenous management practices; and this was measured on a 5-point rating scale with values 5-Very high, 4-high, 3-moderate, 2-low, and 1-very low respectively. The values were added to obtain a total of 15 and divided by 5 to obtain a mean of 3.

RESULTS AND DISCUSSION

Most of the respondents utilized indigenous vegetable farming practices with watering ($x = 4.79$) ranking first, followed by shifting cultivation ($x = 4.78$), crop rotation ($x = 4.74$), weeding ($x = 4.72$), pest and disease control ($x = 4.7$) - Table 1. This result infers that respondents utilize these farming practices highly for vegetable production in the study area. This is an indication that respondents were maximizing income and minimizing cost since most of these practices involve utilizing alternative means to achieve the same or best production results. The report by [11] listed organic practices such as mulching, composting or manuring, legumes planting, application of neem seed, swamp farming, channelling domestic wastewater to wet their vegetable farms and conservation tillage as part of indigenous practices among vegetable farmers.

It was observed that majority of the respondents perceived the following indigenous vegetable farming practices as highly effective; Crop rotation ($x = 4.84$), Proper tillage ($x = 4.82$), Watering, ($x = 4.80$),

Soil management ($x = 4.79$), Pest and disease control ($x = 4.75$) among others (Table 2). This result confirms the submission of [4] that watering, shifting cultivation, crop rotation are two major indigenous vegetable farming practices effectively utilized by local farmers in Kogi State.

CONCLUSION

The study concluded that indigenous vegetable farming practices are highly utilised and perceived as highly effective. It is therefore required that capacity building workshops be facilitated by extension agents and NGOs to encourage the use of eco-friendly indigenous and organic practices for vegetable farming for high productivity in the area.

Table 1: Level of utilisation of indigenous vegetable farming practices

Indigenous practices	Highly utilised		Moderately utilised		Utilised		Slightly utilised		Not utilised		Mean	Rank
					Freq		[%]					
Watering	87	[72.5]	18	[15]	11	[9.2]	4	[3.3]	0	[0]	4.79	1 st
Shifting cultivation	84	[70]	16	[13.3]	13	[10.8]	7	[5.8]	0	[0]	4.78	2 nd
Crop rotation	80	[66.7]	16	[13.3]	13	[10.8]	7	[5.8]	0	[0]	4.74	3 rd
Weeding	79	[65.8]	22	[18.3]	13	[10.8]	6	[5]	0	[0]	4.72	4 th
Test and disease control	76	[63.3]	17	[14.2]	15	[12.5]	12	[10]	0	[0]	4.70	5 th

Source: Field survey, 2024

Table 2: Farmers' effectiveness in the uses of indigenous vegetable farming practices for vegetable production

Indigenous practices	Highly Effective		Effective		Moderately Effective		Slightly Effective		Not Effective		Mean	Rank
					Frequency		[%]					
Crop rotation	90	[75]	20	[16.7]	8	[6.7]	2	[1.7]	0	[0]	4.80	1 st
Proper tillage	86	[71.7]	22	[18.3]	11	[9.2]	1	[0.8]	0	[0]	4.80	2 nd
Watering	84	[70]	19	[15.8]	14	[11.7]	3	[2.5]	0	[0]	4.79	3 rd
Soil management	81	[67.5]	21	[17.5]	12	[12.5]	6	[5]	0	[0]	4.77	4 th
Burning stubbles	78	[65]	24	[20]	15	[12.5]	3	[2.5]	0	[0]	4.75	5 th

Source: Field survey, 2024

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ORGANIC AQUACULTURE IN NIGERIA: CURRENT PRACTICES, ADOPTION AND THE WAY FORWARD

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ABSTRACT

Agriculture is the main occupation of the people of Ekiti and provides income and employment for more than 75% of the population of Ekiti State. A study conducted at the Federal University Oye-Ekiti evaluated indigenous farming practices among vegetable farmers in Ikole local Government Area, Ekiti State. A multi-stage sampling procedure was used to select 120 indigenous vegetable farmers. The objectives of the study were to evaluate the level of deployment and effectiveness of identified organic-farming practices among vegetable farmers. The data were analysed using descriptive statistics such as frequency counts, mean and standard deviation. The mean age of the farmers was 46.24 ± 10.83 years with the majority (70.1%) being males. Majority (69.3%) of the farmers were married with an average household size of 6. About 50.2% of the respondents had secondary education. Watering ($x=4.91$), shifting cultivation ($x=4.86$) and Crop rotation ($x=4.81$) ranked first, second and third as most utilised indigenous farming practices for vegetable production. From the result of study, farmers perceived that the effectiveness of the identified indigenous vegetable farming practices was high. Crop rotation ($x=4.84$), proper tillage ($x=4.82$) and watering ($x=4.80$), ranked first, second and third on the farmers' perception scale. It was concluded that vegetable farmers in Ikole demonstrated a high level of utilisation of indigenous farming practices. It is recommended that capacity building workshops be facilitated by extension agents and NGOs to encourage the use of eco-friendly indigenous and organic practices for vegetable farming for high productivity in the area.

Keywords: Vegetables, farmers, knowledge, indigenous farm practices

DESCRIPTION OF THE PROBLEM

Fish farming is globally regarded as an important agricultural industry in the food production process. It is thought to be an essential agricultural practice that can significantly lower nutritional deficiencies worldwide and, as a result, successfully eliminate poverty [10]. Aquaculture is the industry in Nigeria's agricultural sector that is expected to grow at the highest rate as it includes various elements that ensure farming activity and nature are in harmony [19]. Intensification of aquaculture causes adverse effects not only at the farm level but also on the health of the aquatic environment and ecosystem. Sustainable aquaculture is the need of the hour to accomplish the goal of sustainable development in the fisheries sector [12]. New approaches like organic aquaculture will support the sector's ability to provide an alternative to unsustainable practices of fisheries and aquaculture worldwide as the practice is based on the minimal use of off farm inputs and on management practices that restore, maintain and enhance ecological harmony. and strengthens resistance to diseases [5].

OVERVIEW OF AQUACULTURE IN NIGERIA

Aquaculture, intertwined with human civilization, has a rich and diverse historical background that spans thousands of years [22].

The earliest records of aquaculture dates back to ancient China around 2500 BCE [18]. Chinese fish farmers began rearing common carp in artificial ponds and rice paddies, marking the genesis of intentional fish cultivation. The success of these led to the development of more sophisticated aquaculture techniques, including selective breeding and the construction of intricate pond systems.

Aquaculture in Nigeria has a historical trajectory that reflects the nation's commitment to addressing food security, economic growth, and the increasing demand for fish protein [14].

Communities in Nigeria engaged in small-scale aquaculture activities, constructing fish ponds and utilizing natural water bodies for fish farming. These traditional practices were often integrated into the agricultural systems of different ethnic groups, demonstrating an early recognition of the importance of fish farming in sustaining local diets and economies.

The modern era of aquaculture in Nigeria began in the mid-20th century [4]. The Nigerian government, recognizing the potential of aquaculture to contribute to food production and economic development, initiated efforts to promote and support the industry. In the 1950s and 1960s, the government established experimental fish farms and research institutions to explore suitable species for cultivation and develop appropriate technologies. One significant milestone occurred in 1972 when the Nigerian Institute for Oceanography and Marine Research (NIOMR) was established. NIOMR played a crucial role in conducting research on aquaculture practices, providing technical support, and disseminating knowledge to fish farmers across the country. The government's commitment to aquaculture was further emphasized with the establishment of the Federal Department of Fisheries in 1988, which aimed to regulate and promote sustainable fisheries and aquaculture practices.

In the early 2000s, the Nigerian government intensified efforts to enhance aquaculture production through various policies and initiatives. The National Fisheries Development Program (NFDP), launched in 2004, sought to boost fish production, improve post-harvest processing, and create employment opportunities in the aquaculture sector. The government also encouraged private sector involvement through incentives and partnerships, fostering the growth of commercial aquaculture operations.

CURRENT STATUS OF AQUACULTURE IN NIGERIA

Aquaculture is the practice of farming aquatic organisms, which include fish, molluscs, crustaceans, and aquatic plants [11]. The cultivation process involves various interventions in the breeding cycle to enhance production, such as daily maintenance, feeding, protection from predators, and other measures.

The aquaculture industry is the fastest-growing sector in food production, contributing to over 50 percent of global fish output. Approximately 424 aquatic species are farmed, benefiting millions by providing nutrition, ensuring food security, promoting sustainable livelihoods, and reducing poverty [6].

Aquaculture is a burgeoning industry in Nigeria, poised for continuous growth to bridge a substantial deficit exceeding one million tonnes between fish production and consumption [2, 16]. Despite the abundance of marine water resources, the country's aquaculture sector primarily focuses on inland freshwater aquaculture [1].

Nigeria stands out as a significant player in the global aquaculture landscape, particularly in catfish farming, where it leads the world [15]. This strategic position, positions the country to address the escalating demand for fish protein within its population.

IMPORTANCE OF ORGANIC AQUACULTURE

Aquaculture, contributing to global animal protein supplies, has faced challenges including the depletion of feed sources and environmental pollution. The organic aquaculture sector has emerged, aiming to establish ecologically integrated systems that prioritize environmental preservation, biodiversity enhancement, animal welfare, and the production of high-quality, healthy products (fish).

1. **Environmental Stewardship:** One primary advantage of organic aquaculture lies in its commitment to environmental conservation. By avoiding the use of toxic substances in aquaculture feeds, organic methods mitigate adverse environmental and human health effects.
2. **Diversity and Global Growth.** This sector seeks to provide fish and fishery products that are not only economically viable but also ecologically and socially responsible. The global production from organic aquaculture has seen an impressive 950 percent increase from 2000 to 2008, with projections indicating continued growth.

3. **Species and Production:** The organic aquaculture umbrella encompasses a diverse array of species, including finfish, crustaceans, mollusks, and microalgae.
4. **Feed Management:** Organic aquaculture places a strong emphasis on sustainable feed management. This not only minimizes stress to the organisms but also reduces the occurrence of diseases.
5. **Health and Quality:** Products from organic aquaculture are not only healthier but also tastier, as they are free from synthetic chemicals. This commitment to producing high-quality goods creates a secure and wholesome environment for consumers.
6. **Community Engagement:** Organic aquaculture promotes the use of local resources and services, contributing to a sustainable and socially responsible working environment for employees.
7. **Value-Added Products:** Innovations in organic aquaculture extend to the development of value-added products. Noteworthy examples include fish fingers entirely produced through organic means, sourced from organically grown ingredients.

ORGANIC AQUACULTURE PRACTICES; DEFINITION AND PRINCIPLES

IFOAM Organics International, the global umbrella organization for the organic sector, defines organic agriculture as “a production system that sustains the health of soils, ecosystems and people”. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects.

Organic systems are grounded in four fundamental Principles of Organic Agriculture: health, ecology, fairness, and care. These principles extend beyond traditional agricultural practices, encompassing the holistic approach to managing soils, water, plants, and animals for the production, preparation, and distribution of food and other goods. The application of these principles involves considering how individuals interact with living landscapes, connect with each other, and shape a legacy for future generations [20].

The pivotal debate on whether the organic sector should encompass aquaculture in its scope occurred through public consultation and a vote by the General Assembly of IFOAM Organics International in 2017, resulting in a majority in favor of inclusion. Adapting the Principles of Organic Agriculture to aquaculture systems necessitates a careful adjustment of emphasis and re-contextualization. This ensures that the requirements for organic aquaculture accurately reflect the intentions of the principles to the highest possible extent.

1. Principle of Health in Organic Aquaculture

By prioritizing natural processes and avoiding harmful interventions, organic aquaculture establishes a foundation for a healthier and more environmentally conscious industry [8]

1. **Chemical-Free Approach:** Unlike conventional practices that may employ synthetic chemicals, organic aquaculture emphasizes the use of natural and organic alternatives. This approach not only reduces the potential for environmental contamination but also ensures the production of clean, uncontaminated aquatic products for consumers.
2. **Antibiotic-Free Production:** Organic aquaculture adheres to a strict policy of avoiding antibiotics and other pharmaceuticals in the cultivation of aquatic species. This commitment is essential to prevent the development of antibiotic resistance and the potential transfer of drug residues into the human food chain.
3. **Natural Feed Sources:** Unlike conventional aquaculture, which may rely on feed derived from wild-caught fish or processed with synthetic additives, organic methods prioritize feeds that contribute to the overall health of the cultured species.
4. **Biodiversity Conservation:** Organic aquaculture practices emphasize biodiversity conservation by creating environments that support a variety of species. This holistic approach fosters resilience and ecological balance, contributing to the long-term health and stability of aquatic ecosystems.
5. **Water Quality Management:** Through sustainable practices, efficient waste management, and the use of natural filtration systems, organic principles help ensure optimal water conditions for aquatic species.

STATUS OF ORGANIC AQUACULTURE IN NIGERIA; CURRENT PRACTICES AND ADOPTION

Despite the formulation of aquaculture strategy to increase productivity and conceptualize development lately (2008) in Nigeria, the sector is considered to be significant to the Nation's economy as it provides employment and improve livelihood of many Nigerians. However, due to the environmental impacts of the practice, fish farmers and fishery scientists have opted over the years for a more sustainable approaches such as RAS system, aquaponics and circular economy in fish production. But the recent increasing awareness and prioritization of sustainable and responsible practices by the consumers around the world including Nigerians, on the health impacts of what they consume including fish products had called for the adoption and shift in practice to organic aquaculture which ensures the non-use of toxic substances for feed production and the production of not only economically viable but ecologically and socially responsible fish for consumption. Fish that are produced under natural conditions according to the organic agricultural principles, not exposed to any protective additives or genetic modification, fed with baits prepared with completely natural materials and certificated by a control agency are called "organic fish". Organic fish production is a model of production which raises fishes with low stock density and attaches importance to human health without using any chemical pesticides or the products modified genetically.

Organic aquaculture practices are currently in use in many areas of the Nigerian aquaculture industry, however, no commercial fish farm is certified "organic" as required by laws enacted to manage organic markets in more developed countries where they exist, thus organic fish farming as practiced in many developing countries including Nigeria today is referred to as "near organic". The use of wild seed and broodstock (e.g. heterotis species) as against the conventional method of getting broodstocks from reliable farms, use of pituitary extracts rather than synthetic hormones for hypophysation, liming with organic lime sources (wood ash), fertilization of ponds with cured poultry manure instead of inorganic fertilizers, use of common salt as prophylactic, fish-livestock-crops integrated systems, and use of bio-pesticides and herbicides are some of the organic aquaculture practices currently adopted in the country's fish production while use of various plant extracts as antimicrobial agents to extend fish shelf life, use of plant extracts to remove slime prior to processing, use of salt to immobilize and calm fish prior to slaughter, use of organic preservatives and flavourants are some of the organic way of fish handling, processing and preservation. [3] highlighted 14 organic aquacultural practices including maintaining eco-friendly design, ensuring site is far from polluting substances, ponds are protected from predators, fish management without growth hormones, antibiotics is used in critical cases where no other treatment would work, cultivate without genetic engineering, quality water source, organic fertilizer, low stock density 10kg/m³, manage without synthetic appetizer and coloring, poly-culture, proper record keeping, use of resistant species and natural treatment(homeopathy). Their study on 3 states (Delta, Bayelsa and Akwa-Ibom) from the south south region of the country showed the adoption and awareness of 3 and 6 respectively of the outlined organic aquaculture practices among the fish farmers. This stressed the fact that organic aquaculture practice is still very low among Nigerian fish farmers and cannot be compared to the awareness of organic crop farming as [13] reported in their study, 68.33% awareness and high adoption and practice of organic farming among 240 crop farmers from 60 villages in Ebonyi state.

Study by [9] on the opinions of involvement of fish farmers in organic aquaculture in Osun state, a south-western part of the country, recorded low level of organic aquaculture and observed lack of knowledge of organic aquaculture practice among the sixty-six (66) farmers used for the study.

CHALLENGES AND CONSTRAINTS

Environmental Constraints:

1. Water Quality Management: Maintaining optimal water quality without relying on conventional chemicals may be challenging, requiring sustainable alternatives to ensure the health of aquatic ecosystems.
2. Input Availability: Limited availability of organic inputs like feed and supplements can impact the overall sustainability of organic aquaculture practices, potentially leading to imbalances in the ecosystem.

Economic Constraints:

1. **Market Access:** Limited access to markets that appreciate and pay a premium for organic products may affect the economic viability of organic aquaculture operations, discouraging farmers from transitioning to organic practices.
2. **Certification Costs:** The expenses associated with obtaining and maintaining organic certification can be a significant economic barrier, particularly for small-scale farmers who may struggle with the financial burden.
3. **Infrastructure and Technology:** Limited access to modern aquaculture technologies and infrastructure for organic practices may impede efficiency, leading to higher production costs and reduced competitiveness in the market.

Regulatory Constraints:

1. **Policy and Regulation:** Inconsistent or inadequate regulations and policies specific to organic aquaculture may create uncertainties and difficulties in its implementation, hindering the sector's growth and development.
2. **Research and Development:** Insufficient research and development initiatives focused on organic aquaculture practices may result in a lack of standardized guidelines and best practices, affecting regulatory frameworks and industry standards.

BENEFITS OF ORGANIC AQUACULTURE**Environmental Benefits:**

1. **Biodiversity Preservation:** Organic practices often prioritize maintaining natural ecosystems, contributing to the preservation of biodiversity in aquatic environments.
2. **Reduced Environmental Impact:** Organic aquaculture aims to minimize the use of synthetic chemicals and antibiotics, leading to a lower environmental impact compared to conventional methods.

Economic Benefits:

1. **Premium Pricing:** Organic products often command higher prices in the market, providing economic incentives for farmers engaged in organic aquaculture.
2. **Market Differentiation:** Organic certification allows products to be distinguished in the market, appealing to environmentally conscious consumers and enhancing the marketability of the produce.
3. **Job Creation:** The expansion of organic aquaculture can create employment opportunities, particularly in sectors related to organic input production, certification, and marketing.

Social Benefits:

1. **Community Health:** Reduced use of chemicals and antibiotics in organic aquaculture contributes to healthier fish and seafood, positively impacting the health of consumers.
2. **Knowledge Transfer:** Embracing organic aquaculture practices encourages knowledge transfer and education about sustainable farming methods, benefiting local communities and promoting long-term sustainability.

Health Benefits:

1. **Chemical-Free Products:** Organic aquaculture avoids the use of synthetic chemicals and antibiotics, resulting in products that are perceived to be healthier and free from residues.
2. **Nutrient-Rich Products:** Organically farmed fish may have a higher nutritional content due to the reliance on natural and organic feeds.

OPPORTUNITIES FOR GROWTH

The growth of organic aquaculture in Nigeria can be fueled by a combination of increasing market potentials, proactive government initiatives and support, and ongoing research and development efforts that focus on innovation and best practices. Collaboration between farmers, government agencies, research institutions, and industry stakeholders will be crucial for unlocking the full potential of organic aquaculture in the country.

MARKET POTENTIALS

1. **Increasing Consumer Demand:** A growing global trend towards organic and sustainable food choices presents an opportunity for the expansion of organic aquaculture in Nigeria, as consumers seek healthier and environmentally friendly options.
2. **Premium Pricing:** Organic products often command higher prices in the market, providing financial incentives for farmers and creating a niche for organic aquaculture producers to capture premium markets.

GOVERNMENT INITIATIVE AND SUPPORT

1. **Policy Development:** Government support through the development of clear policies and regulations specific to organic aquaculture can provide a conducive environment for the sector's growth.
2. **Financial Incentives:** Offering financial incentives, subsidies, or grants for farmers transitioning to or practicing organic aquaculture can encourage wider adoption of sustainable practices.
3. **Training and Capacity Building:** Investing in training programs and capacity-building initiatives for farmers can enhance their understanding of organic aquaculture practices, promoting successful implementation.

RESEARCH AND DEVELOPMENT

1. **Innovation in Organic Inputs:** Research into innovative and cost-effective organic inputs, such as feeds and supplements, can contribute to overcoming challenges related to input availability in organic aquaculture.
2. **Technology Adoption:** Investing in research to develop and promote sustainable aquaculture technologies can improve efficiency and productivity in organic farming practices.
3. **Best Practices Development:** Ongoing research to establish and disseminate best practices specific to organic aquaculture can contribute to the sector's long-term success and sustainability.

WAY FORWARD: RECOMMENDATIONS FOR IMPROVING ORGANIC AQUACULTURE IN NIGERIA

1. **Policy Development:**
 - A. **Specific Regulations:** Develop and implement specific regulations and policies tailored to support and regulate organic aquaculture practices.
 - B. **Certification Standards:** Establish and promote standardized organic certification standards to build consumer trust and facilitate market access.
2. **Government Support:**
 - A. **Financial Incentives:** Provide financial incentives, subsidies, or grants to support farmers transitioning to organic aquaculture, encouraging wider adoption.
 - B. **Training Programs:** Invest in training programs and extension services to educate farmers about organic practices, water management, and sustainable farming techniques.
3. **Research and Development:**
 - A. **Innovative Inputs:** Encourage research into innovative and cost-effective organic inputs, such as organic feeds and supplements, to address challenges related to input availability.
 - B. **Technology Adoption:** Invest in research to develop and promote sustainable aquaculture technologies, enhancing efficiency and productivity in organic farming.
4. **Market Development:**
 - A. **Market Promotion:** Implement marketing campaigns to promote the benefits of organic aquaculture, targeting both domestic and international markets.
 - B. **Value Chain Integration:** Facilitate the integration of organic aquaculture into established value chains, ensuring smooth market access.

5. Stakeholder Engagement and Collaboration:

1. Industry Collaboration:

A. Farmers' Associations: Foster collaboration with farmers' associations to disseminate information, share best practices, and collectively address challenges in the organic aquaculture sector.

B. Private Sector Involvement: Encourage partnerships with private sector entities for investment, technology transfer, and market linkages.

2. Research Institutions:

A. Knowledge Sharing: Facilitate collaboration between research institutions and farmers for knowledge sharing, technology transfer, and addressing specific challenges faced by the sector.

B. Applied Research: Prioritize applied research to develop context-specific solutions for organic aquaculture in Nigeria.

3. Government-NGO Partnerships:

A. Capacity Building: Collaborate with non-governmental organizations (NGOs) to enhance capacity building, training, and education programs for farmers.

B. Community Engagement: Engage local communities in decision-making processes, ensuring that policies and initiatives align with the needs and aspirations of the people.

4. International Collaboration:

A. Knowledge Exchange: Facilitate collaboration with international organizations and experts to exchange knowledge, share experiences, and stay updated on global best practices in organic aquaculture.

B. Access to Funding: Explore international funding opportunities and partnerships to support the growth of organic aquaculture in Nigeria.

By implementing these recommendations, Nigeria can foster a conducive environment for the growth of organic aquaculture, ensuring sustainability, economic viability, and positive environmental impacts in the sector.

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ORGANIC FARMERS' UTILIZATION OF WATER CONSERVATIVE MEASURES AMIDST CLIMATE CHANGE IN EKITI STATE

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ABSTRACT

Global climate change affects agriculture due to the rising temperature and changing weather condition which has adversely impacted the world agriculture. Water conservation helps farmers' access clean water for irrigation and helps to adopt more sustainable farming practices. The objectives of this study were: to identify the water conservative measures farmers' practice; examine the level of utilization; evaluate organic farmers' perception of farmers about water conservation measures; and to describe the constraints to the practice of water conservation measures. Multistage random sampling was used and in the first stage, 3 Local Government Areas were selected from the 3 senatorial districts, in the second stage 2 communities were selected from each Local Government Area making six communities, and in the third stage 10 organic farmers were randomly selected from each community, making 60 respondents. Data were analyzed using descriptive statistics such as mean and frequencies. Intercropping (100%) and ridging (100%) are well practiced. For utilization, intercropping has ($x=5.00$), ridging/heaping across the slope ($x=4.98$), mulching ($x=4.82$), zero and controlled burning (4.78), it shows that farmers are utilizing water conservative measures. The farmers' perception of water conservative measures regarded these as stressful and were also limited in finance to purchase inputs for their farms. The constraint with the highest mean was lack of skilled labour of 71.7% and means score of (3.35). In conclusion, there is need for more training programs specifically focused on water conservation by developing hands-on experience, and by engaging in low-cost and sustainable water conservation technologies.

Keywords: Organic farmers, Utilization, Water conservative measures, Perception, Constraints

INTRODUCTION

The rising temperature and changing weather condition has adversely impacted the world agriculture, farmers therefore need to change their farming practices from conventional agricultural practices to environmental benefiting farming practices such as water conservation measures which helps farmers to adopt more sustainable farming practices[1]. In Ekiti state, a faith-based non-governmental organization has trained their organic farmers on water conservative measures, and there are therefore several water conservative measures that have been implemented to address water scarcity. These measures are supposed to help increase the availability of water for agricultural and domestic use, as well as improve the state's resilience to climate change. On this note the following research questions were asked: what the water conservative is measures farmers practice; what their level of utilization is; what the organic farmers' perception about water conservative measures are; and what are the constraints faced during the practice of water conservation measures.

The objective was to identify the water conservative measures farmers' practice; examine the level of utilization of water conservative measures; evaluate organic farmers' perception of water conservation measures and to describe the constraints to the practice of water conservation measures.

METHODOLOGY

A multistage random sampling was used for selecting organic farmers, in the first stage three Local Government Areas were selected from each of the three senatorial districts, in the second stage two communities were selected from each Local Government Area making six communities, and in the third stage ten organic farmers were randomly selected from each community, making 60 respondents that were interviewed. Structured questionnaire was used to gather information from a

faith-based trained organic farmers in the state. Data were analyzed using descriptive statistics such as mean and frequencies.

RESULTS AND DISCUSSIONS

a. Water conservative measures practiced by organic farmers: Intercropping (100%), ridging (100%), mulching (96.7%) spot burning (98.3%) are all well practiced by organic farmers, followed by crop rotation (83.3%) (Table 1). The result shows that organic farmers are fully aware of these water conservative measures and that they are practicing them. This is also in accordance with [4], who reported that most small-scale farmers in developing countries are aware of water conservative measures.

b. Level of utilization of water conservative measures by farmers: A five-point Likert scale of very high, high, moderately high, low and very low was used to measure level of usage. The result shows that organic farmers have high level of water conservative utilization, with intercropping (100%), ridging/heaping across the slope (95%), mulching (85%), spot burning, (81.7%), zero and controlled burning (81.7%) (Table 2). According to [2], water conservative practices can improve farm fertility, keep the much-needed nutrients in the farm, reduce drought and also help reduce the adverse effect of high temperature.

c. Perception of farmers about water conservation measures: Responses were rated on a 5-point Likert scale of strongly agree, agree, disagree, undecided and strongly disagree. A mean score of 1.90 was used as the discriminating index. Any of the item with mean score ≥ 1.90 was considered as high perception and anyone below is considered as low perception. Statements such as “It will not be worth the effort on my farm” $x=(4.39)$ and “limited financial resources to implement the measure” ($x=3.60$) have high mean scores, which indicated that farmers feel that the water conservative measure is stressful and they also face the problem of limited finance to purchase inputs for their farms [1] (Table 3).

d. Constraints to the practice of water conservation measures: a four-point Likert scale of: highly severe, severe, moderately severe and not severe were used to measure constraints faced. Lack of skilled labour of ($x=3.35$) is the most severe constraint, the examples of these skilled labour are access to technical experts, and water- saving technologies which are of great importance to organic farmers [3] (Table 4).

CONCLUSION

Water conservative measures that were well practiced by organic farmers include intercropping, ridging, mulching and spot burning. The study showed that organic farmers have high level of water conservative utilization which helps them improve their farm fertility. Perception statements such as: “It will not be worth the effort on my farm” and “limited financial resources to implement the measure”, both have high mean scores indicating that farmers think water conservative measure is stressful and they also face the problem of limited finance to purchase inputs for their farms. The most severe constraint is lack of skilled labour, such as access to technical experts. The above findings therefore indicates that there is need for more training programs specifically focused on water conservation by developing hands-on experience, and by engaging in low-cost and sustainable water conservation technologies.

Table 1: Frequency of water conservative measures and cultural practices observed among organic farmers

Water conservative measures	YES Freq. (%)	RANK
Intercropping	100	1 st
Ridging/heaping across the slope	100	1 st
Mulching	96	2 nd
Spot burning	93	3 rd
Zero and controlled burning	91	4 th
Crop rotation	83	5 th
Tillage	75	6 th
Planting of cover crops	75	6 th
Crossbars	73.3	7 th
Afforestation	12	8 th
Total 60		

Source: Field survey, 2024

Table 2: Mean performances of water conservative measures and cultural practices observed among organic farmers

Conservative measures	Mean	RANK
Intercropping	5.00	1 st
Ridging/heaping across the slope	4.98	2 nd
Mulching	4.82	3 rd
Spot burning	4.80	4 th
Zero and controlled burning	4.78	5 th
Tillage	4.35	6 th
Crossbars	4.27	7 th
Crop rotation	4.25	8 th
Planting of cover crops	4.17	9 th
Afforestation	3.17	10 th

Source: Field survey, 2024

Table 3: Perception of organic farmers of water conservative measures and cultural practices worth for farming operations

Perception of statements	Mean	RANK
Not worth the effort	4.39	1 st
Inadequate finance	3.60	2 nd
I have the knowledge	2.90	3 rd
Not effective in my area	1.70	4 th
Complicated to implement	1.67	5 th
Cost-effective	1.28	6 th
Improves crops	1.17	7 th
Good for farm sustainability	1.08	8 th
Environmentally friendly	1.07	9 th
Time constraints	1.03	10 th

Source: Field survey, 2024

Weighted mean = 1.90

Table 4: Frequency of water conservative measures and cultural practices observed among organic farmers

CONSTRAINTS	MEAN	RANK
Lack of skilled labour	3.35	1 st
Costly	2.03	2 nd
Lack of infrastructure	1.88	3 rd
Inadequate knowledge	1.60	4 th
Inadequate support	1.35	5 th
Technical know-how	1.33	6 th
Social and cultural barriers	1.27	7 th
Inadequate finance	1.18	8 th
Water scarcity	1.17	9 th
Political/legal constraints	1.12	10 th

Source: Field survey, 2024

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EFFICACY OF CITRUS RECTICULATA (DRY PEEL) ON PSEUDOMONAS SYRINGAE AFFECTING TOMATOES FRUIT ON STORAGE

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ABSTRACT

Pseudomonas syringae pv. *syringae* is a phytopathogenic bacterium responsible for bacterial canker and blast (stone and pome fruits), that infects more than 180 species of plants, among them is *Lycopersicon* sp. The efficacy of *Citrus reticulata* (dry peel) on *Pseudomonas Syringe* affecting tomato fruit in storage was investigated in the Microbiology and Plant Science and Biotechnology Laboratories of Federal University Oye-Ekiti, Ekiti State. The fruits were bought from vendors in Ilupeju market, Ekiti State. The *Pseudomonas syringae* was isolated from the tomato fruits and the pure culture was grown under the influence of *Citrus reticulata* (dry peel extract of ethanol, acetone and methanol) for their inhibiting actions. Antibiotic susceptibility tests were carried out using 21st generation antibiotics. The results showed that the ethanol and acetone extract of the dry orange peel proved more inhibitory on *Pseudomonas syringae* than all the 21st generation antibiotics used except the ofloxacin (OFX) and levofloxacin (LBC) antibiotics that excelled above all. Thus, the *Citrus reticulata* dry peel extracts of ethanol and acetone can be recommended for use to control *Pseudomonas syringae* in tomato fruit spoilage especially at a concentration of 512 µg/ml.

Keywords: *Pseudomonas Syringe*, *Citrus reticulate*, tomato fruits, storage, pathogens

INTRODUCTION

Pseudomonas syringae is one of the best-studied plant pathogens and serves as a model for understanding bacterial pathogenicity, molecular mechanisms of plant-microbe interactions as well as microbial ecology and epidemiology. *P. syringae* was originally isolated from diseased plants and was largely studied concerning its plant pathogenic potential (11; 7). *Pseudomonas syringae* has a huge impact on scientific understanding of microbial pathogenicity and continues to cause economically important plant diseases to both woody and annual crops (4). It represents not only the first plant pathogenic bacteria but also the top of all-time pathogen charts including fungi and oomycetes (5). Furthermore, in three consecutive years (January 2015 to July 2018), reports of diseases caused by strains of the *P. syringae* species group are more frequent than those caused by any other group of phytopathogenic bacteria (8). The wide genetic diversity of *P. syringae* pv. *syringae* is probably the cause of its large host range (6).

Pseudomonas syringae pv. *syringae* is a phytopathogenic bacterium responsible for bacterial canker and blast (stone and pome fruits). This bacterium infects more than 180 species of plants, among them is *Lycopersicon* sp. (10). It affects all commercially grown *Lycopersicon* species, *P. syringae* pv. *syringae* is also responsible for a bacterial blast of some Citrus species and mandarin (*Citrus reticulata*) and black pit of orange fruits, causing economic losses worldwide (2). *P. syringae* pv. *syringae* causes damage especially under cold and humid conditions in spring when the development and spread of the bacterial blast happen quicker and more easily, and when the shoots or fruits are damaged by wind, hail, or thorns (10; 2). The disease symptoms appear as water-soaked lesions extended to the mid-vein and the twigs surrounding the base of the petiole. Ultimately, the leaves dry and curl, while still firmly attached, and eventually fall without petioles. The necrotic areas on twigs further enlarge and the twigs are eventually killed within three to four weeks (10; 2).

Citrus reticulata, also known as the mandarin or mandarine, is a small citrus tree fruit. Treated as a distinct species of orange, it is usually eaten plain or in fruit salads (4). Mandarins are smaller and oblate, unlike the spherical common oranges (which are a mandarin–pomelo hybrid). The taste is considered sweeter and stronger than the common orange (4). A ripe mandarin is firm to slightly soft, heavy for its size, and pebbly-skinned. The peel is thin, loose, with little white mesocarp (4), so they are usually easier to peel and to split into segments.

Hitherto, the 21st generation antibiotics have been used including the ofloxacin (OFX) and levofloxacin (LBC) antibiotics. However, various plant-based botanicals have been reported as being efficacious in the control of many microbial organisms causing serious economic losses in crop production have caused setbacks in the production of tomatoes. The aim of this study was to investigate the efficacy of *Citrus reticulata* in control of harmful effects of *Pseudomonas syringae* on the productivity and storage of tomato compared to selected 21st generation antibiotics.

MATERIALS AND METHODS

Experimental Site

The research was carried out at Federal University Oye-Ekiti, in the Plant Science and Biotechnology Laboratory. Samples collection: Ripe fruits of (*Citrus reticulata*) were bought from the Ilupeju-Ekiti market while tomato fruits were gotten from Oye-Ekiti market, Ekiti State.

Experimental Procedure

The *Citrus reticulata* fruit was taken to the laboratory and its skins were peeled off for the study. The peels were air dried for 3 weeks in the laboratory before being pulverized into a fine powder, 50 g of grounded dried sample was weighed into three different beakers. 200 ml each of ethanol, acetone, and methanol was added to the prepared 50g of samples and left for 7days. It was then placed in the water bath at a regulated temperature of 40°C to evaporate the concentrated filtrate leaving the plant crude extract. Nutrient agar, Mueller Hinton agar Kovac's Reagent, peptone water and Crystal Violet were used in culturing the microorganisms.

The stock was prepared by pouring 90 ml of peptone water into 10 g of sample (tomatoes) into a conical flask and shared across the board into test tubes containing 9 ml of distilled water to reduce microbial load across the board (1 ml from the stock solution was poured to the first test-tube i.e. first diluents 10-1 then shake thoroughly then poured into the next test-tube this process was repeated in 10 folds diluents 10-10). From plate diluents 4, 6 and 7 in triplicate 1 ml was picked out of each diluent into a petri-dish and made a pour plate to grow *pseudomonas syringe* and then inoculated for 24 hours. A loopful of *Pseudomonas syringae* was streaked on the solidified agar evenly to ensure that the microbial growth will be confluent and evenly distributed across the entire plate surface. Then, a hole with a diameter of 6mm has punched aseptically with a sterile cork borer, and a 20 ml of the *Citrus reticulata* extracts solution at working concentration of 512 µg/ml, 256 µg/ml, 128 µg/ml and 64 µg/ml is introduced into the well. The agar plates are incubated at 37°C. The antimicrobial agent diffuses in the agar medium and inhibits the growth of the microbial strain tested.

Organisms were purified on the appropriate medium and preserved as slant cultures. Agar slants were preserved from nutrient agar in inclined sterile Bjou bottles with screw caps. A colony of *pseudomonas syringae* plate was stabbed into streaked on the slant using sterile inoculating wire loop. These cultures were then incubated at 37°C for 18-24 hours. Identification was done using overnight culture while cultural and morphological characteristics including shape, size, appearance, texture and arrangement of the cell were used in identifying the pathogens. Biochemical tests including gram staining, Indole test, catalase test, oxidase test, urease test and starch hydrolysis were further carried out to identify the organisms. Antimicrobial activism of the orange peels was tested by inoculating the pathogen into the agar medium, inputting the extract from the peel and zones of inhibition measured three days after culturing. The sauseptibility the pathogens to the peels were compared with known 21st generation antibiotics.

RESULTS

A total number of six biochemical assays were conducted to underline the characteristics of the *Pseudomonas syringae* isolated from the tomatoes collected. The result revealed that all the biochemical parameters were tested negative, the gram staining techniques that showed that the *Pseudomonas syringae* is a gram-negative bacterium with a rod-like shape while the urease tested positive.

Microbial characteristic of the *Citrus reticulata* crude extracts

The microbial characteristics of the *Citrus reticulata* against the isolated *Pseudomonas syringae* revealed that the extracts are indeed active against the isolate, except the 64 µg/ml concentration which have no inhibitory performance. The inhibitory power of the extracts was correlated against the standard antibiotics concentration and the result revealed that the extracts have no significant different except the ethanolic and acetone extract which are significantly higher than most of the standard antibiotic concentration except OFX and LBC which have higher inhibitory effect. Moreso, 128 µg/ml of the ethanolic extracts of the *Citrus reticulata* is significantly lower in inhibitory than most of the standard antibiotic concentration.

DISCUSSION

The pattern of the effects of *Citrus reticulata* on *Pseudomonas syringae* was observed in respect to the concentration gradients (the higher the concentration, the higher the inhibitory performances of the extracts) irrespective of the extraction mode that was deployed. Furthermore, the least concentration model adopted in this study had no inhibitory impact on the *Pseudomonas syringae* irrespective of the extract. However, the highest concentration of the extracts (512 µg/ml) had the most inhibitory effects. A phylogenetic tree obtained from MLSA in past literature revealed that this study filled a gap that was previous described by (9) that mandarin could be a source of *Pseudomonas syringae* biocontrol (1).

CONCLUSION

The antimicrobial effect of *Citrus reticulata* crude extracts varied greatly with concentration on the application of *Citrus reticulata* crude extracts irrespective of the extraction solvents used. However, acetone extract poised to be the best inhibitory effects against *Pseudomonas syringae*, and was found capable of doing the work of conventional antibiotics. Mandarin (*Citrus reticulata*), extract was found to have inhibitor effect against the growth of *P. syringae* pv. *Syringae* under in vitro assessments. In conclusion, the antimicrobial activity of applied treatments showed effectiveness, and gave interesting opportunities to substitute the copper compounds treatments and could become useful alternative in organic agriculture.

Table 1: Biochemical parameter of the isolate

Gram staining	Oxidase	Catalase	Urease	Indole	Starch hydrolysis
-ve	-ve	-ve	+ve	-ve	-ve

Table 2: Inhibition effects of the *Citrus reticulata* extracts on *Pseudomonas syringae*

	Tests	Concentration of <i>C. reticulata</i> extracts			
		512 (µg/ml)	256 (µg/ml)	128 (µg/ml)	64 (µg/ml)
Extracts Solvent	<i>Ethanol</i>	15.93 ± 0.12*	14 ± 0.00	9.9 ± 0.10**	-
	<i>Methanol</i>	11.63 ± 0.55	10.33 ± 0.58	-	-
	<i>Acetone</i>	16.63 ± 0.64*	14.67 ± 0.58	11.67 ± 0.58	-
21 st Generation Antibiotics	NF	15.03 ± 0.25	15.03 ± 0.25	15.03 ± 0.25	
	CXM	10.07 ± 0.12	10.07 ± 0.12	10.07 ± 0.12	
	CRO	11.00 ± 0.00	11.00 ± 0.00	11.00 ± 0.00	
	ACX	11.87 ± 0.12	11.87 ± 0.12	11.87 ± 0.12	
	ZEM	11.00 ± 0.00	11.00 ± 0.00	11.00 ± 0.00	
	LBC	18.07 ± 0.12	18.07 ± 0.12	18.07 ± 0.12	
	NA	15.07 ± 0.58	15.07 ± 0.58	15.07 ± 0.58	
	GN	13.10 ± 0.17	13.10 ± 0.17	13.10 ± 0.17	
	OFX	21.93 ± 0.12	21.93 ± 0.12	21.93 ± 0.12	
	CTX	10.00 ± 0.00	10.00 ± 0.00	10.00 ± 0.00	
	AUG	9.87 ± 0.12	9.87 ± 0.12	9.87 ± 0.12	
	IMP	12.93 ± 0.12	12.93 ± 0.12	12.93 ± 0.12	

*Note: the double subscript indicated significant increase in inhibition and single subscript indicate significant decrease in inhibition of the extracts when compared with the standard antibiotics' inhibitory effects

NF (Nitrofurantoin); CXM (Cefuroxime); CRO (Ceftriaxone sulbactam); ACX (ampiclox); ZEM (Cefexime); LBC (Levofloxacin); NA (Nalidixic acid); GN (Gentamycin); OFX (Ofloxacin); CTX (Cefotaxime); AUG (Amoxicillin clavulanate); IMP (Imipenem or Cilastatin)

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NODULATION POTENTIALS OF AFRICAN YAM BEAN ACCESSIONS IN STERILIZED AND UNSTERILIZED ALFISOL

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ABSTRACT

Information on nodulation potential by African yam bean (AYB) accessions in Alfisol are rare. The present investigation seeks to provide information on the potential of few AYB accessions under sterilized and unsterilized Alfisol. Three AYB accessions were used for the study. A screen house factorial experiment containing two soil conditions (sterilized and unsterilized) and three accessions of AYB were laid out in completely randomized design (CRD) with three replications. The results revealed significant ($P < 0.05$) variations between the sterilized and unsterilized conditions. Moreover, intra-accession variation was equally significant ($P < 0.05$) for nodules count. For all the accessions, nodulation had commenced earlier before 4 weeks within unsterilized soil. However, zero quantity was recorded in the sterilized soil at week four of termination. Nodules were first observed at 8th week for the three accessions in the sterilized soil. At each of the five intervals of experiment termination, TSs98 had the highest nodule count within sterilized and unsterilized soil. Nodulation had occurred before the 8th weeks in the sterile alfisol, this seems to reveal the promising potential of African yam bean genotype to initiate nodulation in sterile soil. In conclusion, performances of AYB revealed that it could be a utility crop for soil physico-chemical properties and fertility improvement.

Keywords: African yam bean, alfisol, genotypes, land reclamation, sterilized soil, root nodules

INTRODUCTION

Sustainable crop production is possible when depleted nutrients are naturally replenished in agricultural soils. The options for soil stabilization and nutrient replenishment have been the practice of various forms of organic agriculture. Enhancement of Nitrogen supply to the soil naturally through nitrogen fixation has remained a very promising option. Biological nitrogen fixation through legumes has a great potential to contribute to the productivity and sustainability of the tropical agricultural systems by substituting for synthetic fertilizer inputs [1].

Nitrogen fixation occur mostly among members of the Leguminosae (Fabaceae) in symbiotic relationship with a group of soil bacteria diazotroph known as *Rhizobia* [2, 3, 4]. African yam bean (*Sphenostylis stenocarpa*), a tuberous legume, was identified to be a highly promiscuous legume capable of nitrogen fixation with two notable species: *Rhizobium* and *Bradyrhizobium* [5]. This property is rare in most legumes, and may have been responsible for the profuse nodule productivity [5, 6, 7, 8]. This unique taxon equally has dual economic products: the seeds and underground tubers which are sources of food for human and livestock. Its many wealth and promises are still obscured because it is an underutilized crop [9].

Apart from the above reports on the prolific nodulation characteristic of African yam bean, information on nodulation potentials of different accessions of African yam bean is very scarce. A study to assess nodule production potential of few accessions of African yam bean under sterilized and unsterilized soil was thought worthwhile to provide understanding on the relative nodulation potentials of different accessions. Discoveries from this study is aimed at enhancing the promotion of the crop as a natural agent for soil reclamation.

MATERIALS AND METHODS

The experiment was conducted in a Screen house at the Department of Crop Science and Horticulture, Federal University, Oye-Ekiti (FUOYE), Ikole-Ekiti, Nigeria. Three African yam bean (AYB) accessions were employed in this study. Top soil was gotten within the depth of 0-15

centimetre from the Teaching and Research farm, FUOYE, Ikole-Ekiti. Fasina *et al.* [10] documented the lithological description of the site and the soils was classified as Typic Udipsamment (Cambic Arenosol-Makun series) of Alfisol.

The collected soil mass was divided into two and a portion was thermally sterilized. Four hundred and fifty pots, each with a depth and diameter of 23 cm and 17 cm respectively was filled with sterilized or unsterilized soils. Each pot held 2.28 ± 0.85 kg of soil. Two seeds of the three accessions were initially planted per pot, after germination, thinning was done to one plant per stand in a pot. Individual staking, watering and weed control was done.

The experimental design was factorial arrangement in a completely randomized design (CRD). The two factors in the experiment were: AYB accessions (three levels) and sterilized statuses (two levels). The number of replications was three and the plot size for each treatment was five. The experiment had five experimental units which were different intervals of experiment terminations after planting, namely, 4, 6, 8, 10 and 12 weeks. At every termination, data were collected on the number of nodules per plant.

Data from each experimental units were subjected to analysis of variance (ANOVA) using PROC GLM in SAS, version 9.4, (2011). The trend of nodules/plant was expressed graphically.

RESULTS

Nodule count at the five periodic intervals revealed significant ($p < 0.01$) variations for the two soil statuses (Table 1). The three AYB accessions (DSs4, TSs98 and TSs333) produced nodules in the soil samples used. AYB nodules existed in clusters along the root length.

For the three AYB accessions and at the five intervals of measurements, nodule counts on each plant was significantly higher in unsterilized soils than in the sterilized soils (Figure 1). The mean differential nodule count gap between genotypes in the unsterilized and the sterilized soil was least (5) at four weeks after planting (WAP) and highest (42) at the 12th WAP (Figure 1). The figure further revealed that TSs 98 had significant lead in nodule count under the sterilized and unsterilized soil condition.

DISCUSSION

Nodulation by the three AYB accessions differed in sterilized and unsterilized soils. For each of the two soil conditions, accession TSs 98 produced the highest number of nodules/plant while DSs 4 produced the least. The high number of nodules recorded for TSs 98 is an indication that African yam bean is a good nitrogen fixing crop, this seems to justify some of the initially employed descriptive remarks on the nodulation potential of African yam bean, including: profuse [8] and promiscuous [5]. Higher nodulation in legumes is essential in soil fertility improvement.

Our study considered nodule production from 2 weeks to 12 weeks after planting. The twelfth week after planting is within the active nodulation period in *Sphenostylis stenocarpa* because nodule production by each of the accessions still exhibited positive linearity up to the 12th week. This infer that nodule production is a continuous process after initiation at the early stage of crop development in a natural soil. However, an earlier report by Burton [11] on some annual arable legumes informed that nodulation ceases of increase from the time of pod filling; during this period, nodules generally lose their ability to fix nitrogen because the sink's movement is more active to the developing seed in the pod. Further research will therefore be necessary to ascertain the full trend of nodule production period in African yam bean. Like every other arable legumes, *Sphenostylis stenocarpa* produced nodules in the Alfisol of Ikole-Ekiti, Nigeria. Notably, its symbiotic association could be with *Rhizobium* and *Bradyrhizobium* species which had been reported in literatures [5; 7]. There may be other genera yet to be identified and investigation on this may be worthwhile. Further research to reveal nodule production/ha may be leading this crop to a wider attention for soil reclamation, fertility improvement for sustainable organic crop production.

Table 1: Analysis of variance showing the variance components and significance for nodules count in five intervals of experiment termination.

Sources of variation	DF	4WAP	6 WAP	8 WAP	10 WAP	12 WAP
Soil Status	1	288.80**	678.55**	3879.68***	5538.19***	11186.58***
Genotypes	2	10.80	47.07	16.94	252.48	133.33
Soil Status*Genotypes	2	7.85	46.45	27.85	72.28	93.93
Error	12	37.94	46.34	97.85	167.45	143.30

Note: *, ** and *** - Significance at $P \leq 0.05$, 0.01 and 0.001

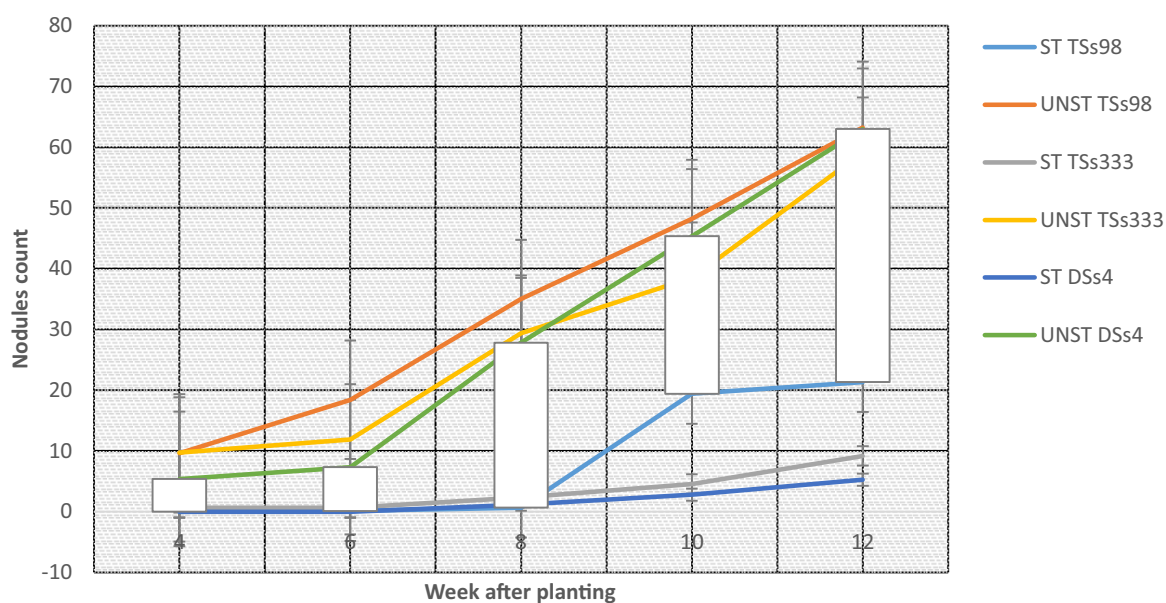


Figure 1: The trend in the mean nodules count of the three African yam bean accessions in sterilized and unsterilized soil samples (ST – Sterilized soil, UNST – Unsterilized soil)

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THE ASSESSMENT OF FOOD SAFETY AND PRACTICES IN ORGANIC AGRICULTURE WITHIN THE HOSPITALITY AND TOURISM INDUSTRIES

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ABSTRACT

The organic agriculture sector is experiencing significant growth due to growing consumer demand for sustainable, health-conscious food options. Its integration into the hospitality and tourism industries is becoming a strategic imperative. The experiment evaluates the food safety practices in the hospitality and tourism sectors, focusing on adherence to organic farming standards, potential risks, and overall food safety measures. The study was conducted using comprehensive approach, including simple percentage counts, interviews, and consumer surveys, to gain a comprehensive understanding of organic agriculture in various industries in Akure, Ondo State, Nigeria (N = 113). Organic foods and culinary tourism are crucial to meeting consumer expectations as sustainable and locally sourced options become more popular. The study investigated the challenges faced by organic farmers, suppliers, and hospitality businesses in maintaining food safety standards, proposing improvements and strategies for collaboration. The findings revealed a gender distribution of 49 males and 64 females in hotels in Akure South and North, Ondo State, with a mix of youth valuing organic agriculture, sustainable products, and wellbeing. In conclusion, the assessment is crucial in guiding industry stakeholders towards sustainable practices and ensuring the growth and resilience of organic foods in the hospitality and tourism sectors.

Keywords: Organic agriculture, food safety, hospitality industry, tourism industry, organic food practice

INTRODUCTION

Organic agriculture has emerged as a pivotal component within the broader landscape of sustainable and responsible practices, revolutionizing the way food is cultivated and supplied across various industries. In recent years, the hospitality and tourism sectors have witnessed a significant shift in consumer preferences towards healthier, ethically sourced, and environmentally friendly food options, [7]. The shift towards organic foods has brought it to the forefront of stakeholders' consciousness, emphasizing the necessity of incorporating sustainable practices into their supply chains. Organic agriculture, rooted in principles that prioritize soil health, biodiversity, and the avoidance of synthetic inputs, has gained momentum as a viable and eco-conscious alternative to conventional farming methods. This shift is not only attributed to the growing awareness of the environmental impact of industrial farming but also to the increasing demand from consumers for high-quality, pesticide-free, and nutritionally rich foods and products [8].

In the realm of hospitality and tourism, where culinary experiences and local gastronomy play a crucial role, the adoption of organic agriculture holds particular significance. Travelers and diners alike are becoming more discerning, seeking not only delectable dishes but also those that align with their values of health, sustainability, and social responsibility. As a result, hotels, restaurants, and tourism establishments are recognizing the need to incorporate organic farm produces into their menus to meet the evolving expectations of their clientele, [5]. The symbiotic relationship between organic agriculture and culinary tourism is evident in the rising trend of culinary travellers actively seeking destinations that showcase local, organic, and farm-to-table experiences. This movement not only promotes healthier eating but also fosters a deeper connection between consumers and the origins of their food, offering a unique and authentic dimension to the overall tourism experience, [2].

MATERIALS AND METHODS

The study area was presented with a structured method for evaluating food safety and practices in organic agriculture within the hospitality and tourism sectors of Akure, south-west Nigeria. The approximate latitude and longitude coordinates for Akure, the capital city of Ondo State in south-western Nigeria, are Latitude 7.2526° N and Longitude 5.2110° E. This research was achieved with the use of well – structured questionnaire. South west is made up of six States and Akure was randomly selected. The questionnaire was designed to obtain information on the role of organic practices in risk mitigation, traceability, and transparent supply chains in the hospitality and tourism industries. The administration of questionnaire was randomly selected on Restaurants, fast food, hotel and kitchen and Bar in the location. A total of one hundred and thirty (130) questionnaire was randomly administered among the hospitality industries and one hundred and thirteen was retrieved in the study area. The questionnaire was admitted to seek the participation of the respondents and their perception toward the impact of Organic agriculture, product handling, processing and preservation. The structured questionnaire was analyzed using percentage descriptive analysis.

RESULTS AND DISCUSSION

Findings of the demographic data in Table 1 shows a gender distribution of 49 (43.4%) males and 64 (56.6%) females, with 30.1% married, 51.1% single, 7.1% widowed, and 9.7% divorced. The age distribution is 48 (42.5%) 18-29 years, with the highest age range being 18-29 years, indicating a mix of youth in hotels in Akure South and North Local Government Area, Ondo State. The majority of respondents (42.5%) have secondary education, followed by tertiary education (27.4%). The lowest is no formal education (8.1%). Monthly salaries range from ₦30,001–60,000, with the highest being ₦61,001–90,000. Most respondents have worked in the hospitality/tourism industry for 7-9 years, with the lowest being ₦91,001–120,000.

The respondent's perspective on organic agriculture, expressed the relative importance of product handling, processing, and preservation services rendered in the tourism and hospitality business (Table 2). The grand mean is $((x)^{-}=3.50)$, which is greater than the criterion $((x)^{-}=2.50)$. This indicates that the perspective of respondents on organic services is high. The findings showed that customers prefer the global demand for organic and sustainably sourced products, which helps to grow the environment for tourism or hospitality online $((x)^{-}=3.51)$. Respondents were of the view that embracing organic agriculture supports local farmers and communities with the products they offer online $((x)^{-}=3.80)$. Organic goods are frequently linked to advantages for wellbeing and health. $((x)^{-}=3.73)$, and organic farms and processing facilities offer educational experiences, culinary lessons, and workshops $((x)^{-}=3.94)$. This is in agreement with Xue's (2020) findings, which state that the majority of organic agriculture, product handling, processing, and preservation services significantly influence the tourism and hospitality industries, offering both opportunities and challenges. This highlights the perspective on organic agriculture, product handling, processing, and preservation services rendered in the tourism and hospitality business.

CONCLUSION

In conclusion, the assessment of food safety and practices in organic agriculture within the hospitality and tourism industries revealed a complex interplay of factors that influence both the production and consumption of organic foods. While organic farming is generally associated with a commitment to environmental sustainability, soil health, and reduced chemical inputs, the task of ensuring food safety in the context of hospitality and tourism presents unique challenges and considerations. This not only supports local economies but also reduces the carbon footprint associated with transportation and promotes transparency by highlighting local suppliers and their organic practices to guests.

Table 1: Socio Demographic of the Respondents

Variables	Categories	Frequency	Percent
Gender	Male	67	59.3
	Female	46	40.7
	Total	113	100
Age	<20 yrs	6	5.31
	21- 30yrs	14	12.39
	31 – 40yrs	27	23.9
	41 – 50 yrs	31	27.4
	51 - 60yrs	25	22.1
	>60yrs	10	8.9
	Total	113	100
Marital status	Single	48	42.5
	Married	32	28.31
	Divorced	9	7.96
	Widow(er)	24	21.23
	Total	113	100
Religion	Christianity	76	67.3
	Islam	23	20.4
	Traditional	8	7.00
	Others	6	5.30
	Total	113	100
Nationality	Nigerian	98	86.73
	Non-Nigerian	15	13.27
	Total	113	100
Educational status	Non formal	68	60.18
	Primary	14	12.39
	Secondary	9	7.96
	Tertiary	22	19.47
	Total	113	100
YEARS OF SERVICE	1-3 years	12	10.62
	4-6	43	38.05
	7-9	18	15.93
	Above 10 years	40	35.4
	Total	113	100
N = 113			

Table 2: respondents' perspective on organic services rendered in the tourism and hospitality business

S/N	Perspective on Organic Agriculture , Product Handling , Processing , and Preservation Services	SD	D	U	A	SA	Mean	Std. Dev.
1.	The global demand for organic and sustainably sourced products helps grow the environment.	19 (16.8)	17 (15.0)	7 (6.2)	27 (23.9)	43 (38.1)	3.51	1.530
2.	Embracing organic agriculture supports local farmers and communities.	16 (14.2)	9 (8)	5 (4.4)	35 (31)	48 (42.5)	3.80	1.428
3.	Organic goods are frequently linked to advantages for wellbeing and health.	9 (8)	19 (16.8)	11 (9.7)	29 (25.7)	45 (39.8)	3.73	1.351
4.	Organic farms and processing facilities offer educational experiences, culinary lessons, and workshops.	40 (35.4)	28 (24.8)	9 (8)	19 (16.8)	17 (15)	2.51	1.489
5.	Organic techniques are gaining popularity in the travel and tourism sector	7 (6.2)	17 (15.0)	3 (2.7)	35 (31)	51 (45.1)	3.94	1.284
	Grand Mean						3.50	

Source: Field Survey (2024)

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PERCEPTION OF SMALL-SCALE POULTRY FARMERS TOWARDS ORGANIC PRACTICES IN EKITI STATE, NIGERIA

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ABSTRACT

The study assessed perception of small scale poultry farmers' towards organic practices in Ekiti State, Nigeria. Multistage sampling procedure was used to select 120 poultry farmers for the study. Primary data on respondent's socio-economic characteristics, sources of information, organic practices used, perception and the constraint encountered by small scale farmers' in assessing organic practices were obtained using a structured questionnaire. Analysis involved frequency counts, percentages, mean, and Chi-square statistics. Findings reveal that 61.7% of the respondents were males, 60.0% were married with a mean age, household size and annual income of 42 years, 6 persons and ₦ 35,493.30 respectively. Radio (44.2%), extension agent (20.8) and farmer's cooperatives (18.3%) were reported as the major sources of information on organic practices. Key organic practices included the use of organic feed ingredients (58.0%), litter materials (65.0%), the application of Apple cider, vinegar or raw honey as multivitamin (61.0%) and disinfectant (53.0%). The majority (66.0%) of the respondents has favourable perception towards organic practices. Main constraint identified were inadequate information (79%), lack of capital (75%), inadequate credit facilities (73%) and high cost of production (64%) were major constraints faced by small scale poultry farmers in raising their birds organically. The study concludes that there is need for targeted educational and training programs to enhance farmers' knowledge and understanding of organic practices and recommend that there should be interventions that address the identified constraints and capitalize on the perceived benefits fostering the adoption of organic practices among small-scale poultry farmers.

Keywords: Information, Organic, Practices, Sources and Perception

INTRODUCTION

In Africa, agriculture has remained at the focus of economic activities. About three-quarters of the total population in Africa depend on agriculture for livelihood and the demand for various agriculture products has continued to increase in recent years [1]. Organic farming combines traditional, innovation and science to benefit the shared environment and promote fair relationships and good quality of life for all involved. [2 and 3]. Organic poultry system of farming referred to a safe method for raising birds to ensures healthy consumption of poultry products on the other hand Inorganic poultry farming practices involve the use of chemical drugs , inorganic feeds, antibiotics, and veterinary drugs for raising poultry birds from day old until maturity, prolong consumption of the product with this method has a negative effect on human health because residues from the chemicals administered to the birds remain in them and if consumed by humans may cause serious health issues. Moreover, lack of awareness may hinder the widespread use of organic practices, affecting the sustainability and environmental impact of small scale poultry farming. Hence, understanding the perception of small scale poultry farmers towards organic practices is crucial for the development of sustainable and environmentally friendly farming methods. [4] Organic farming offers several benefits over conventional farming practices such as biodiversity, environmental sustainability, health and safety and economic benefits. The study assess the perception of small-scale poultry farmers towards organic practices in Ekiti State. The specific objectives are to describe the respondent's socio-economic characteristics, identify the sources of information, identify the organic practices used, ascertain respondent's perception towards organic practices and identify the constraint encountered by small scale poultry farmers' in organic practices.

METHODOLOGY

The study area was Ekiti State, Nigeria. A multistage random sampling technique was used in selecting respondent for the study. The first stage is the selection of 4 local governments including

Ado, Ido-Osi, Oye, and Ikole Local Government Area LGA. At the second stage, two towns were selected in each local government while the third stage was the selection of 30 respondents from each local government making a total of 120 respondents. Farmers perception towards organic practices was measured by adopting a 5point likert scale using the following perception indices 1 = strongly agree 2 = agree 3 = undecided 4 = disagreed 5 = strongly disagree. Data was analyzed using descriptive (mean, median, mode) and inferential statistics was used for this study this include frequency distribution, percentage and mean

RESULTS AND DISCUSSION

Socio-economic characteristics of Poultry Farmers

Findings in Table 1 reveals that 61.7% of the respondents were male, 60.0% were married, with a mean age of 42 years, 6persons in the household, and an annual income of ₦35,493.30. This implies that majority of the respondents were adults who should be able to state their perception on organic poultry practices. Radio (44.2%), extension agent (20.8), and farmers' cooperatives (18.3%) were reported as major sources of information on organic practices. These sources can help in addressing any misconceptions, providing education and highlighting the benefits of organic practices can help to promote the adoption of more sustainable farming methods in the poultry industry.

Organic practices used among small scale poultry farmers

Organic practices used among small scale poultry farmers were organic feed ingredients (58.0%), litter materials (65.0%), use of Apple cider, vinegar or raw honey as multivitamin (61.0%) and disinfectant (53.0%) as indicated in table 2.

Perception towards organic practices

Results in figure 1 shows that majority (66.0%) of the respondents have favourable perception towards organic practices. This can contribute to improved animal welfare, reduced environmental impact, and increase consumer trust in the products of small scale poultry farming.

Constraints faced by small scale poultry farmers towards organic practices

Constraint faced by the small scale poultry farmers towards Organic Practices in Ekiti State were inadequate information (79%), lack of capital (75%), inadequate credit facilities (73%) and high cost of production (64%), while low profitability (48%) was the least constraint. These constraints constitutes significant challenges to the widespread implementation of sustainable agricultural practices. Overcoming these constraints will promote more adoption of organic practices, leading to improved animal welfare and increase sustainability within poultry farming industry. This will benefit both farmers and consumers by promoting healthier and more ethically produced poultry products.

CONCLUSION AND RECOMMENDATION

The study sheds light on the perceptions of small-scale poultry farmers towards organic practices and highlights significant challenges impeding the widespread adoption of organic practices in Ekiti State, Nigeria. There is need for targeted educational and training programs to enhance farmers' knowledge and understanding of organic practices and recommended that:

1. There should be concerted effort from agricultural organizations, policy makers and relevant stakeholders to provide support education, and resources that can help small scale poultry's to overcome constraints associated with organic farm practices.
2. Extension agent should ensure effective supervision on the farmers so that the farmers can acquire adequate knowledge needed for proper production and also disseminate prompt information on organic agriculture to the poultry farmers and ensures feedback mechanism to know where the farmers need improvement and assistance.

Table 1: Socio-economic characteristics of Poultry Farmers

Variable	Responses	Frequency	Percentage	Mean
Age	< 36	36	30	42
	37-47	46	38	
	48-58	33	28	
	59	5	4	
Gender	Male	74	61.7	42
	Female	46	38.3	
Marital Status	Married	72	60.0	42
	Divorced	38	31.7	
	Widowed	10	8.3	
Group Experience	<6	69	57.5	6.7417
	7-12	43	35.8	
	12-20	8	6.7	
Main Occupation	Farming	87	72.5	6.7417
	Trading	11	9.2	
	Civil Service	22	18.3	
Educational Status	Formal	87	72.5	6.7417
	Non-Formal	33	27.5	
No of Birds	< 500	73	60.8	6.7417
	501-1500	37	30.8	
	1501-2500	9	7.5	
	Above 2500	1	0.8	
Source of Information	Radio	53	44.2	6.7417
	Extension Agent	25	20.8	
	Farmers Cooperative	22	18.3	
	Relatives and Others	20	16.7	
Income per Annum	<150,000	21	17.5	354933.30
	150,000-300,000	37	30.8	
	301,000-450,000	30	25.0	
	>450,000	32	26.7	

Table 2: Organic poultry practices

Organic poultry practice	Used	Not used
Use of apple cider, vinegar or raw honey as multivitamin	73(61%)	47(39%)
Use of accessories such as perching rails, dark seclusion and sust bath	51(43%)	69(58%)
Disinfectant	64(53%)	56(49%)
Litter_materials	78(65%)	42(35%)
Feed_ingredients	81(68%)	39(33%)
Disease_prevention	70(58%)	50(42%)
Improve immune system	69(58%)	51(43%)

Source: field survey 2022.

Table 3: Frequency Distribution of Respondent According to their Perceptual Statement

Perception Statement	SA	A	U	D	SD	Mean
Rearing of Poultry Birds Organically is Effective	42(35%)	24(20%)	16(13%)	25(11%)	13(11%)	2.522
Eating Organic Birds is Healthy	35(29%)	37(31%)	9(7.2%)	20(17%)	19(16%)	2.592
Farming Organically is Profitable	39(33%)	34(28%)	11(9%)	25(21%)	11(9%)	2.458
Organic Poultry Farming Increases my Output	41(34%)	16(13%)	17(14%)	36(30%)	10(8%)	2.650
Organic Poultry Farming is The Best Practice	44(37%)	28(23%)	9(7.2%)	29(24%)	10(8%)	2.442
Better Quality Organic Poultry	38(32%)	29(24%)	12(10%)	22(18.3%)	8(6.6%)	2.625
Market for Organic Birds	43(36%)	38(32%)	10(8%)	21(17.5%)	23(19%)	2.275
Organic Feed Material is Available	38(32%)	33(28%)	10(8%)	16(13%)	23(19%)	2.608
Physiological Difference	34(28%)	41(34%)	12(10%)	16(13%)	17(14%)	2.508

Source: field survey 2022.

**Figure 1: Respondents level of perception towards organic practices****Table 4: Frequency Distribution of Respondents According to Their Constraints**

Constraint	Yes	No
Not Reliable For Birds Health	73(61%)	47(39%)
Labour Intensive	92(77%)	28(23%)
Inadequate Information	95(79%)	25(21%)
Inadequate Credit Facilities	94(73%)	26(22%)
High Cost of Production	77(64%)	43(36%)
Low Profitability	58(48%)	62(52%)
Lack of Capital	90(75%)	30(25%)
Lack of Access To Organic Input	83(69%)	37(31%)

Source: Field Survey 2022.

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ASSESSMENT OF ADOPTION RATE OF ORGANIC FARMING PRACTICES AMONG ARABLE CROP FARMERS IN ONDO STATE, NIGERIA

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ABSTRACT

This study assessed the adoption rate of organic farming practices among arable crop farmers in Ondo state, Nigeria. Multi-stage sampling procedure was used for data collection of 225 respondents. Majority (92.9%) of the respondents were aware of organic farming practices. The highest rating organic farming practices adopted were manual weeding with 99.5 %, mixed cropping with 95.52% then crop rotation with 92.04% and animal manure with 90.55%, off farm organic waste 42.29% and finally, biological pest control with 36.32%. Level of adoption of organic farming practices results revealed that manual weeding ranked first, while biological pest control ranked least. The two tailed independent sample t-test shows that the two samples have equal variances, and p-value = 0.565 which implies that there is no significant difference between male and female farmers in the adoption of organic farming practices. In conclusion, the study revealed that there was no significant difference in the mean yield before and after adoption and in the male and female farmers in the adoption of organic farming practices.

Keywords: Organic farming, Adoption rate, biological pest control, Pollution.

INTRODUCTION

Organic farming, characterized by chemical-free practices using natural manures and biological pest controls, emphasizes soil health, biodiversity, and sustainable agro-systems [1]. Beyond avoiding synthetic inputs, it aims for holistic production management, promoting environmental protection, economic efficiency, and improved agricultural health [2; 3]. It provides high-quality products, environmental benefits, and economic efficiency, making it a low-risk and viable alternative for small-scale farmers [4,5 & 6]. The goals include ensuring nutritional quality, enhancing biological cycles, maintaining soil fertility, minimizing pollution; and emphasizing sustainable practices [6]. In contrast, conventional agriculture, marked by mechanization and synthetic inputs, has negative environmental and health impacts, necessitating a shift towards environmentally friendly organic farming [7]. Studies highlight the adverse health effects of pesticides in conventional farming and advocate for the nutritional superiority and safety of organically grown foods [8]. The awareness and perception of organic farming's advantages over conventional methods remain understudied among arable crop farmers, creating a research gap this study aims to address. Encouraging organic farming is crucial for addressing contemporary agricultural challenges and ensuring sustainable, high-quality food production. The objectives of the study were to ascertain the level of awareness of organic farming practices by the farmers in the study area, identify the organic farming practices adopted, ascertain the level of adoption among arable crop farmers and ascertain the difference in farmers yield as a result of the adoption of organic farming practices in the study area.

MATERIALS AND METHODS

This study was conducted in Ondo State, South West Nigeria. The State has 18 Local Government Areas with Farming constituting the main occupation of the people. All arable crop farmers in the State form the population for this study. Multi-stage sampling procedure was used in selecting the respondents for this study. In the first stage, two Zones were randomly selected from the four (ADP) Zones in the state. Second stage was the selection of five (5) blocks out of ten (10) blocks in the two Zones, selection of cells in the third stage. Finally, selection of arable crop farmers based on probability proportionate to size due to unequal farmers' number per cell and 225 respondents were selected as the sample size for this study.

Validated questionnaires were used to elicit information from farmers. The data collection exercise was conducted between 17th May and 18th June, 2021. Descriptive Statistics (frequency, mean, percentages and standard deviation) and t-test were used to analyze the stated hypothesis for this study. The hypothesis of the Study states as follows, H_0 1. There is no significant difference between male and female farmers in the adoption of organic farming practices in the study area.

RESULTS AND DISCUSSION

Awareness of Organic Farming Practices

Results in Table1 showed that 92.9% of the respondents were aware of organic farming practices, while 7.1% were not aware. The level of awareness was relatively high and this could be as a result of their high accessibility to extension agents. Even though awareness does not imply or mean adoption, it is a prerequisite.

Level of Awareness of Organic Farming Practices

The respondents were aware of all the Organic Farming practices listed based on the level of awareness in Table2, except one, which is biological pest control. The practices were crop rotation mean = 3.15, SD = 0.88, mixed cropping mean = 3.23, SD = 0.85, animal manure mean = 2.93, SD = 0.97, legumes/cover crop mean = 2.81, SD = 1.01, green manure mean = 2.72, SD = 1.04, off farm organic waste mean = 2.54, SD = 0.95, compost manure mean = 2.59, SD = 0.99, wood ash mean = 2.61, SD = 1.00, mulching mean = 2.98, SD = 0.91, tillage mean = 2.60, SD = 0.98, organic fertilizer mean = 2.89, SD = 0.99 and manual weeding mean = 3.33, SD = 0.88. The mean score of biological pest control practice fell below the discriminating index of 2.5.

In general, the level of awareness was high as twelve (12) out of thirteen (13) items (92.3%) had the mean scores above 2.50 which was the discriminating index. This could be attributed to the high level of education of the respondents in the study area.

Adoption of Organic Farming Practices

Results in Table3 shows that the majority of the respondents adopted organic farming practices but not in fullness, because the results in Table4 on the level of adoption of organic farming practices reveals that. This could be linked with their perception that no value was placed on organic products by consumers.

Adoption of each of the Organic Farming Practices

The adoption of organic farming practices among crop farmers in the study area varied in percentage. The highest rating organic farming practice was manual weeding with 99.5 % followed by mixed cropping with 95.52% then crop rotation with 92.04% and animal manure with 90.55%. Mulching had 87.56%, organic fertilizer 74.13%, legumes/cover crop 67.66%. Also, green manure had 65.67%, compost manure 55.22%, wood ash 52.74%, tillage with hoe 50.75%, off farm organic waste 42.29% and biological pest control with 36.32% adoption. The high percentage of adoption rating could be attributed to the fact that some of the practices involve are in line with traditional ways of farming such that its adoption doesn't get those farmers confused.

Level of adoption of organic farming practices

The result in Table 5 reveals the level of adoption of organic farming practices and mixed cropping ranked first, followed by crop rotation, manual weeding, animal manure, mulching, organic fertilizer, cover crops, green manure, compost manure, tillage with hoe, wood ash, off farm organic waste and biological pest control ranked last on the table. It could be deduced from this result that mixed cropping, crop rotation and manual weeding were the most adopted organic farming practices while, biological pest control, off farm organic waste and wood ash were the least adopted among the practices. Planting different kinds of crop help farmers to generate income at different intervals of harvests. As farmers wait for crops with long time maturation, they harvest the ones that have short maturation duration and take them to the market for sale [9].

T-Test Analysis to Determine the Significant Difference between Male and Female Farmers in the Adoption of Organic Farming Practices.

The results of the two tailed independent sample t-test from Table 8 shows that the two samples have equal variances, and P value of 0.565 which is greater than 0.01 and 0.05 (accepted level of significance adopted for the study). The null hypothesis was accepted and this implies that there is no significant difference between male and female farmers in the adoption of organic farming practices.

CONCLUSION AND RECOMMENDATIONS

In summary, despite widespread awareness, the study reveals a significant gap in the complete adoption of pure organic practices among farmers. While prevalent practices like mixed cropping and manual weeding are observed, the perceived labour intensity and time consumption associated with organic farming act as barriers to its comprehensive adoption. This suggests a need for further investigation into the underlying factors hindering full-scale adoption. To encourage widespread adoption of organic farming practices, the establishment of comprehensive enlightenment programmes is essential to bridge the awareness-to-adoption gap.

**Table 1: Distribution of the Respondents by Awareness of Organic Farming Practices
n = 225**

Awareness	Frequency	Percentage (%)
Aware	209	92.9
Not aware	16	7.1

Source: field survey, 2021

Table 2: Distribution of the Respondents by Level of Awareness of Organic Farming Practices. n = 209

Organic farming						
Practices	Not at all	Low	Moderate	High	Mean	SD
Crop rotation	4(1.9)	13 (6.2)	106 (50.7)	86 (41.2)	3.15	0.88
Mixed cropping	2 (0.9)	8 (3.8)	104 (49.8)	95 (45.5)	3.23	0.85
Animal manure	9 (4.3)	39 (18.7)	87 (41.6)	74 (35.4)	2.93	0.97
Legumes/cover crops	22 (10.5)	26 (12.4)	102 (48.8)	59 (28.2)	2.81	1.01
Green manure	26 (12.4)	36 (17.2)	90 (43.1)	57 (27.3)	2.72	1.04
Off farm org. waste	22 (10.5)	62 (29.7)	91 (43.5)	34 (16.3)	2.54	0.95
Compost manure	26 (12.4)	48 (23.0)	94 (45.0)	41 (19.6)	2.59	0.99
Wood ash	28 (13.4)	40 (19.1)	100 (47.9)	41 (19.6)	2.61	1.00
Mulching	7 (3.5)	26 (12.4)	109 (52.2)	67 (32.1)	2.98	0.91
Tillage with hoe	24 (11.5)	50 (23.9)	95 (45.5)	40 (19.1)	2.60	0.98
Biological pest control	34 (16.3)	54 (25.8)	84 (40.2)	37 (17.7)	2.48	1.01
Organic fertilizer	14 (6.7)	32 (15.3)	95 (45.5)	68 (32.5)	2.89	0.99
Manual weeding	1 (0.5)	10 (4.8)	80 (38.2)	118 (56.5)	3.33	0.88

Source: Field survey, 2021. Mean score ≥ 2.50 = aware (A), mean score < 2.50 = not aware (NA); Figures in parenthesis are percentages

Table 3: Distribution of the Respondents by Adoption of Organic Farming n = 209

Adoption	Frequency	Percentage (%)
Adopt	201	96.17
Not Adopt	8	3.83

Source: Field survey, 2021.

Table 4: Distribution of Respondents by Adoption of each of the Organic Farming Practices n = 201

Organic farming practices	Adopt	Percentage (%)	Not Adopt	Percentage (%)
Crop rotation	185	92.04	16	7.96
Mixed cropping	192	95.52	9	4.78
Animal manure	182	90.55	19	9.45
Legumes/cover crops	136	67.66	65	32.34
Green manure	132	65.67	69	34.33
Off farm org. waste	85	42.29	116	57.71
Compost manure	111	55.22	90	44.78
Wood ash	106	52.74	95	47.26
Mulching	179	87.56	22	10.95
Tillage with Hoe	102	50.75	99	49.25
Biological pest control	73	36.32	128	63.68
Organic fertilizer	149	74.13	52	25.87
Manual weeding	200	99.50	1	0.50

*Multiple responses indicated. Source: Field survey, 2021.

**Table 5: Distribution of the Respondents by their Level of Adoption
n = 201**

Organic farming practices	Never	Occasionally	Always	Mean	Std Deviation	Rank
Mixed cropping	9 (4.48)	45 (22.39)	147 (73.13)	2.51	0.74	1 st
Crop rotation	16 (7.96)	65 (32.34)	120(59.70)	2.36	0.77	2 nd
Manual weeding	2 (0.99)	94 (46.77)	105(52.24)	2.35	0.68	3 rd
Animal manure	18 (8.96)	112 (55.72)	71 (35.32)	2.13	0.71	4 th
Mulching	21 (10.45)	113 (56.23)	67 (33.33)	2.11	0.70	5 th
Organic fertilizer	51 (25.37)	99 (49.25)	51(25.37)	1.90	0.74	6 th
Legumes/cover crops	55 (27.36)	99 (49.25)	47 (23.38)	1.86	0.74	7 th
Green manure	67 (33.33)	111 (55.22)	23 (11.44)	1.71	0.65	8 th
Compost manure	88 (43.78)	89 (44.28)	24 (11.94)	1.61	0.67	9 th
Tillage	99 (49.25)	68 (33.83)	34 (16.91)	1.60	0.74	10 th
Wood ash	94 (46.77)	82 (40.78)	25(12.43)	1.59	0.68	11 th
Off farm org. waste	115 (57.21)	79(39.30)	7 (3.48)	1.45	0.55	12 th
Biological pest control	129 (64.18)	44 (21.89)	28 (13.93)	1.44	0.71	13 th

Source: Field survey, 2021. Mean score ≥ 2.0 = Adopt, mean score < 2.0 = not Adopt.
Figures in parentheses are percentages

Farmers Yield of Selected Crops in Kilogram per Plot of Land before and after Adoption Over a Planting Season

Table 6: Mean Yield of Selected Crops in KG

Crops	Mean yield before adoption	Mean yield after adoption
Maize	3,345.42	3, 278.69
Yam	4,414.32	4,392.21
Cocoyam	3,567.64	3,678.43
Cassava	8,347.89	8,335.72
Potato	4,217.28	4,209.81
Okra	2,143.16	2,146.02
Eggplant	2,596.46	2,593.60
Total mean yield	4090.31	4090.64

Source: field survey, 2021

Table 7: T-Test Analysis to Determine the Significant Difference in the Yield of Farmers before and after Adoption of Organic Farming Practices. n = 201

	Before	After
Observation	201	201
Mean	4090.31	4090.64
Std. Deviation	329.05	330.29
Variance	21.4677	21.4677
T-value	34.646	
Df	199	
Sig.(p-value)	P ≤ 0.431	

Source: field survey, 2021

Table 8: T-Test analysis to Determine the Significant Difference between Male and Female Farmers in the Adoption of Organic Farming Practices. n = 201

Sex	Male	Female
Observation	143	58
Mean	23.1313	22.8000
Std. Deviation	3.87399	4.00078
Variance	0.33125	0.33125
T-value	0.576	
Sig.(p-value)	P ≤ 0.565	

Source: field survey, 2021

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GROWTH PERFORMANCES OF TWO TOMATO (*Solanum lycopersicum*) VARIETIES CULTIVATED BY ALTERNATIVE FARMING SYSTEMS

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ABSTRACT

Alternative farming system as opposed to conventional farming provides a process of crop production using materials of natural origin to enrich soil and protect crops. Padma and Platinum tomato varieties were cultivated using both conventional and alternative cropping systems. Agrochemicals were used on the conventional plot. On the alternative system farming plot, cured cow dung manure and manual weeding were used. Insect pest control was achieved with a concoction of garlic (6 g/l), ginger (10 g/l), clove (5 g/l), onions (10 g/l) and dried capsicum pepper (4 g/l). Fungicidal treatment was by an infusion of leaves from Siam weed, neem and bitter leaf (5 g/l each). The results showed tallest plant (107.5 cm) was observed in Padma tomato plants, while the shortest plant (103.5 cm) was obtained for Platinum variety, at week 12. However, there was no significant difference ($P < 0.05$) in the heights of the two tomato varieties at full maturity and in between the cropping systems. The same trend was observed for number of leaves, flowers and fruits produced. The alternative farming plot produced similar growth performances in the two tomato varieties, and can be utilized as a competent substitute for the conventional cropping system of tomato as practiced by the small holder farmers. In conclusion, the alternative farming practice can mitigate against the health and environmental concerns that arise from the use of agrochemicals in cropping tomatoes.

Keywords: alternative, agrochemicals, conventional, tomato, variety.

INTRODUCTION

Agricultural chemicals have been reported to persist in the ecosystem which leads to deterioration of soil health, environmental pollution, degradation of the agricultural ecosystem, contamination of ground water, and development of pesticide resistance in the pathogens in the environment [1]. The challenges caused by these excessive and indiscriminate use of agrochemicals have resulted into researchers and agriculturists developing an alternative system of agricultural practice called organic agriculture. Alternative farming system provides practices that protect crop health, improve yield, to make the farming enterprise profitable, while protecting the environment from risks of agricultural chemicals [2]. It is a form of organic agricultural system [3]. Broad implementation of alternative farming system for cropping has potential to promote and support agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and reduce emission of greenhouse gases [4].

MATERIALS AND METHODS

Experimental Procedures

The tomato plant (*Solanum lycopersicon*) varieties used for the study were Platinum 701 F1 and Padma 108 F1, whose seeds were obtained from commercial agro-based materials store at Akure, Southwest Nigeria. The farm location was at the Federal College of Agriculture, Akure, Ondo state, Nigeria. It lies within latitude 6.895929°N, and longitude 4.893563°E. Tomato cultivation was carried out in October 2022 to January, 2023. Cocoa peat was used as the substrate for nursing the seedlings in seed trays. The cocoa peat was soaked in water for 24 hr and mixed with cured poultry droppings at ratio 2:1. This was placed in the seed trays and one seed of tomato is placed inside each hole. The seeds were hydrated lightly in the morning and evenings for 21 days. The seedlings were placed in the sun during the day and kept safe from reptiles and rodents. The same nursery method was employed for both varieties of tomato and the two farming systems. Beds were made treated with a copper (I) oxide fungicide. Holes of 0.2m depth were made in the beds with a spacing of 30 cm. The holes were filled with cured poultry droppings and sprinkled with Furadan (a carbofuran compound) as an anti-helminthic agent. A seedling is placed in each hole. After, the seedlings were irrigated daily.

This was carried out on a fallow plot of about 300 m away from any cultivated plot. The procedure for transplanting was same as with the conventional farming method except for antifungal treatment of soil with a fungicidal infusion made from a combination of crushed leaves of Siam (5 g/l), Neem (5 g/l) and bitter leaf (5 g/l) in water. Use of Furadan was avoided. Each experimental plot was set up with each mulched bed consisting of fifteen stands of tomato, with a total of 150 stands per plot per variety. At flowering, dangerous insects like whiteflies were attracted and confronted with foliar treatment with an insecticide (a methyl oxalate compound). Similar treatment was applied on the sustainable farming plot by using a domestically developed concoction containing garlic (6 g/l), ginger (10 g/l), clove (5 g/l), onions (10 g/l) and dried powder of capsicum pepper (4 g/l), all ground and mixed together before steeping in water for 48 hr. Pesticide treatment was repeated on weeks 5, 7 and 9 and 11. Foliar fungicidal treatment on the conventional plot using Saaf (a carbendazim compound) was carried out on weeks 4, 6, 7, 8 and 10 respectively. The fungicidal infusions described above for soil treatment was used on the alternative farming plot. Weed control was achieved by manual means on both plots. For soil fertilization, NPK (15:15:15) was applied on week 4 and NPK (11:46:14) on week 6, while this was achieved on the alternative farming plot by weekly application of cured cow dung. Irrigation was carried out manually throughout the period of the experiment twice in a day; morning and evening. At the fruiting stage, from immature to mature fruits were treated weekly with another insecticide (emamectin benzoate) that is active against caterpillars, while the alternative farming plot was sprayed with the concoction made from garlic, ginger, clove, onions and dried powder of capsicum pepper.

Data collection

Ten (10) stands of tomato plant per bed and five beds per variety were selected for collection of data. The data collected were plant height, number of leaves, number of flowers, and number of fruits per week through-out the duration of the experiment. The height was measured using a metre tape while the number of leaves, number of flowers and number of fruits were counted manually. Data were collected for each variety for both treatments, and the means were compared using Analysis of Variance (ANOVA).

RESULTS AND DISCUSSION

Growth parameters measured were plant height, number of leaves, number of flowers and fruits produced per plant per variety in 12 weeks of cultivation.

The plant heights of the two varieties of tomato increased from week 2 to 12, with the highest (107.2cm) at full maturity recorded for the Padma variety grown by conventional method. However, there was no observable statistically significant difference in the heights of all the plants through the period of observation except on weeks 2 and 6 in which the Platinum tomato on the alternative farming plot and that planted on the conventional method plot showed significant differences in heights at 13.9 cm and 63.0 cm respectively. Padma variety exhibited higher heights than Platinum variety all through the observation period. As reported by [5] similar finding in comparing plant heights of Debora and Santa Clara varieties of tomato grown by both conventional and organic farming systems, where the heights showed no statistical difference.

The number of leaves on both varieties of tomato increased across the observation period. However, Platinum tomato exhibited higher number of leaves with the highest mean figure recorded on week 12 at 61.3 for both grown alternatively and conventionally. The difference in number of leaves is significantly different between the varieties. This probably indicated that production of leaves in tomato is dependent on the variety but independent of the farming system because foliar development in both tomatoes were similar in the two cropping systems.

The number of flowers produced on the plants increased initially and dropped after, with the peak observed on week 6 (Table 3). This was as a result of fruits being already developed by week 6 from the flowers. Flower development rate appeared slower in the two tomato varieties grown by the alternative farming system than in the conventional procedure, though, the numbers of flowers are not statistical different in between the farming systems. Generally, the conventional farming system supported flower production more than the alternative system as indicated by higher mean figures on Table 3. However, no statistically significant difference was noted in the numbers of flowers produced by the two varieties and between the two cropping systems except on week 6. Similarly, [5] reported differences in the numbers of flower clusters between Debora and Santa Clara tomato varieties as the days of planting increased, showing more conspicuous difference in the organic system. However, these workers recorded slightly higher number of flower clusters in the tomatoes grown conventionally than the organically cultivated plants. Flower production in tomato is highly influenced by adequate supply of Nitrogen and Potassium [6]. The better flower production observed in the conventionally cultivated tomatoes could be as a result of the use of NPK fertilizer which has a higher nitrogen and potassium quantity than the animal manure.

The mean number of fruits produced in both Padma and Platinum tomato fruits under the two cropping systems (Fig. 1). There is no significant difference in fruits production between cropping systems, but between the varieties, there were significant differences until week 10. At the end of observation in week 12, there was no difference in the number of fruits produced between the varieties of tomato and between the cropping systems. Rate of fruit development appeared to be faster in the Padma tomato, irrespective of the cropping system, but at the end, Platinum tomato produced higher number of fruits (Fig. 1). This study observed that the cropping system did not influence the number of fruits produced per variety.

CONCLUSION

The alternative farming method produced good growth performances in the both varieties of tomato in comparison to the conventional method. The finding provides a strong basis for the advocacy for utilizing alternative farming system by small holder farmers in cultivating tomatoes against the commonly used conventional methods that expose consumers and the environment to high risks.

Table 1: Plant heights (cm) of Padma and Platinum varieties of tomato plants

Treatments	Weeks After Planting					
	2	4	6	8	10	12
PD _{nf}	16.9 ^a	49.9 ^a	73.2 ^a	88.0 ^a	101.8 ^a	107 ^a
PT _{nf}	13.9 ^b	40.0 ^a	65.2 ^a	83.4 ^a	101.3 ^a	105.4 ^a
PD ₀	15.2 ^a	44.8 ^a	71.1 ^a	85.2 ^a	100.2 ^a	107.2 ^a
PT ₀	13.5 ^a	40.1 ^a	63.0 ^b	79.6 ^a	97.7 ^a	103.5 ^a
F(Test)	*	NS	*	NS	NS	NS

Means followed by the same letter are not significantly different from one another based on Tukey's test at $P < 0.05$ *= significant, NS = Not Significant, PD_{nf} = Padma alternative, PT_{nf} = Platinum alternative, PD₀ = Padma conventional, PT₀ = Platinum conventional.

Table 2: Number of leaves on Padma and Platinum tomato plants

Treatments	Weeks After Planting					
	2	4	6	8	10	12
PD _{nf}	6.9 ^a	9.9 ^b	21.0 ^b	30.9 ^b	41.5 ^b	42.6 ^b
PT _{nf}	4.1 ^b	14.2 ^a	24.6 ^a	45.2 ^a	59.4 ^a	61.3 ^a
PD ₀	4.9 ^b	9.9 ^b	21.1 ^b	30.9 ^b	40.1 ^b	45.0 ^b
PT ₀	6.1 ^a	14.2 ^a	24.3 ^a	45.1 ^a	59.4 ^a	61.3 ^a
F (Test)	*	*	*	*	*	*

Means followed by the same letter are not significantly different from one another based on Tukey's test at $P < 0.05$ *= significant, NS = Not Significant, PD_{nf} = Padma alternative, PT_{nf} = Platinum alternative, PD₀ = Padma conventional, PT₀ = Platinum conventional.

Table 3: Number of flowers produced by Padma and Platinum tomato plants

Treatments	Weeks After Planting				
	4	6	8	10	12
PD _{nf}	0.4 ^a	8.8 ^b	6.2 ^a	4.0 ^a	2.2 ^a
PT _{nf}	0.8 ^a	12.2 ^a	7.0 ^a	3.8 ^a	3.0 ^a
PD ₀	3.6 ^a	7.00 ^b	6.4 ^a	5.2 ^a	3.4 ^a
PT ₀	4.8 ^a	9.00 ^a	6.5 ^a	5.4 ^a	4.0 ^a
F(Test)	NS	*	NS	NS	NS

Means followed by the same letter are not significantly different from one another based on Tukey's test at $P < 0.05$

*= significant, NS = Not Significant, PD_{nf}= Padma alternative, PT_{nf}= Platinum alternative, PD₀= Padma conventional, PT₀= Platinum conventional.

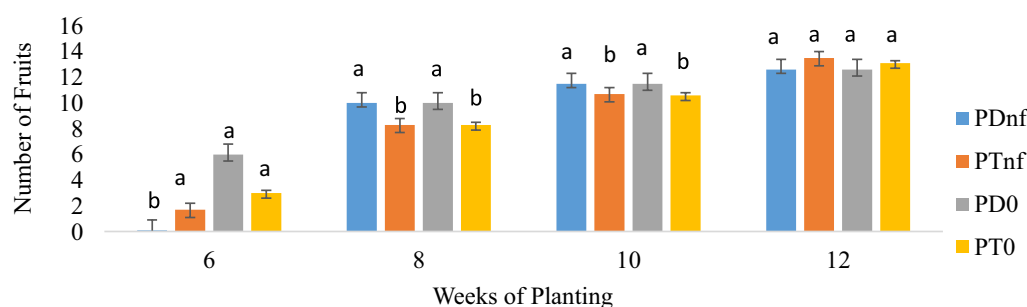


Fig. 1: Number of fruits produced by Padma and Platinum tomato plants

Means followed by the same letter are not significantly different from one another based on Tukey's test at $P < 0.05$,

PD_{nf}= Padma alternative, PT_{nf}= Platinum alternative, PD₀= Padma conventional, PT₀= Platinum conventional.

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PROMOTING GREEN LIVING THROUGH ORGANIC AGRICULTURE FOR ECOLOGICAL CIVILIZATION

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ABSTRACT

Green living is all about sustainability to secure the ecosystem by reducing, reusing and recycling for continuity of species. The study examined ways of promoting green living through organic agriculture for ecological civilization. The study dealt deeply into the concept of green living and its importance, organic agriculture and ecological civilization. The benefits of organic agriculture to man and the ecosystem such as promoting action to combat climate change and optimize ecosystem services, functioning of soil ecosystem and soil organisms at their best when the environment is green as against brown environment among others, were also discussed. The challenges combating the ecosystem and ways of promoting green living through organic agriculture to ameliorate these challenges were explored in the study. In conclusion, green living through organic agriculture is ecofriendly and is a panacea for ecological civilization and recommended among others that consumption of products such as aquatic, livestock and forestry products among others made from organic sources will promote healthy living and prevent health deterioration.

Keywords: Green Living, Organic Agriculture, Sustainability, Ecological Civilization

INTRODUCTION

Green living is all about sustainability to secure the ecosystem by reducing, reusing and recycling for continuity of species. Green spaces filter pollutants and dusts from the air. They produce shade and lower temperature in urban areas. They also increase productivity, promote green living that helps to conserve energy and prevent air, water and noise pollution. They are borne for the environment, hence prevent health deterioration. **Green living** is a means of developing sustainable habits in one's daily life so that their daily routines work alongside the resources of nature instead of depleting them, or doing more long-term damage to the environment or ecological system (14). The paper noted that green environment also known as ecofriendly, nature friendly or nature green refers to goods and services, laws, guidelines and policies that help to reduce, minimize the harm upon the ecosystem or the environment. Living green can improve general efficacy of a business and can trim operation costs for the business. Green living activities result to more environmentally friendly practices that help to safeguard the environment and sustain natural resources according to Agbogidi, (5). They are borne for the environment, hence prevent health deterioration.

The environment is the most important resource for life where we get water, power and oxygen hence regarded as our closest neighbour needed for survival. Living green is a choice and it contributes to the development of the planet and makes the place a healthier habitation to live for both present and future generations. The study established that we have been living on nature and living green is the only time we pay back. Living green brings happiness and satisfaction to one because green is natural, wealthy, fruitful and productive hence helping to keep the environment secure (5) Living green helps to live a healthier lifestyle. Green living is not just about the ability to produce clean energy, but also, technologies that allow cleaner production processes as well as the growing market for products which takes a smaller amount of energy from fluorescent light bulbs to organic and locally produced food, hence, green living involves products, processes and services that lessen environment effect or improves natural resource use. Living green makes cities more sustainable and ensures sustainable production and consumption models. Green living can be better actualized when it is being managed through organic farming or agriculture.

Organic agriculture is the practice of growing, raising, or processing goods using organic measures. Organic agriculture is an agriculture that advocates healthy products free from components that may harm humans and nature (7). It is a system of production whose principles are health, ecology, fairness, and care. Synthetic chemical inputs of fertilizers and pesticides are generally advantageous in terms of decreasing pests and increasing yields, nevertheless the negative consequences on human and environmental health have encouraged many producers to pursue organic options. It is the practice of farming or raising crops and other livestock without using any inorganic chemical fertilizers, pesticides or any other genetically modified organisms. With organic farming, the productivity of the farming fields is enhanced along with economic growth, thus promising a sustainable environment. Nowadays, farmers are aware of the harmful and toxic effects of fertilizers and other chemicals used. As a result, they started to rely on organic farming. It has many benefits over other farming practices. They are eco-friendly and help to reduce soil infertility and soil erosion issues. It also promotes a healthy lifestyle.

Organic agriculture is a type of farming that sustains the health of the soil, ecosystem and people. It relies on ecological process, biodiversity and cycles. It circles around crop rotation, green manure and compost. It is based on principle of health, ecology, fairness and care. It is regenerative farming essential to fighting climate change and other environmental crises and degradation (14). It is ecologically based and may not use agrochemicals. In spite of all the benefits obtained from environment and the ecosystems, numerous threats are challenging, population explosion now estimated to be 7.7 billion is an overriding factor (6). Anthropogenic forces and factors affect the environment negatively. These include deforestation, desertification, extractive industries like mining, dredging oil and gas. Organic agriculture is the practice of growing, raising, or processing goods using methods that avoid the use of most synthetic pesticides and fertilizers, bioengineering, ionizing radiation, and sewage sludge. The US Department of Agriculture's National Organic Program is the governing entity for certified organic farming in the U.S. The certification standards were described by Congress in the Organic Foods Production Act, and continue to be developed by the National Organic Standards Board. The process of certification and practice of organic agriculture is explicitly detailed through the USDA Organic Standards (OFPA, 2005).

The USDA standards outline a variety of necessities for creating and maintaining an organic agricultural system. These include methods for farmers and processors to preserve natural resources and biodiversity, support animal health and welfare, use only approved materials, and pass regular onsite inspections and certification requirements. Although some of the materials and mechanisms for chemically intensive farming were developed earlier, the global boom in fertilizer and pesticide use coincided with the end of World War II and the increased sense of urgency surrounding the need to feed a rapidly expanding global population. The first Green Revolution emerged in response to increasing numbers of underfed and malnourished populations and allowed for the spread of agricultural technologies, such as pesticides and fertilizers, to developing countries. These chemical inputs contributed to yield increases around the world. Modern organic farming grew in response to concerns about the impact of chemically intensive farming on ecosystem and human health. Although a “chemical-free” farming movement began earlier, organic agriculture gained significant traction in the 1970s due to an increasing awareness of the negative environmental effects of some synthetic pesticides and fertilizers (13).

Challenges of the Ecosystem: The Rationale for Organic Agriculture

Organic agriculture is aimed at decreasing ecological risks and environmental sacrifices for sustainable development without degrading the ecosystem. In Africa, the top five greenest economy, practicing organic agriculture are Mozambique, Ethiopia, Zambia, Kenya and Ghana as submitted by Scialabba, (10). This shows that, our country, Nigeria is invariably left out of this. In spite of all the benefits obtained from environment and the ecosystems, numerous threats are

challenging, such as population explosion which is seen as an overriding factor, anthropogenic forces and factors that affect the environment negatively. These include deforestation, desertification, extractive industries like mining, dredging, oil and gas, global warming, climate change, poor and bad agricultural activities such as land clearing, inappropriate irrigation, overgrazing intensive farming, over drafting, introduction of exotic species, flooding, soil erosions, pollution of all kinds, salinization, unsustainable exploitation and consumption, acid rains, soil acidification, plastic pollution, mass extinction, urban sprawl and commercial development, drought (11, 12). All these activities have led to different forms of environmental degradation, ecological crisis and ecological collapse. Studies upon studies including that of Agbogidi, et. al. (4). and Agbogidi (2) have shown that our current lifestyle or living practices impact global warming, food shortages, water depletion and energy shortages. The only way out of these predicaments is to adopt a green living through organic agriculture which will help in enhancing ecological civilization.

Ecological Civilization

Ecological civilization describes a world in which human communities (our systems of economics, agriculture, education, production and consumption, among others) are designed to promote the overall well-being of people and the planet. It's a vision for a more sustainable and just society; a world that works for all. The transition toward ecological civilization will require transformation at a far deeper level than most people realize. Beyond important changes like adopting renewable energy, driving electric cars, and eating less meat, transitioning toward an ecological civilization requires a paradigm shift in which the fundamental systems and structures of our civilization are reorganized according to ecological values. This paradigm shift arises out of an awareness that our major social and environmental challenges are all interconnected, requiring integral solutions for the common good (1). In order for this to be a reality, there is a need for ecological civilization construction.

Ecological civilization construction is the fundamental task related to the sustainable development of a nation. When ecology thrives, civilization thrives; when ecology declines, civilization declines. Therefore we must take responsibility for history and comprehensively promote the construction of ecological civilization. Among the various aspects, lifestyle has almost been the most direct and impactful component of ecological civilization construction, involving our scientific attitude toward nature. To comprehensively promote ecological civilization construction, we must start from the specifics of our daily lives, promoting green living and fostering green development. This involves establishing a circular link between production and life systems, advocating for a simple, moderate, green, and low carbon lifestyle, and opposing extravagance, waste, and irrational consumption.

Benefits of organic agriculture

The benefits of organic agriculture are enormous. These include saving energy, water, waste reduction, protection of natural resources, slow down climate change, improvement of overall health and sustainable eco-friendly bright future. Greening the environment through organic agriculture will improve upon nature for the perceived benefits of humanity, promote actions to combat climate change and optimize ecosystem services. It improves soil conditions and subsequently the conditions, structure and functionality of soil organisms (3). Soil ecosystem and soil organisms function best when the whole environment is organic as against inorganic environment (8). Organic agriculture helps to restore missing glory of the environment. As earlier established, ecological degradation need to be restored and resuscitated and the only way out is green living through organic agriculture.

Other benefits of organic agriculture include:

- Improves soil fertility and maintains biological diversity.
- Good for the environment and yields are healthy for human and animal consumption.
- Prevents soil erosion, degradation and crop failure.
- Decrease pollution and the whole farming can easily rely on renewable energy sources.
- Improves soil fertility and enhances its chemical and physical properties.

We can thus say that organic farming is a future scope and the best method for farmers which is profitable, rewarding and healthier for consumption. A study by Yesufu, Aremu, Kasali & Adebayo (15), authenticated this. The study was on Consumers' preference for organic vegetable with emphasis on awareness, perception and willingness to pay. One hundred consumers were randomly selected. A questionnaire was used to obtain information on socioeconomic characteristics and other relevant variables. The result showed that Consumers preferred organic vegetables to conventional ones as it was perceived to be healthier (77%), of better quality (76%), tastier (66%), less harmful (66%) but expensive (30%) respectively. There was good supply of organic vegetable in the market and Okro (21.6%), Amaranths vegetables (20.4%) and tomato (19.8%) were the organic vegetables mostly consumed in the metropolis. Health concern (80%), satisfaction (79%) and safety (78%) respectively are the major reasons why consumer opted for organic vegetable.

CONCLUSION

Ecosystem services are useful from cradle to grave. Living green is the only way and time we pay back to nature all that we have been living on. Green living through organic agriculture indeed guarantees a secured environment. It brings happiness and satisfaction to one because organic is natural, wealthy, fruitful and productive hence helping to keep the environment secured. Hence, consumption of products such as aquatic, livestock and forestry products among others made from organic sources will promote healthy living and prevent health deterioration; living green by practicing organic agriculture will help to reduce and minimize the harm upon the ecosystem or the environment; farmers should adopt the use of organic manure (such as compost, farmyard manure and green manure) and organic practices (such as crop rotation, shifting cultivation, bush fallowing among others) for sustainability of the health and fertility of the soil; agricultural products should be cultivated in an environment free from pollution in order to ensure the organic nature of the products.

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UNLOCKING THE MARKET POTENTIALS OF ORGANIC FARM PRODUCE IN EKITI STATE, SOUTHWESTERN NIGERIA

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ABSTRACT

Organic agriculture is fast growing in its importance internationally and Nigeria is not left out. its farmers have suffered a lot of shortages in terms of profit due to neglects in terms of distinct marketing channels and organic farming produces are greatly affected in this problem that have been confronting farming as a business. This paper sought to reveal the unnoticed constraints that have been hindering the marketing of organic farming produces with a view to presenting recommendations as practicable solutions that will make the marketing of these produce more profitable one. Structured questionnaires were used in collecting data from 100 respondents which were purposively selected. Descriptive statistic and Likert Scale were used in analyzing the demographics characteristics and the problem faced by these respondents in accessing the markets of organic farms produce respectively. The findings showed that there are more males in the organic farming business compared to females. Fifty percent (50%) of the respondents had primary education, while 41% were married. The Likert scale enumerated the problems as perceived by the respondents. Information about and on Organic farming is still grasping, some of infrastructures were not in place and the quantity of organic farm produced were still very scanty which formed the major limitation to the highly flying potentials of organic farm produce. Further research outcome showed that organic farm produces have a potential in to leveraging a sustainable food security agenda if properly monitored.

Keywords: Organic farming, profit-making, Purposively, Likert Scale, Demographic

INTRODUCTION

Organic food production is a new major innovation that has been impactful and beneficial to the future agricultural sustainability and food security [1], still the conventional farming is leading the major role in solving the food needs of the teaming population. The upsurge in the food demand world over cannot be met by indigenous subsistence farming [2]. The introduction and practice of organic farming has been seen as a means of sustainable development leading to poverty reduction and promoting food security agenda among the rural households.

Organic farming is defined as a process that excludes the use of synthetic pesticides, fertilizers and all the additives in livestock feeds and other drugs for managing growth. The new system of organic farming relies solely on crop residues, crop rotation, green and legumes, off farm organic wastes, biological pest control, in all a balanced soil fertility is gain [3]. In 2002, [4] said the organic farming is a way out from the environmental limitations of the chemical dependent in conventional farming. Organic agriculture has begun to add value in creating income and generating foreign exchange for the economy but as it is in most other African countries, the non-financial benefits of organic farming have not been properly documented [5]. There is a huge potential for organic farms produce which can be achievable by growing a sizeable market [6] where all the barriers facing it can be attended to as domestic organic markets. There is an export markets for organic farms produces in South African with an estimated of 100 million rand. The study objectives or research questions include the assessment of Socio-economic characteristics of the organic farmers, and the constraints faced by the farmers in the marketing of Organic produce.

MATERIALS AND METHODS

This study was carried out in Ekiti State, Nigeria. The State lies in the rain forest zone of Nigeria. Ekiti State is bounded in the north by Kwara State, west by Osun State, south by Ondo state and in the east by Kogi State. Ekiti State lies between Latitude 7°40'N 5°15'E and longitude 7.667°N 5.250°E occupying 6,353km² (2,453sq m) of land and ranked 31st of the 36 states in the federal republic in terms of land mass. The projected population of the state is 3,270,798 [7].

Furthermore, the population distribution shows that youths within the age range 20 – 24 years are about twelve percent (12%) of the total population. The State has 16 local councils. The state is credited as having a high level of educated citizens in the country and education is highly regarded and prioritized in the state. There are two distinct seasons which are wet and dry seasons. The dry season lasts from November to March. The area is blessed with 12 diurnal sunshine hours and a moderate year-round temperature of 25° C. Annual rainfall averages at 200mm. A large percentage of the inhabitants of the state engage in agriculture. The major food crops include, rice, maize, yam, cocoyam, cassava, pepper and tomatoes varieties.

Experimental Procedure

The population for the study comprises of matured individual living in the study area. A three-stage random sampling technique was used. Four Local Governments were purposively chosen, Ado, Ido Osi, Oye and Ikole Local Governments were picked. In the second stage, 2 villages that have records of organic farming practices were also purposively selected and finally 25 respondents were randomly selected from each Local Government thus, having 100 respondents that structured questionnaire were administered.

Analytical tools

Descriptive statistics was used to capture the socioeconomic characteristics of the respondents, such as age, sex, marital status, educational level, occupation and household size. While Likert scale was used in profiling the problem mitigating the free flow of marketing potentials of organic farm produces.

RESULTS AND DISCUSSION

The result in 1 shows some dominant indicators in the socioeconomic characteristics of the respondent in the study area. The descriptive statistics used was presented in the tabular form. It revealed that 31% of the respondents that belongs to the age group of 30-69 years indicating that we have matured people in the respondents. Thus, the intention of the researcher is cleared to them. 41% of the respondents were married, this matches with the work of [8]. According to the result, male headed family occupied 65% indicating that most of the respondents were married.

Problem mitigating the free flow of market Potentials of Organic Farm Produces

The means scores of four statements relating to the views of the respondents on the organic farming produce ranging from 2.57-3.01 which was within the real limit of 2.50-3.49 (Table 2). This indicates that these four statements agreed that there were markets for organic farming produces in the study area.

CONCLUSION

In conclusion, it was observed that there was a poor awareness by the consumers of organic farming produces, the output was very small due to lack of infrastructures, and there was little or no existence of storage facilitates, and where they existence was in bad shape. The organic farmers association should work very hard in advertising the new innovations so that people can know the health advantages of the new produces, Farmers association must work on how to improve on the storage methods to expand the shelf life of the produces.

Table 1: Socioeconomic characteristics of the Respondents

Variables	Dominant Indicator	Frequency	%
Age	Between 30-69 years	31	31
Marital Status	Married	41	41
Education	Primary school	50	50
Gender	Male headed house	65	65
Occupation	Others, apart farming	58	58
Household size	1-5 people	63	63

Source: Field Survey, 2022

Table 2: Problem mitigating the free flow of organic marketing potentials

Statement	Mean	Sd	Decision
There is no adequate information on organic products	3.01	1.068	Agree
The supply is not in adequate for sales	2.77	1.100	Agree
There are lots of production challenges	2.64	1.030	Agree
Some structures are not put in place and this is affecting the marketing of organic farming products	2.57	0.998	Agree

Sd= Standard Deviation; Source: Field Survey, 2022

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SWEET SORGHUM – AN AFRICAN CROP FOR SUSTAINABLE FOOD SUPPLY AND ITS BIOPROCESSING INTO GNS ETHANOL

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ABSTRACT

Sustainable growth and development in Africa is heavily reliant on a successful agricultural sector. With improved crop productivity, Africa has the potential to not only feed her own people, but to indeed become the breadbasket of the world. One important crop species that could play a dominant role is Sweet Sorghum. Sorghum originates from Africa and is a naturally drought, salinity and alkalinity tolerant cereal crop, noted for its good yields in these harshest of environments. This paper reviews role of Sorghum as a key agricultural crop for Africa development. It discusses the evaluation of Sorghum's present contribution to World agriculture and its potential as a sustainable source of food and fuel supplies. Currently, Africa's indigenous Sorghum varieties composed of important genetic resources for the development of successful future crops, therefore, there is a critical need to protect and develop this genetic inheritance to best serve Africa benefits.

Keywords: Bioethanol, Sorghum, Sustainable Food Supply

INTRODUCTION

Accesses to food and energy have been described as the engine of economic progress [1]. This is not only critical for human and industrial growths, but are also important for improvement and delivery of vital social services such as better healthcare, clean water, and access to education; all of which enhances community standard of living. Importantly, the current international interest in finding alternative sources of energy to the diminishing supplies of fossil fuels has encouraged more efforts in the development of biofuel production technologies. Thus the future energy needs of any country leans on the commitment to build a vibrant renewable energy sector, of which biofuel (more importantly bioethanol) greatly play a significant role.

Globally, food and energy supplies have played central roles in economic and industrial developments, thus a decisive strategy for securing the immediate and future food and energy needs of any country cannot be over emphasized. One important part of this strategy involves a commitment to build a vibrant sustainable food supplies and renewable energy sector, of which grain crops and biofuels production will increasingly play significant roles. In particular for Africa, the development of a successful agro and biofuel sectors are very vital for her long term growth and economic stability as 70% of African states are dependent on imported food and energy resources, coupled with and the high oil prices that weigh heavily on public purse, and this may account for up to 20- 40 % of the income of many households. Investing in sustainable crop and biofuel production, essentially in Nigeria can reduce her high dependence on fuel imports, and this will in turn make substantial savings on our foreign expenditure. Not only would this serve to enhance energy sovereignty and security, but would also contribute much to the development of rural economies, by boosting local agricultural production, thereby increasing farmers' revenues, creating more jobs and improving the social infrastructure.

One important crop species that has been playing a dominant role in this vision of green revolution is Sweet Sorghum [*Sorghum bicolor* (L) Moench (**SSB**)], as developed countries like USA, Australia, China, Brazil and India have all invested hugely into the cultivation and its bio-processing to ethanol. Although **SSB** originates from Africa, however, many countries in the continent are yet to fully tap from the potential of this wonder crop. Sorghum is currently the world's fifth most cultivated cereal crop (after wheat, rice, maize and barley), and over 300 million people across semi-arid and tropic regions of the developing world relied on it as a primary source of food [2].

It is a natural resilient crop that can thrive in semi-arid climate, drought, salinity and alkalinity tolerant crop that required minimal or no irrigation or fertilization for optimum grains yield. More importantly, for SSB variety stalks; which are naturally high reservoirs of primarily fermentable sucrose sugar, presents potential for bioprocessing into Grain and Neutral Spirits (GNS) ethanol [2]. Thus, Sorghum provides multifaceted roles in addressing sustainable food supply and bioenergy production, consequently it enhances: economic growth/developments, food security and provides a transition towards renewable energy sources in Africa. Ironically, Nigeria which currently is one of world big producers still has to import from other producing countries such as Sudan, Ethiopia, etc, in order to meet the local demands. Hence, there is need for robust and well driven agricultural investments into mass production of **SSB** in Nigeria, however not only for the generation of food but towards the production of green fuel energy.

Sorghum in Africa - World Agricultural Development

Sorghum was originally domesticated from wild stock around 7000 years ago by African farmers in the Sahel region [3]. The cultivated varieties that emerged were therefore highly adapted to the hot and dry conditions in which they originated and evolved. This made sorghum an extremely useful and attractive crop, and it was swiftly distributed along trade routes throughout the rest of Africa, the Middle East and Asia [2]. In the 18th century, the crop was introduced to the Americas via the slave trade and since then has spread all the way to the Oceanic regions. Today, sorghum is grown across a range of climatic regions and on all continents (except Antarctica). Current estimates of global production exceed 60 million tonnes per year, with the biggest harvests occurring in the Nigeria, United States, India, Mexico, Sudan, China, Brazil, Argentina, Ethiopia and Australia [4].

Cultivated sorghum (*Sorghum bicolor* L. Moench) is a highly versatile crop species that has been selectively bred into four main varieties: grain; fibre; multi-purpose and sweet [5]. Grain sorghum is typically seen as a food source for people in the developing world and is used to make a variety of important staple foods such as bread, couscous, porridges and even traditional beer [2]. Among the developed nations, grain sorghum is used mostly as an animal feed, but interest in its nutritional quality for Western diets is growing as it can serve as an alternative for those who are wheat (gluten) intolerant [2]. Furthermore, sorghum grains contain highly resistant starches with digestive properties which may be of benefit to those who are obese or diabetic [6]. While the grain sorghums are grown mainly for household food security, the other sorghum types are sought after mainly for their commercial value. Sorghum fibre for example can be utilised in the manufacture of various paper and cardboard products [5]; whilst the sweet-stemmed varieties of sorghum are highly valued for their sucrose content which is used to produce syrup or bio-ethanol [7]. The multi-purpose Sweet Sorghum [*Sorghum bicolor* (L) Moench (**SSB**)], seems to combine the best of characteristics of both grain and non-grain varieties. These varieties are hailed as 'ideal smart crops' because they have the potential to produce food, animal feed, fuel and fibre altogether in one crop. It thus goes beyond the traditional sorghum varieties, as these additional benefits have made it garnered increased attention largely from farmers, researchers, industry, policy makers and other agriculture stakeholders.

Rising need for sustainable agricultural practices and renewable energy has created a great interest in crops such as SSB. SSB's potential to transform rural economies in Africa is therefore immense. Not only is the crop vital for addressing the needs of food security, but it can also be an important driver of economic growth and sustainable development. It is estimated that as much as 90% of Africa's rural communities are poor resource farmers who depend on agriculture to make a living [8]. Agriculture therefore, must be made to work for Africa's rural communities and sorghum is one such candidate crop that has the potential to propel a shift in African farming from the level of precarious subsistence to that of sustainable profitability. Furthermore, the current advancements in bioprocessing technologies have also enhance opportunities for the conversion of SSB stem juices to GNS ethanol, in a modular approach that is operational even in the rural communities.

This has thus offered a good and sustainable way and solution in tackling energy challenges that currently face many African countries. Moreover, it will create opportunities for rural development and job creation within the communities as farmers can simultaneously meet food supplies and generate more income through bioethanol production.

Sweet Sorghum for Biofuels/Bioethanol Production

Biofuels are liquid or gaseous fuels that are primarily derived from plant biomass [9]. Interest in biofuels as a viable alternative to fossil fuels has intensified in recent years amidst growing concerns over energy security, oil price volatility and climate change [10]. The world's oil reserves are also a finite resource that is being rapidly depleted. It is estimated that global consumption of fossil fuels has increased more than twenty-fold over the last hundred years [11; 12]. The increasing demand for this limited resource has inevitably lead to higher petroleum prices, which in turn has placed considerable pressure on oil-importing countries. Moreover, the emissions associated with the burning of fossil fuels are linked to severe environmental problems such as air pollution, global warming and climate change [1]. Biofuels are viewed as a viable alternative to fossil fuels, because they constitute a natural renewable resource that can be produced locally and is far less polluting than its fossil fuel counterparts [13]. Thus, the potential of biofuels to provide a viable alternative to petroleum-based fuels is steadily becoming a reality and perhaps no greater endorsement of this view can be found than the recent commitment made by Royal Dutch Shell to invest hugely in research and development of renewable energy into biofuels [14].

For Africa, the development of a successful biofuels sector is vital for the continent's long term growth and economic stability. With over 70% of African states dependent on imported energy resources [1], higher oil prices weigh heavily on the public purse and can account for up to 20% of the national income of several Sahelian States [12]. By investing in biofuels, African states that are highly dependent on fuel imports can make substantial savings on foreign expenditure by developing their own domestic supplies. Not only would this serve to enhance energy sovereignty and security on the continent, but such a move would also contribute much to the development of rural economies, by boosting local agricultural production, thereby increasing farmers' revenues and creating more jobs.

According to a recent study, the bio-energy potential of Sub-Saharan Africa after accounting for food production and resource constraints is the highest in the world [15]. This high potential is mainly attributable to three key factors. Firstly, the Africa's favourable climates, which allows biomass production five times greater in the tropical and subtropical zones as compared to temperate regions [16]. Secondly, Africa also has vast tracts of arable land which can be devoted to bio-energy crop cultivation. According to an estimate by the Food and Agricultural Organisation (FAO) of the United Nations, of the 378.8 million hectares of arable land available in Africa, only 43 million hectares (11%) of this land is currently in use [17]. In Europe however, approximately 213.7 million hectares out of the 384.2 million hectare (56%) of the total arable land is currently under cultivation [17]. Thirdly, the relatively cheap and plentiful labour supply gives Africa a competitive edge over other regions for biofuel production. The combinatorial effects of these factors thus make Africa the global centre of attraction for biofuels development [1; 17].

The successes achieved by India and United State of America (USA) on sorghum as a potential crop source for present and future food and fuel supplies is worth emulating by Africa. It could be argued the USA has the finances and research capacities to maximise on the potential of sorghum cultivation, however, India is also a developing nation just as many Africa nations, yet India is not prepared to concede her potentials to the West. In 2007, the world's first commercial bioethanol plant, using sweet sorghum as a feedstock, began operations in Andhra Pradesh, India [18]. This flagship achievement came about as a result of an inspired collaborative effort between the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), a non-profit research agency focused on innovative agricultural methods for capacity and building and sustainable

development; a private partner Rusni Distilleries and close to 800 local farmers of the Andhra Pradesh district. The Rusni Distillery now produces about 40 kilolitres of ethanol per day, whilst local sorghum farmers have seen their incomes improve by an average of about 20% [18]. India's success with sweet sorghum serves as a sterling example of how developing nations can gain a competitive foothold in the biofuels sector in a manner that can uplift rural economies, owe to its environmental sustainability and posed no threat to food security. By growing its own fuel, India has reduced its expenditure on foreign oil imports and invests the savings in her own local development [19; 20].

CONCLUSION

As there is a continuous awareness for sustainable food supplies for an ever increasing population growth in Africa, Africa stands a very good chance to capitalize on the potentials inherent in sweet sorghum cultivation by increasing its production via utilizing more of the agricultural land along with the existing arable land for its cultivation, which in turn will increase its production than the current output. This consequently will not only provide more food for Africans, but the excess could be channel for industrial use for generation of bioethanol for fuel. Thus, sweet sorghum represents a great opportunity for Africa to embrace, which in no other way will bring economic transformation and an inclusive sustainable development. There is therefore a need to embrace innovations and promote collaborations between governments, research institutions and private sectors; Africa can thus harness the economic potentials of sweet sorghum which offers both food security and bioenergy supplies and chart a path towards a brighter and sustainable future.

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YIELD COMPONENTS OF SOYA BEAN GROWN ON BIOCHAR AMENDED CHARNOCKITIC SOILS

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ABSTRACT

Soyabean (*Glycine max*), is of high nutritional and commercial value and one of such legumes being integrated into the cropping systems of small-holder farmers in Nigeria particularly in Ekiti State. Alternative and environmentally friendly nutrient sources is being encouraged to ameliorate the impoverished tropical soils. A single application of maize stover biochar (mB) and sawmill waste biochar (sB) at 0-, 5-, 10- and 20-ton ha⁻¹ on charnockite developed soils in Ire-Ekiti and Ijan-Ekiti were made to evaluate the yield components of soyabean for three cropping seasons. Results showed that mB outperformed the sB having higher values across the application rates and the locations. The Grain Yield (GY) generally increased with biochar rates and 20-ton mB ha⁻¹ and 10-ton sB ha⁻¹ had the significantly highest values of 7.77- and 4.98-ton ha⁻¹, respectively in Ire-Ekiti and Ijan-Ekiti. At both locations and biochar types, the seasonal yield performance of the soyabean was in the order of 2016 > 2018 > 2017 and the GY correlated significantly with all other yield components but was higher with Total Dry Matter Yield (TDMY) at Ire-Ekiti (0.915**) and Ijan-Ekiti (0.637**). The findings affirmed biochars' effectiveness in increasing crop productivity. Therefore, 20-ton ha⁻¹ biochar is advised for soyabean production, particularly when mB is involved. However, depending more on the indigenous soil and climatic status biochar could be location specific.

Keywords: Biochar, Charnockitic, Maize stover, Sawmill waste, Seasonal, Soyabean, Yield.

INTRODUCTION

Soyabean (*Glycine max*), is of high nutritional and commercial value and one of such legumes being integrated into the cropping systems of small-holder farmers particularly in Ekiti State. More so, it contains about 40% protein, and substantial amount of calcium, phosphorus, dietary fibre and cholesterol free [1] consumable for both human and animals [2] and preventing recurrent soil erosion, moisture loss and fixes atmospheric N [3, 4] during field production. These implicated promoting its integration into the farming systems where the nutrient depleted soils are continuously cultivated to meet the food needs of the burgeoning population. Geologically, granitic parent rocks with varietal minerals such as charnockite dominated Ekiti State, Nigeria and from which the marginally fertile and tropically characterized agricultural soils were developed [5].

Thus, the maintenance of such soils' fertility beckons for an alternative and environmentally friendly nutrient sources such as the usage of agricultural waste converted biochars which are regarded as a multipurpose material relevant for agricultural and environmental management [6]. As a soil amendment, biochar improves both physical, chemical and biological properties of the soils while sequestering carbon to mitigate climate change [7], all of which promote plant growth and yield. Hence, the objective of this study is to evaluate the potentials of two biochar types for optimum yield and yield components of soyabean grown on charnockite-developed soils.

MATERIALS AND METHODS

The experiment took place at Ire-Ekiti (7° 45' N and 5° 23' E) and Ijan-Ekiti (7° 37' N and 5° 23' E) in soils formed from charnockite rocks in Ekiti State. Both were agrarian regions belonging to the tropical savannah (Aw) [8] with average annual precipitation and temperature of 1316 mm and 24.8 °C. The soils are alfisols, having classified respectively as Grossarenic Plinthic Kandiudalf and Plinthic Kandiudalf [9]. Ire-Ekiti is moderately acidic loamy sand soil (pH 5.6) while Ijan-Ekiti is slightly acidic sandy soil (pH 6.3), both were deficient in available P and total N with moderate Cation Exchange Capacity (CEC) [10]. Characterized biochars made from maize stover (mB) and sawmill waste products (sB) [11] were used for the evaluation.

Field trials were conducted in Ire-Ekiti and Ijan-Ekiti over three cropping years: 2016, 2017 and 2018 with a single initial biochar application. Land preparation was done manually and laid out in a Randomized Complete Block Design (RCBD) of 3-block representing the replicates with each experimental plot measuring 1.0 m x 1.6 m with intra-plot and inter-block spacing of 0.5 and 1.0 m respectively. The crushed biochars were applied by spreading on the plot and worked into the soil using hoe and rake at the rates of 5-, 10-, and 20-ton ha⁻¹ and a control (0-ton biochar ha⁻¹), and allowed to equilibrate for 7 days. Seed of soyabean (TGX 1440-IE, a determinate variety that matures in 110-120 days) was sowed at 0.1 m x 0.6 m spacing to achieve a plant population density of 333,333 plants ha⁻¹ at 2-seedlings per hill after thinning at seven Days After Sowing (DAS).

A non-selective systemic pre-emergence herbicide, Paraquat Dichloride 276 g L⁻¹ was applied at 2.0 litre ha⁻¹ immediately after sowing and subsequent weeding done manually. Earthening of the plants was done to prevent lodging and the pods from touching the ground before maturity. There was no issue of pest and disease infestation during the cropping years. Yield components' data were determined at maturity by uprooting the three inner most plant stands and parameters determined were averaged for data on per plant basis for number of pods per plant, 100-seed weight (g) per plant after hand threshing, Grain Yield (GY, ton ha⁻¹) was extrapolated from grain yield per plant (g), total dry matter yield weighed and the harvest index calculated as:

$$\text{Harvest Index (HI)} = \text{GY/Total dry matter yield} \dots\dots\dots (1)$$

Data obtained were subjected to analysis of variance (ANOVA) using Generalized Linear Model of IBM SPSS Statistical Package Version 20 [12] and means separated by Duncan multiple range test (DMRT).

RESULTS AND DISCUSSION

Biochar rates and Yield Components of Soyabean

Biochar rates generally had significant effects on the soyabean yield components across the locations with 20-ton ha⁻¹ biochars' rate recording the highest values (Table 1). For the maize stover biochar (mB), the highest soyabean pod production (270.50 pods plant⁻¹) and grain yield (7.77-ton ha⁻¹) were recorded in Ijan-Ekiti at 20-ton mB ha⁻¹ compared to other rates particularly the control (0-ton mB ha⁻¹) that had a generally statistically low values for the yield components. Similarly, 20-ton sB ha⁻¹ (sawmill waste biochar) had significantly higher values in Ire-Ekiti site. However, in Ijan-Ekiti 10-ton sB ha⁻¹ had higher but not significantly better values than the 20-ton sB ha⁻¹. Few reports showed significant increase in the number of pods per plant in soyabean applied biochars compared to non-biochar treated [13, 14]. Furthermore, Yooyen *et al.* [13] also found significantly higher grain yield in soyabean grown on 30-ton ha⁻¹ biochar amended soil. This was attributed to the general ability of biochar to retain and increase nutrients, in addition to moisture retention and reduced soil bulk density in amended soils. Several authors have reported such increase in crop yield following biochar applications even in combination with chemical fertilizers [15, 16]. Mete *et al.* [17] in a pot experiment also observed a lower soyabean grain yield on control soil (440 kg ha⁻¹) compared to sawdust mixture of unknown tree species biochar amended soils.

Harvest Index (HI), an indicator of nutrient partitioning to the grain, relative to total above ground biomass yield were not consistent with the biochar application rates. However, 20-ton mB ha⁻¹ had significantly higher values of 0.27 and 0.34 respectively in Ire-Ekiti and Ijan-Ekiti while the 10-ton sB ha⁻¹ recorded higher but not significant values of 0.23 (Ire-Ekiti) and 0.33 (Ijan-Ekiti). This is in line with the report of Wijitkosum and Kallayasiri [18] of the positive impacts of biochar. Generally, the mB outperformed the sB in contributing to the yield components of soyabean. This could be attributed to the properties and nature of the biochars as reported in Ilori *et al.* [11]. Similarly, the results from Ijan-Ekiti in relation to the biochar amendments were better off the Ire-Ekiti which could strictly be due to the soils' properties and an indication that biochar effectiveness could be location specific.

Seasonal Comparison and Correlation between the Yield Components of Soyabean

The seasonal comparison (Table 2) showed that the yield components were generally higher in the first cropping season (2016) compared to others, for the locations and the biochar types evaluated. The values generally decreased significantly in the 2017 cropping season and then non-significantly increased in the 2018 cropping season for virtually all the yield components. For the mB, significantly higher grain yields were recorded in 2013 at Ire-Ekiti (6.38-ton ha⁻¹) and Ijan-Ekiti (7.28-ton ha⁻¹) compared to the least values of 3.16- and 5.90-ton ha⁻¹ respectively. Other components followed similar trend with the exception of HI at Ire-Ekiti that reduced significantly with the cropping seasons. Furthermore, the sB had highest grain yield of 2.69-ton ha⁻¹ (Ire-Ekiti) and 5.21-ton ha⁻¹ (Ijan-Ekiti) but was only significant at Ijan-Ekiti site. Other yield components followed similar trends with the respective component just like in mB amended soil except for the number of pods that increased non-significantly with cropping season. The findings were contrary to the early reports of Major *et al.* [19] and SARE [20] that in some soils, biochar additions did not increase yields in the first year.

However, the first-year outstanding performance of the soyabean could be due to optimum nutrient flush from both the previously fallowed soils and biochars added while the subsequent increased observed in 2018 season compared to 2017 cropping season showcased the potential residual effects of single biochar application compared to manures, compost and conventional inorganic fertilizers [19, 21]. More so, Agboola and Moses [22] reported increased soyabean yield due to addition of rice husk biochar and Gebremedhin *et al.* [23] also found significant increase in grain and straw yields of wheat by 15.7 and 16.5% respectively, over the NPK fertilizer application. Recently, Katterer *et al.* [24] in their over 10 years field experiment, found that *Acacia spp.* wood biochar applied at 50 Mg ha⁻¹ in the first two years increased the maize yield of the successive years and the subsequent unfertilized soyabean grain yield.

The correlation between the evaluated yield components of soyabean (Table 3) showed positive significant relationships at both locations, except for total dry matter yield (TDMY) that exhibited a non-significantly negative relationship with HI ($r = -0.037$) at Ijan-Ekiti. However, the GY had significantly higher r -values with TDMY at Ire-Ekiti (0.915**) and Ijan-Ekiti (0.637**). It has been reported that crop yield is influenced by the yield components [25].

Table 1: Effects of biochar application rates on yield components of soyabean in Ire-Ekiti and Ijan-Ekiti

Yield component	Maize Stover Biochar, mB				Sawmill Waste Biochar, sB			
	Application Rates (ton ha ⁻¹)				Application Rates (ton ha ⁻¹)			
	0	5	10	20	0	5	10	20
Ire-Ekiti								
NoP	54.67d	109.78 ^c	195.06b	256.89a	54.67c	94.78b	103.67b	143.11a
100-SW	10.03b	10.99a	11.26a	11.60a	10.03b	10.99a	11.20a	11.34a
GY	0.90d	2.63c	4.41b	6.65a	0.90c	2.17b	2.33b	3.25a
TDMY	23.20d	61.66c	89.59b	123.08a	23.20c	47.69b	48.89b	63.82a
HI	0.18c	0.21bc	0.22b	0.27a	0.18	0.21	0.23	0.23
Ijan-Ekiti								
NoP	106.44b	201.22 ^a	210.78a	270.50a	106.44 ^b	128.72a ^b	158.33a	162.22a
100-SW	9.98c	11.07b	11.12b	12.16a	9.98	10.49	10.89	10.55
GY	3.55c	5.78b	5.81b	7.77a	3.55b	4.11ab	4.98a	4.26ab
TDMY	65.74b	119.10 ^a	102.68a ^b	142.74a	65.74b	80.46ab	89.36a	93.56a
HI	0.32	0.31	0.33	0.34	0.32a	0.29ab	0.33a	0.27b

Means with the same letters or without letters in a row are not significantly different at $P \leq 0.05$

GY = Grain Yield (ton ha⁻¹), NoP = Number of Pods plant⁻¹, 100-SW = 100 Seed Weight (g), TDMY = Total Dry Matter Yield (g) and HI = Harvest Index.

Table 2: Seasonal comparison of yield components of soyabean as influenced by biochar types in Ire-Ekiti and Ijan-Ekiti

Yield Components	Maize Stover Biochar, mB			Sawmill Waste Biochar, sB		
	Cropping Seasons			Cropping Seasons		
	2016	2017	2018	2016	2017	2018
Ire-Ekiti						
Number of Pods (pods plant ⁻¹)	201.95a	147.53b	155.43b	94.71	110.19	111.29
100 Seed Weight (g)	13.03a	9.65c	10.58b	13.02a	9.56c	10.37b
Grain Yield (ton ha ⁻¹)	6.38a	2.58b	3.16b	2.69	1.97	2.37
Total Dry Matter Yield (g)	109.71a	62.72b	72.65b	54.89	44.54	47.99
Harvest Index	0.34a	0.23b	0.11c	0.30a	0.24b	0.11c
Ijan-Ekiti						
Number of Pods (pods plant ⁻¹)	240.62	185.05	204.95	165.86a	126.14b	138.71a
100 Seed Weight (g)	13.36a	10.12b	10.23b	13.17a	9.17b	9.31b
Grain Yield (ton ha ⁻¹)	7.28a	4.94b	5.90ab	5.21a	3.58b	4.19b
Total Dry Matter Yield (g)	142.38a	93.92b	104.32b	103.72a	70.77b	79.45b
Harvest Index	0.34	0.31	0.33	0.30	0.30	0.31

Means with the same letters or without letters in a row are not significantly different at $P \leq 0.05$

Table 3: Correlation coefficient (r) among the yield components of soyabean in Ire-Ekiti and Ijan-Ekiti

	Ire-Ekiti				Ijan-Ekiti			
	GY	100 SW	TDMY	HI	GY	100 SW	TDMY	HI
GY	1	.447**	.915**	.519**	1	.441**	.637**	.506**
100-SW		1	.405**	.432**		1	.479**	.227*
TDMY			1	.312**			1	-.037
HI				1				1

* and ** significant at the 0.05 and 0.01 probability levels, respectively (2-tailed).

GY = Grain Yield (ton ha⁻¹), 100 SW = 100 Seed Weight (g), TDMY = Total Dry Matter Yield (g) and HI = Harvest Index.

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EFFECT OF STRAIN ON PHYSIO-CHEMICAL PROPERTIES OF BROILER BREAST AND THIGH MEATS

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ABSTRACT

A Study was conducted to evaluate the effect of strain on physico-chemical properties of the breast and thigh meats of broiler birds. One hundred and thirty-five (135) day-old broiler chicks from three strains of Arbor Acres, Cobb and Ross 308 were used in this study. Each strain was replicated three (3) times with fifteen (15) birds per replicate. The birds were raised for seven (7) weeks under deep litter system with diets composed from natural agricultural ingredients, free of antibiotics, growth hormones, chemicals and pesticides. Data were collected on breast and thigh meat quality traits was subjected to GLM and mean separation ($\alpha=0.05$). The result showed that breast and thigh meats temperature at slaughter was significantly ($P<0.05$) highest in Arbor acre (39.675° and 37.150° respectively) and lowest in Ross 308 (26.875° and 26.650° respectively). Breast meat temperature at 24 hours after slaughter was highest in Arbor acre (8.025°) and lowest in Ross 308 (3.20°). Arbor acre thigh meat has the highest drip loss (10.652) at 24 hours after slaughter than Cobb (7.575) and Ross 308 (3.174). Ross-308 strain has the lowest drip loss and temperature at slaughter and 24 hours after slaughter. Ross 308 was recommended because of its potential to retain more nutrients and produce least economic loss to meat processors and retailers.

Keywords: Strains of broiler, natural ingredients, drip loss, meat temperature, breast and thigh meats, consumer preference

INTRODUCTION

Organic poultry production is becoming popular for the supply of high-quality poultry products to Nigerians. Broilers are domesticated chickens raised for table meat supply [1]. Nigerian poultry industry has witnessed introduction of different broiler strains to supply poultry meat and products. Poultry is one option in reducing problem of protein deficiency in the diet of Nigerians [1]. Its white meat is considered superior to red meat due to low-fat content and low cholesterol level [2]. Thus, feed fed to birds should be composed of natural ingredients without antibiotics, chemicals and artificial ingredients. Major attributes which define the quality of meat include drip loss and its functionality – pH: a measure of the acidity or basicity of meat ranging from about 5.2 to 7.0. Poultry farmers have to select broiler strains that will reach market weight at a reasonable age in order to maximize profit [3].

Nigerians need high quality and wholesome poultry products produced through organic processes for high quality protein products in the market. Certified organic poultry products are still limited in supply because of the processes producers have to undergo for certification. However, study was conceived to determine the effect of broiler strain differences on carcass yield and physico-chemical properties of the breast and thigh meats produced under organic conditions.

There is need to provide insights into the influence of strain on carcass yield and meat quality of broilers fed with natural ingredients. This could provide guide to farmers, breeders and processors in selecting suitable strains for specific production objectives, market and consumer preferences. The objectives were to determine effect of strain on carcass yield and meat quality of three strains of broiler fed with natural ingredients. The hypothesis of study was that strain of broiler shall have effect on carcass yield and meat quality.

Experimental Birds used consisted of one hundred and thirty-five (135) day-old broiler chicks of three strains of Arbor Acres, Cobb and Ross 308 at 45 chicks per strain were used for the study. The housing and bio-security procedures provided adequate space, shade, fresh air and sunlight to the birds. The brooding temperature was carefully monitored and maintained according to the specified schedule, to ensure that the chicks were comfortable and healthy. The amount of heat was gradually reduced over time to allow chicks to acclimate to the environment, thus reducing stress or disease. After the first 4 weeks of life, the brooding temperature was gradually reduced over time until they were about 7 weeks old. Daily cleaning and feeding were carried out during rearing. Finished feed composed from natural agricultural feedstuffs were free of antibiotics, growth hormones, chemicals and pesticides. Formulated feed and nutrient composition were as outlined below in Table 1. Within-strain (Arbor acre, Ross 308 and Cobb 500) all chicks were fed at 5% of the mean body weight for the previous week at the beginning of the new week. Fresh and cool drinking water was provided *ad libitum* [4].

At 7 weeks, the birds were subjected to 24h feed withdrawal with free access to water and weighed to the nearest gram before slaughtering. Two birds were picked at random from each replicate, labeled, weighed, and slaughtered humanely using slaughtering cone for analysis. Bleeding was achieved with a sharp knife, and the birds were allowed to bleed for 5 minutes, before carcass processing.

Each bird was weighed, scalded, defeathered and beheaded. Furthermore, neck and legs were removed. Birds were eviscerated, washed and inspected before cutting to parts. The weights of body parts were recorded. Visible fat was removed from the viscera, gizzard and subcutaneously, and then weighed to the nearest gram.

Meat quality traits were determined on boneless and skinless broiler breast fillets and thigh meat. These were carcass temperature (at slaughter, 24-hr), pH value (slaughter, 24-hr), Drip or Purge loss were determined as $[100 \times (\text{weight of drip}/\text{initial sample weight})]$, Water Holding Capacity (WHC) of raw meat as $\{(\text{initial} - \text{final weight}) \times 100\} / \text{initial weight}$. Cooking loss was determined as $\{(W1 - W2)/W1\} \times 100$. Where W1: Weight of sample before cooking (g) and W2: Weight of sample after cooking (g).

Data was analyzed using one-way analysis of variance (ANOVA). Means were separated using Duncan Multiple Range Test (DMRT) at a significance level of 0.05, using SAS[®] v9 [5].

RESULTS

Table 2 indicates that hot and chilled breast meat temperature, at slaughter and at 24 hours differ significantly ($P < 0.005$) among breeds. Table 3 indicates that thigh meat temperature at slaughter also differ significantly ($P < 0.005$) among strains. Drip loss in thigh was higher in Arbor acre strain (10.65) and lowest in the Ross 308 strain (3.17), while Cobb broiler birds were in-between (7.58) strains ($P < 0.05$).

DISCUSSION

Strain affected the breast and thigh meat temperature at slaughter among birds, but after 24 hours, only the breast meat temperature was influenced by strain. Meat temperature, the time it takes the meat to chill and the rate of pH decline in the meat all interact to determine meat quality. The shorter the time interval to chilling, the higher the quality of the meat. The raw breast and thigh muscle pH at slaughter and 24hrs post-mortem (5.53 - 5.69), and water holding capacity (39.8 - 54.8, %) were similar among strains. This revealed a small change in meat pH among strains after 24hrs post-slaughter; and minor differences in water holding capacity of both breast and thigh meats among strains at 24hrs post-mortem. The threshold range for the pH-value of breast meat of broilers was reported as 5.4 to 5.8 for PSE-condition and 5.8 to 6.3 for standard meat quality [6].

Results classify the meats obtained from the strains as pale soft and exudative. This is caused by a combination of low pH value shortly after slaughtering and a high temperature within meat above 37°C. Water holding capacity at 24hrs post-mortem is the ability of the meat to retain inherent or added water through processing and storage. This is important in broilers because it influences product yield for processors and sensory quality for consumers [7], while low or poor WHC leads to diminished visual appeal due to excess purge in meat packages and inferior palatability traits related to juiciness and tenderness [7]. The WHC of AA strain above 50% in both breast and thigh muscles seemed better than that of Cobb and Ross strains. Drip is the loss in flavour, fluid or tissue juice after thawing of frozen meat. It consists of water and proteins which are expelled from meat without mechanical force other than gravity. It is bound to a period depending on the strain. The drip loss at 24-hours post-slaughter drip among strains was highest in the thigh meat of Arbor acre and lowest in Ross-308. The pH and drip loss in present study of both breast and thigh meats among Arbo acre, Cobb 500 and Ross 308 were below the values reported by [8], but cooking loss was higher. *The mechanism of drip loss from meat is said to be influenced by pH of the tissue, amount of space in the muscle cell and the myofibril that exists for water to reside [9].* Drip is important for broiler meat palatability, overall quality and acceptability to consumers [10].

CONCLUSIONS

There were temperature differences among strains in breast and thigh meats at slaughter. Breast meats among strains differ in mean temperature at 24-hour post-slaughter. Drip loss at 24-hours post-slaughter differ among strains. Ross-308 strain with the lowest drip loss was observed as suitable for consumer acceptance based on its possible better nutrient retention.

Table 1: The experimental diets and their proximate composition

Ingredients	Starter Diet	Finisher Diet
Grinded Yellow Maize	45.00	60.00
Fishmeal (65%)	3.00	2.00
Soyabean meal	35.5	31.0
Bone meal	2.00	2.00
Limestone	1.00	1.00
Salt	0.25	0.25
Methionine	0.20	0.20
Vitamin-Mineral Premix	0.25	0.25
Wheat offal	13.30	3.30
Total	100.00	100.00
Calculated Nutrient composition		
Energy (Kcal/kg ME)	2725.91	2928.31
Crude Protein (%)	22.35	20.14
Energy/Protein ratio	121.9:1	14543:1
Ether Extract (%)	3.70	3.74
Crude Fibre (%)	4.68	3.96
Calcium (%)	1.24	1.15
Phosphorus (%)	0.79	0.73
Lysine (%)	1.27	1.08
Methionine (%)	0.57	0.54
Cystine	0.37	0.32

Table 2: Effect of commercial strain on physico-chemical properties of broiler breast meat

Traits	Arbo acre	Cobb	Ross 308	SEM	P-Value
Breast meat Temp. (at slaughter, O °C)	39.675 ^a	36.700 ^b	26.875 ^c	1.690	0.001
Breast meat Temp. (24hrs post -mortem, O °C)	8.025 ^a	3.675 ^b	3.200 ^c	0.501	0.009
Raw breast muscle P ^H (at slaughter)	5.633	5.560	5.525	0.055	0.759
Raw breast muscle P ^H (24hrs post -mortem)	5.550	5.530	5.150	0.089	0.107
Water Holding Capacity (24hrs post -mortem, %)	54.00	46.30	39.80	4.159	0.477
Drip loss (at 24hrs)	4.168	2.546	2.515	0.404	0.163
Cooking loss (at 24hrs)	47.794	46.247	42.00	1.811	0.441

Means with different superscripts were significantly (P<0.05) different. Temp = Temperature

Table 3: Effect of commercial strain on physico-chemical properties of broiler thigh meat

Traits	Arbor acre	Cobb	Ross 308	S.E.M	P-Value
Thigh Temp. (at slaughter, O °C)	37.150 ^a	33.250 ^b	26.650 ^c	1.338	0.001
Thigh Temp. (24hrs post -mortem, O °C)	7.925	7.750	6.125	0.531	0.343
Raw thigh muscle P ^H (at slaughter)	5.690	5.683	5.633	0.050	0.896
Raw thigh muscle P ^H (24hrs post -mortem)	5.753	5.660	5.553	5.655	0.414
Water Holding Capacity (24hrs post -mortem, %)	54.80	46.700	43.00	3.313	0.416
Drip loss (at 24hrs)	10.652 ^a	7.575 ^b	3.174 ^c	1.143	0.008
Cooking loss (at 24hrs)	51.601	48.644	47.856	1.361	0.541

Means with different superscripts were significantly (P<0.05) different. Temp = Temperature

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NUTRIENT AND PROXIMATE COMPOSITION OF TOMATO VARIETIES (*LYCOPERSICON ESCULENTUM* MILL) FRUITS AS INFLUENCED BY BOTANICALS AND STORAGE MEDIA

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ABSTRACT

Tomato (*Lycopersicon esculentum* Mill) fruits are highly perishable, requiring appropriate pre and postharvest handling for improved shelf life. The experiment was conducted in the laboratory of Horticulture Department, Federal University of Agriculture, Abeokuta to study the effects of storage media on proximate composition of tomato (*Lycopersicon esculentum* Mill) fruits as influenced by varieties, botanicals and storage media. This experiment was a 3 x 3 x 3 factorial experiment in a completely randomized design replicated three times. The treatments included, three tomato varieties: Signatala F1, Sodagar F1 and PO404 F1 fruits grown with compost, stored with; *Jatropha* leaves powder, neem leaves powder and control as botanicals in three media: Block-in-Block; Wooden Ventilated Box Media and Open shelf (control). The proximate analysis of the harvested fruits was carried out using the methods described by AOAC, 2022. The results showed that Signatala F1 fruits treated with powder botanicals stored in evaporative coolant structure (ECS) had lowest concentration of moisture content while those treated with powder *jatropha* leaves had highest lycopene, vitamins A and C content. It was concluded that Signatala F1 fruits harvested at breaker stage stored with either powder *Jatropha* or neem leaves in evaporative coolant structure increased its nutritional quality as compared to control that had greater compositional changes with maximum quality loss during storage in other storage media.

Keywords: Botanicals, nutrient, proximate composition, storage media, tomato fruits, variety

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is an important fruit crop with high nutritional value, rich in antioxidants, vitamins, and dietary fiber [1]. Tomato and tomato-based foods contains high amounts of lycopene, carotenoid with antioxidants [2]. Plant products contains biochemical constituents which are less expensive, biodegradable, ecofriendly and equally efficient with synthetic fungicide without causing hazards to the environment [3]. The attributes of plant in preservation of food enhances its economic value [4]. Postharvest losses (PHL) threaten food, nutrition and income security [5]. The use of chemical preservatives to extend shelf life of tomato fruits have resulted to loss of nutritional quality and aftermath human health hazard. Therefore, there is need to evaluate the effect of compost on the nutrient content of tomato and the influence of powdered botanicals at the different storage media as it affects tomato fruit quality.

MATERIALS AND METHODS

The experiment conducted in the laboratory of the Department of Horticulture, Federal University of Agriculture, Abeokuta, Nigeria was a 3 x 3 x 3 factorial laid out in a completely randomized design and replicated three times. The factors were varieties (Signatala F1, Sodagar F1 and PO404 F1), botanicals (*Jatropha* leaves powder, neem leaves powder and control) and storage media (Block-in-Block; Wooden Ventilated Box and Open shelf). Proximate analysis was carried out to evaluate percentages of moisture, lycopene, vitamins A and C content as described by [6]. Data were subjected to analysis of variance (ANOVA) using SAS 9.4M8 package, 2023. The initial and final means of the data obtained from the proximate analysis were compared using t-test.

RESULTS

There was significant difference on effect of varieties by botanicals by storage media on fruit moisture content (g/100g) between the initial and the final values obtained for Signatala F1 fruits treated with powders of botanicals stored in evaporative coolant structure as compared with open shelf (Table 1). Higher lycopene content was obtained in Signatala F1 and PO404 F1 treated with *Jatropha* leaves powder and Sodagar F1 treated with neem leaves powder irrespective of the medium of storage.

However, Signatala F1 treated with *Jatropha* leaves powder had the highest lycopene content (Table 2). Higher vitamin A content was obtained Signatala F1 treated with *Jatropha* leaves powder and Sodagar F1 treated with neem leaves powder irrespective of the medium of storage. However, Signatala F1 treated with *jatropha* leaves powder had the highest vitamin A content (Table 3). Higher vitamin C content was obtained in Signatala F1 treated with *jatropha* leaves powder and Sodagar F1 treated with neem leaves powder irrespective of the medium of storage. However, Signatala F1 treated with *jatropha* leaves powder had the highest vitamin C content (Table 4).

DISCUSSION

The effect of storage media on proximate content of tomato fruits revealed that there was percentage increase in moisture content in storage media. This is in agreement to a reported study who confirmed an increase in moisture content of tomato fruit during storage [7]. This was also in support of reported study that moisture content in orange and tomato increased compared to the initial [8]. The results of the fruit proximate analysis showed that vitamins A and C content of tomato fruits was significantly influenced by variety x botanicals x storage media. There was percentage increase in vitamin A and C content of tomato juice in fruits. The increase experienced in vitamin A was in line with a reported work [9].

CONCLUSION

In conclusion, tomato fruits harvested at breaker stage stored well with either the *Jatropha* or neem leaves powder in evaporative coolant structure. This led to increased nutritional quality compared to the control which had greater compositional changes with highest quality losses. Therefore, evaporative coolant structure can serve as an important postharvest tool to maintain quality of tomato fruits and extend its storage life. Adoption by farmers could lead to higher profit and improved livelihood of the farmers in rural and urban areas of Nigeria.

Table 1: Interaction effect of variety x botanicals x storage media on fruit moisture content in different storage media

Variety	Botanicals	Evaporative coolant structure		Wooden Ventilated Medium		Open Shelf	
		Initial	Final	Initial	Final	Initial	Final
Sinag tala F1	<i>Jatropha</i> leaves powder	93.24	94.63	93.24	95.53	93.24	95.28
	Neem leaves powder	93.24	95.96	93.24	96.44	93.24	96.15
	Control	93.24	96.41	93.24	95.71	93.24	96.46
Sodagar F1	<i>Jatropha</i> leaves powder	93.58	96.38	93.58	95.76	93.58	93.72
	Neem leaves powder	93.58	94.44	93.58	95.91	93.58	96.36
	Control	93.58	94.44	93.58	95.44	93.58	95.59
PO404	<i>Jatropha</i> leaves powder	94.59	96.03	94.59	95.38	94.59	95.86
	Neem leaves powder	94.59	95.50	94.59	95.63	94.59	95.75
	Control	94.59	95.15	94.59	95.58	94.59	95.21
t-test		0.19					

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A PRELIMINARY STUDY OF DIFFERENT LEVELS OF *TITHONIA DIVERSIFOLIA* FRESH LEAF MULCH FOR WEED CONTROL IN CUCUMBER (*Cucumis sativus* L.)

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ABSTRACT

Tithonia diversifolia has been recognized for its herbicidal properties of inhibiting weed growth. A field experiment was conducted in 2023 cropping season at the Organic Skill Acquisition Demonstration Plot, Federal University of Agriculture, Abeokuta, Nigeria to evaluate the effect three levels (2.0, 4.0 and 6.0 t/ha) of fresh leaf mulch *Tithonia diversifolia* on weed control in cucumber; hoe-weeding (HW) and weedy check (WC) were included as controls. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replicates. The results showed that plots treated with 4.0 t/ha produced the lowest weed dry matter from 2 to 8 WAP and this was significantly higher than 2.0 t/ha and weedy plot. Similar result was obtained in weed density with 6.0 t/ha; however, significant effect was only observed at 2 WAP where weed density recorded with 6.0 t/ha was higher than the controls. Cucumber fruit length and girth obtained from the treated plots were similar to that of the HW while fruit fresh weight recorded in the both 2.0 and 6.0 t/ha were not significantly different from the HW. The application of the *T. diversifolia* fresh leaf mulch at 4 t/ha reduced weed dry matter than the HW while cucumber fruit fresh weight obtained in 6 t/ha was comparable to the maximum in HW.

Keywords: weed dry matter, weed density, fresh leaf mulch, *Tithonia diversifolia*, cucumber

INTRODUCTION

Tithonia diversifolia (Hemsl.) A. Gray commonly known as Mexican sun flower or tree marigold in the family Asteraceae) is an annual weed growing luxuriantly and aggressively along road side, abandoned and cultivated farmlands especially in South Western Nigeria [1, 2]. Earlier research works have focused on the use of *T. diversifolia* for animal feed [3] and soil improvement [4] very little is known on its use as a mulch material for weed control in crops. Mulch materials weather in the fresh or dry form have the ability to cast shade on the weeds thereby preventing sunlight from reaching the weeds for photosynthesis thus preventing growth especially when applied at reasonable rates [5, 6]. Past studies have shown that *Tithonia diversifolia* deteriorates easily when placed on soil surface as green manure and also increased the yield of yam when applied at 7.5 t/ha [7, 8]. This research was proposed to identify the potential efficacy of *T. diversifolia* fresh leaf mulch in managing weeds in cucumber plot. Understanding the dynamics of this natural mulch's impact on weed growth in cucumber fields can provide valuable insights into developing sustainable, organic, and cost-effective weed control strategies. Therefore, this present study was designed to evaluate different rates of *T. diversifolia* fresh leaf mulch for weed suppression in cucumber before it decays.

MATERIALS AND METHODS

The experiment was carried out at the Organic Skill Acquisition Demonstration Plot ((07° 2.34'N 03° 3.44'E) at the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria between August and October in 2023 late cropping season. Cucumber variety F1 TOKYO used for the experiment was sourced from a local market at Abeokuta. The experiment consisted of three rates (2.0, 4.0, and 6.0 t/ha) of *T. diversifolia* fresh leaf mulch with hoe weeding and weedy as controls. The experiment was laid out in a randomized complete block design with three replicates. Land was ploughed and harrowed after which five beds, each at 2m × 2m size were made per replicate with 0.5m spacing between each bed. Cucumber seeds were sown at 2 seeds per hole at a spacing of 0.75m × 0.25m. *T. diversifolia* fresh leaves were weighed on a measuring scale (Goat head) and spread evenly with hand to cover the surface of each bed. Insect pests were controlled with the application of solution made from the leaves of Eucalyptus. Data were collected at 2, 4, 6, 8 WAP and at harvest. Weed parameters were determined using a quadrat of 0.5m × 0.5m placed twice randomly on each bed, weeds within the quadrats were counted by species for weed density while weed samples were oven dried at 48°C for three days and weighed to constant weight to compute weed dry matter.

Cucumber number of leaves was determined by counting the leaves on a plant per plot while vine length, fruit length and fruit girth were determined using meter rule and harvested fruits from each plot were weighed fresh on a sensitive weighing balance. Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using LSD at 5% probability level.

RESULTS AND DISCUSSION

Application of *T. diversifolia* leaf mulch at 4.0 t/ha produced the lowest weed dry matter from 2 to 8 WAP, and this was significantly higher than 2.0 t/ha treatment and weedy plot (Table 1). Similar result was obtained in weed density with the application of the leaf mulch at 6.0 t/ha, however, significant effect was only observed at 2 WAP where weed density recorded with the application of 6.0 t/ha of the leaf mulch was higher than the controls (Table 1). This could probably be because of allelopathic properties of *Tithonia diversifolia*, which was earlier reported to contain secondary metabolites, including sesquiterpene, lactones and flavonoids that inhibited weed germination and growth (9, 10). Cucumber fruit length and girth obtained from the treated plots were similar to that of the HW while fruit fresh weight recorded in both 2.0 and 6.0 t/ha treatments were not significantly different from the maximum obtained in HW (Table 2). The application of the *T. diversifolia* fresh leaf mulch at 4 t/ha reduced weed dry matter than the HW while cucumber fruit fresh weight obtained in 6 t/ha was comparable to the maximum in HW. These observations however need further investigation.

Table 1: Effect of *Tithonia diversifolia* fresh leaf mulch on weed density (no/plot) and weed dry matter (g/plot) in 2019 cropping season at Abeokuta

Treatments	Weed density (no/plot)				Weed dry matter (g/plot)			
Mulch t/ha	2 WAP	4 WAP	6 WAP	8 WAP	2 WAP	4 WAP	6 WAP	8 WAP
2.0	11	22	28	33	0.63	23.1	44.7	25.9
4.0	11	18	20	30	0.14	5.4	11.6	17.1
6.0	8	15	18	20	0.3	8.9	53.2	21.9
HW	14	30	35	23	0.63	5.8	14.8	15.6
WD	17	31.7	20	26	0.7	52.3	100	53.9
LSD	3.27	Ns	Ns	Ns	0.358	18.55	67.46	29.13

HW = Hoe Weeding

WD = Weedy

WAP = Weeks after planting

t/ha = tons per hectare

Table 2: Effect of *Tithonia diversifolia* fresh leaf mulch on the yield and yield components of cucumber in 2019 cropping season at Abeokuta

Treatments Leaf mulch (t/ha)	Cucumber yield and yield components			
	Fruit girth (cm)	Fruit length (cm)	Fruit fresh weight (g/plot)	
0.02	6.37	7.43	225	
0.04	4.00	7.77	153	
0.06	6.07	7.47	249	
HW	8.07	8.07	293	
WD	2.37	2.37	70	
LSD	4.309	3.347	132.1	

HW = Hoe Weeding

WD = Weedy

WAP = Weeks after planting

t/ha = tons per hectare

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EVALUATION OF NUTRITIONAL QUALITY OF CO-FERMENTED RICE (*Oryza sativa*) AND PAKALA (*Phaseolus lunatus*) AS INFANT COMPLEMENTARY FOOD

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ABSTRACT

A major health challenge affecting infant in developing countries is protein energy malnutrition. This research aims to evaluate the nutritional quality of co-fermented rice (*Oryza sativa*) and *pakala* (*Phaseolus lunatus*) as infant complementary food. The local rice (*Igbemo*) and *pakala* were obtained from Oja-Oba local market, while the infant formula which serve as control, was bought from the superstore in Ado Ekiti. Seeds of the staples were prepared and allowed to co-ferment in 70:30 and 90:10 proportions at different periods of 24, 48, 72 and 120 hours respectively. The plant samples were analyzed for proximate and essential amino acids profile using standard procedures. The results showed that the ash and moisture contents were significantly ($p < 0.05$) higher than values in the infant formula. On the other hand, levels of crude fat, crude fiber and energy were significantly ($p < 0.05$) lower than those in commercially produced CF. Formulated CF of 70:30 composition had higher levels of essential amino acids. CF 6 had the best general acceptability among them, followed by CF 4. In conclusion, Co-fermentation of staples such as local rice and *pakala* in 70:30 formulation can be adopted for economic production of nutritious complementary food for infant and children.

Key words: Co-fermentation, Complementary food, Infant, Local rice, *Pakala*

INTRODUCTION

One of the major health challenges affecting infant in developing countries is protein energy malnutrition, which occur during weaning. As reported, exclusive breast feeding is usually inadequate to provide for the nutritional demand of the growing infant after six months of age, because at this time, the child is undergoing rapid growth, physiological maturation and development [1]. Hence, there is need to introduce other foods that is nutrient-dense, and of adequate consistency, digestible and acceptable to the infant alongside breast milk [2]. Protein Energy Malnutrition incidence is prevalent based on the fact that about 40% of the Nigeria population live below poverty line, and cannot afford commercial weaning foods for their infant [3]. Also, traditional weaning foods of infant consist fermented mono cereal grain into gruel referred to as akamu or ogi, lack adequate required nutrients and of poor quality and hence risk factor for childhood mortality and morbidity in developing countries [4]. Among concerned major international and national organizations the United Nations system standing committee on nutrition (SCN), suggested effort to mitigate malnutrition such as formulation of traditional complementary food with accessible and affordable non defective and nutritious staples using cheapest traditional processing methods- fermentation, for low income mothers which infant formula is out of their financial reach [5]. Fermentation has been reported efficient to improve health benefits, quality and nutrients bioavailability in food [6]. Therefore, this study evaluated the nutritional quality of co-fermented rice (*Oryza sativa*) and *pakala* (*Phaseolus lunatus*) as infant complementary food.

MATERIALS AND METHODS

Experimental Procedures

Local staples and infant formula were purchased from local market in Oja-Oba local market. Staples were sorted and cleansed to remove dirt and extraneous materials. The weaning food blends formed with *Igbemo* rice and *pakala* in the proportions of 90:10 and 70:30 was co-fermented at 26°C for 24, 48, 72 and 120 hours respectively. Thereafter, samples were thoroughly washed and drained in 1.0 mm mesh sieve; *pakala* was sorted out and dehulled. The dehulled co-fermented *pakala* and *Igbemo* rice were dried to constant weight, pulverized using a hammer mill, sieved and stored in an airtight container. Proximate composition (moisture, ash, crude fat, protein and crude fiber) was determined in accordance with the AOAC methods [7].

Carbohydrate was determined by difference. Essential amino acids profile was determined with waters acquity ultra-high performance liquid chromatography (UHPLC) with H-class and H-class Bio Amino Acid Analysis Systems. Sensory evaluation of the formulated CFs was conducted using a 20 semi-trained panelist comprising of nursing mothers of children at the PHC, Ido, Ekiti State. A nine-point hedonic scale was used to evaluate the CFs for colour, texture, taste, aroma and general acceptability. To each of the panelists, clean water was provided to rinse their mouth in between testing of the food samples to avoid residual effect.

Data generated from the samples' chemical analysis were subjected to analysis of variance (ANOVA) using statistical product and service solutions (SPSS) version 20. The means were separated, and statistical significance was considered at $p < 0.05$.

RESULTS AND DISCUSSION

The proximate content of the CFs was analyzed (Table 1). The ash (3.49-5.26%) and moisture (4.10-7.10%) contents of the formulated CFs were significantly ($p < 0.05$) higher than those of the commercially distributed CF. The crude protein (8.12-20.33%) and carbohydrate (54.23-72.47%) on another hand were comparable with those of commercial CF. However, the crude fat (1.10-2.20%) and energy (318.03-340.45Kcal/100g) of the formulated CFs were significantly ($p < 0.05$) lower than those of commercial CF.

The moisture content obtained in this study were higher compared to that of the commercially distributed CF, the reason for this might be attributed to addition of water during preparation and prolong duration of fermentation [5]. However, the values were within acceptable limit of $>10\%$ for infant complementary foods for a prolonged shelf life and quality of food product [8].

Increase in crude protein in CFs 2, 4, 6 and 8 in 70:30 blends of local rice and lima beans could be attributed to incorporation of more lima beans in the preparation. This trend was similarly reflected in the levels of essential amino acids obtained from these CFs compared with others that have 90:10 composition of local rice and lima beans. Adequate protein nutrient is required in infants and children to serve as antibodies, energy reserve, build and repair body tissue, cell repair and body growth and development [10]. Infant diets deficient in protein predispose infant to symptoms such as kwashiorkor-marasmus form of malnutrition [6]. There is significant ($p < 0.05$) increase in crude fat of the formulated CFs as the fermentation time increased is in agreement with [5]. It is likely that the increased carbohydrate content of the CF might have been used by the fermenting microflora during fermentation process and the limited fat available could be due to increase activities of lipolytic enzyme [6]. Dietary fats is important in the CF of older infant and young children for energy, absorption fat soluble vitamins, enhancement of sensory qualities of the CFs, growth, immune function and child development [1]. The value of fat obtained in this study is lower than the RDA value for older infants of 9-11 months (3%) and young children of 12-23 months (9%) [9]. Thus, it may be helpful to adopt processing with reduced fermentation time and addition of milk to the food before feeding the infants and young children.

The levels of amino acids in the formulated CFs analyzed are presented in Table 2. The levels of amino acids are higher in formulated CFs 2, 4, 6 and 8, which had 70:30 proportion of local rice and lima beans, compared with others, which had 90:10 proportion of local rice and lima beans.

There are nine essential amino acids that cannot be synthesized in the body of the infants, hence are supplied in the CFs of infants and young children, and these include: phenylalanine, Valine, Threonine, Tryptophan, Methionine, Leucine, Isoleucine, Lysine, Histidine [10]. Essential amino acids play vital roles in growth and development of infant and children ranging from formation of new muscles and tissues, enzymes and hormone synthesis and development of immune system. As observed in this research work CFs 2, 4, 6 and 8 in 70:30 blend is well enriched in essential amino acids (Table 2) which is in agreement with the previous report which might be attributed to incorporation of more legumes in the composition [10].

The details of sensory evaluation of the formulated CFs are presented in Table 3. CF 6 had the best general acceptability among them, followed by CF 4. The commercially distributed CF was better than all the formulated CFs.

The formulated CFs 4 and 6 with better general acceptability compared with others are recommended for consumption by infant and children at aged 6-23 months. However addition of sweetener and milk are suggested to improve the acceptability and nutritional value of the Complementary food to the consumers.

CONCLUSION

Complementary foods formulated from local rice and lima beans after co-fermentation is highly nutritious for the consumption by infants and young children. The blends with 70:30 local rice and lima beans are strongly recommended to mothers, especially the CF 4 and 6 for their infants and young children nourishment. Milk and sweetener can be added to enhance the nutritional quality of the CFs.

Table 1: Effects of Fermentation on percentage Proximate Composition of Formulated CFs

CF	Ash%	Moisture Content %	Crude Protein %	Crude Fat %	Crude Fiber %	% CHO by diff.	Energy Kcal/100g
1	5.12 ^a	4.10 ^e	10.52 ^d	1.02 ^c	4.53 ^e	71.56 ^a	330.00 ^a
2	5.11 ^a	4.45 ^e	8.12 ^e	1.04 ^c	5.40 ^{de}	2.47 ^a	338.00 ^a
3	5.10 ^a	4.72 ^e	11.18 ^d	1.01 ^c	7.07 ^c	70.93 ^a	337.54 ^a
4	5.26 ^a	7.10 ^a	14.58 ^{bc}	1.46 ^b	7.89 ^c	63.71 ^c	326.28 ^b
5	5.01 ^a	5.04 ^{cd}	12.48 ^{cd}	1.19 ^c	10.38 ^b	65.90 ^{bc}	324.20 ^b
6	3.96 ^c	5.25 ^{bc}	15.22 ^b	1.09 ^c	7.90 ^c	66.93 ^b	338.38 ^a
7	4.39 ^b	7.10 ^a	20.33 ^a	2.20 ^a	11.67 ^a	54.23 ^d	318.03 ^c
8	3.49 ^d	5.42 ^b	15.21 ^b	1.42 ^b	7.96 ^c	66.70 ^b	340.45 ^a
CONTROL	2.50	4.00	15.00	8.30	16.8	68.10	412.00

Note: Values represent means (n = 3); mean values with the same alphabet as superscript across column indicated CF with no significant difference at $p < 0.05$; Control – Commercially distributed complementary food (CF)

CF 1 – 90% local rice and 10% lima bean, 24 hours co -fermented; CF 2 – 70% local rice and 30% lima bean, 24 hours co -fermented; CF 3 – 90% local rice and 10% lima bean, 48 hours co -fermented; CF 4 – 70% local rice and 30% lima bean, 48 hours co-fermented; CF 5 – 90% local rice and 10% lima bean, 72 hours co -fermented; CF 6 – 70% local rice and 30% lima bean, 72 hours co-fermented; CF 7 – 90% local rice and 10% lima bean, 120 hours co -fermented; CF 8 – 70% local rice and 30% lima bean, 120 hours co -fermented.

Table 2: Effect of fermentation on essential amino acid profile of the formulated CFs (mg/100g)

Amino Acid	CF 1	CF 2	CF 3	CF 4	CF 5	CF 6	CF 7	CF 8
Phenylalanine	4.06	4.08	4.17	4.97	3.14	4.83	2.99	4.03
Valine	4.18	4.24	4.39	4.86	3.75	4.83	2.69	4.00
Threonine	2.20	2.25	2.34	2.79	2.22	2.64	1.89	2.23
Tryptophan	0.70	0.76	0.73	0.80	0.69	0.85	0.55	0.70
Methionine	2.10	2.23	2.17	2.25	1.89	2.24	1.71	2.06
Leucine	7.00	7.22	7.14	7.66	6.48	7.36	5.69	6.42
Isoleucine	2.80	2.95	2.94	3.30	2.64	3.31	1.84	2.42
Lysine	3.20	3.31	3.29	4.11	3.10	3.87	2.40	3.10
Histidine	3.45	3.57	3.72	4.04	2.75	3.88	1.91	3.34

Note: Values represent means (n = 2); mean values with the same alphabet as superscript across column indicated CF with no significant difference at $p < 0.05$; CF – Complementary food

CF 1 – 90% local rice and 10% lima bean, 24 hours co -fermented; CF 2 – 70% local rice and 30% lima bean, 24 hours co -fermented; CF 3 – 90% local rice and 10% lima bean, 48 hours co -fermented; CF 4 – 70% local rice and 30% lima bean, 48 hours co-fermented; CF 5 – 90% local rice and 10% lima bean, 72 hours co -fermented; CF 6 – 70% local rice and 30% lima bean, 72 hours co-fermented; CF 7 – 90% local rice and 10% lima bean, 120 hours co -fermented; CF 8 – 70% local rice and 30% lima bean, 120 hours co -fermented.

Table 3: Sensory Evaluation of Formulated CFs

CF	Colour	Texture	Taste	Aroma	General Acceptability
1	5.02	4.25	4.20	4.25	4.15
2	5.04	4.80	4.40	4.30	4.80
3	4.56	4.64	4.28	4.16	4.60
4	6.04	5.80	5.04	5.66	5.82
5	5.56	5.48	4.92	5.60	5.80
6	6.08	5.68	5.28	5.92	6.40
7	5.08	5.20	4.96	5.00	5.12
8	5.12	5.16	5.00	5.12	5.12
CONTROL	7.20	7.64	7.24	7.17	7.56

Note: Values represent means (n = 20); Control – Commercially distributed complementary food (CF)

CF 1 – 90% local rice and 10% lima bean, 24 hours co -fermented; CF 2 – 70% local rice and 30% lima bean, 24 hours co -fermented; CF 3 – 90% local rice and 10% lima bean, 48 hours co -fermented; CF 4 – 70% local rice and 30% lima bean, 48 hours co-fermented; CF 5 – 90% local rice and 10% lima bean, 72 hours co -fermented; CF 6 – 70% local rice and 30% lima bean, 72 hours co-fermented; CF 7 – 90% local rice and 10% lima bean, 120 hours co -fermented; CF 8 – 70% local rice and 30% lima bean, 120 hours co - fermented.

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TRENDS OF CATTLE AND CHICKEN MANURE UTILIZATION IN NIGERIA (1961-2021)

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ABSTRACT

The study analysed the trend of cattle and chicken manure utilization in Nigeria (1961-2021). The specific objectives were to assess the trend of manure utilization in Nigeria between 1961-2021, examine the cumulative and instantaneous growth in cattle and chicken manure utilization in Nigeria during the period and forecast the consumption of cattle and chicken manure in Nigeria for future forecast. Data on cattle dairy, cattle non-dairy, chicken broiler, chicken layer manure utilization for growing crops were sourced from secondary sources only. The trends of manure utilization were analysed using Simple line graph, Growth in manure utilization was estimated using the dynamic ordinary least square technique while the compound interest formula was used to forecast future utilization. The result revealed a mixture of linear and quadratic trends for cattle manure utilization while chicken manure utilization experienced a higher utilization growth from the layer sources compared to the broiler; although both revealed a mixture of linear and quadratic trends. An instantaneous growth of 2.05% and 1.76% and a cumulative growth of 4.8% and 4.1% were recorded for cattle manure utilization from dairy and non-dairy sources respectively. While an instantaneous growth of 1.45% and 3.17% and cumulative growth of 3.4% and 7.6% were obtained for broiler and layer manure utilization. The study predicted an increase in cattle manure utilization to 17,631,092 kg and 16,975,131kg from dairy and non-dairy sources, and of 4,167,024.8 kg and 22, 207, 680 kg from broiler and layer sources respectively by the year 2031. The study concluded that manure utilization in Nigeria has been on the increase but chicken manure is being utilized more compared to cattle manure.

Keywords: Utilization Trend, Manure Sources, Instantaneous Growth and Cumulative Growth

INTRODUCTION

Manures are usually such soil enhancement additives incorporated into soils in order to improve their fertility. In the past few decades, chemical fertilizers (inorganic manures) have been used widely the world over. In Nigeria, government continues to make provision for fertilizer disbursement to farmers yearly. However, it is now known that in fields under intensive monoculture with only heavy applications of inorganic fertilizers, gradual decline in farm output [1] take place. Over time, soils treated only with synthetic chemical fertilizers lose organic matter and the all-important living organisms that help to build quality soil. As soil structure declines and water-holding capacity diminishes, more and more of the chemical fertilizer applied will leach through the soil. In turn, it will take ever-increasing amounts of chemicals to stimulate plant growth. However, the use of organic fertilizers helps to avoid this condition. The manufacturing process of most chemical fertilizers depend on non-renewable resources, such as coal and natural gas. Others are made by treating rock minerals with acids to make them more soluble. Fortunately, there are more and more truly organic fertilizers coming into the market. These products are made from natural plant and animal materials or from mined rock minerals. Applications of nitrogenous fertilizers like Ammonium tetra-oxo sulphate VI and Ammonium tri-oxo nitrate V usually result in the release of greenhouse gases like nitrogen II oxide (N_2O) and ammonia (NH_3). Apart from providing nitrogen, ammonia also cause soil-acidity when it undergoes soil reaction, excessive nitrogen fertilizer application can lead to pest problems by increasing the birth rate, longevity and overall fitness of certain pests [2].

However, organic fertilizer mixtures can be as convenient and effective as synthetic fertilizers such as cattle manure which is a potential source of nutrients and benefit to soil amelioration especially for communal farmers who cannot afford fertilizers. However, getting the maximum value out of manure requires applying it at proper rates and frequency in conjunction to particular soils [3]. Another benefit from increased use of organic materials is that it helps to ameliorate pollution problems caused by agro-industrial wastes. Despite these advantages of organic fertilizers, its utilization in Nigeria has been limited due to bulky nature and relative scarcity. This study seeks to analyse the trend of manure utilization in Nigeria (1961-2021) with specific emphasis on;

- i. The trend of manure utilization in Nigeria between 1961-2021
- ii. The cumulative and instantaneous growth in cattle and chicken manure utilization in Nigeria
- iii. Forecasting the consumption of cattle and chicken manure in Nigeria

Materials and Methods

Data Collection Technique

Data collected for this research were from secondary sources only. Data on cattle dairy, non-dairy cattle, chicken broiler and chicken layer manure utilization were obtained from the Food and Agriculture Organisation (FAO) of the United Nations online site.

Trend Analysis Model

Following [4, 5, 6], the compound interest formula was applied to the problem of cattle and chicken manure utilization in Nigeria.

MATERIALS AND METHODS

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Following [4, 5, 6], the compound interest formula was applied to the problem of cattle and chicken manure utilization in Nigeria.

$$Y_t = Y_0(1+r)^t \dots\dots\dots (1)$$

Where;

Y_t = Quantity of cattle and chicken manure utilized in year t

Y_0 = amount of cattle and chicken manure utilized in the base year

r = compound rate of growth of Y

t = time in chronological years

Taking the natural log of equation (1) to make it linear, it becomes:

$$\ln Y_t = \ln Y_0 + t \ln (1+r) \dots\dots\dots (2)$$

Substituting $\ln Y_0$ with β_1 and $\ln (1+r)$ with β_2 , equation (2) can be rewritten as:

$$\ln Y_t = \beta_1 + \beta_2 t \dots\dots\dots (3)$$

By adding the disturbance term to equation (3) we obtain:

$$\ln Y_t = \beta_1 + \beta_2 t + \mu t \dots\dots\dots (4)$$

Equation (4) is the growth rate model developed for this study. A semi-log growth rate model was developed for this study instead of a linear trend model because the point of interest in this study is both absolute and relative change in the parameters of interest. The most important parameter in equation (4) is the coefficient of β_2 . This is the coefficient of the slope which measures the constant proportional or relative change in Y for a given absolute change in the value of the regressor t . Multiplying β_2 by 100 gives the instantaneous growth rate at any point in time.

$$IGR = b_2 \times 100 \dots\dots\dots (5)$$

Where IGR = Instantaneous growth rate

b_2 = is the least-square estimate of the coefficient of the slope β_2 , then taking the antilog of b_2 and subtracting 1 from it and then multiplying the difference by 100 will give the compound growth rate (CGR) over a period of time.

$$CGR = [\text{antilog } b_2 - 1] \times 100 \dots\dots\dots (6)$$

If the coefficient b_2 is positive and statistically significant or negative and statistically significant, there is acceleration or deceleration in growth process, respectively. If b_2 is not statistically significant there is stagnation in the growth process.

The linear trend analysis model with the form $Q = b_0 + b_1 T + e$ and the quadratic model with the form $Q = b_0 + b_1 T + b_2 T^2 + e$ was also tested but did not demonstrate the best fit.

RESULTS AND DISCUSSION

Trend of Manure Utilization in Nigeria

The trend of cattle and chicken manure utilized in Nigeria between 1961 and 2021 is presented in figure 1 and 2 below. The trend of cattle manure utilization from dairy cattle witnessed a linear trend from 1961 till 1996 when it sharply declined before continuing with the linear trend until 2005 and then sharply declining to 2006 and this kept fluctuating till 2012 before achieving a linear trend until 2021. Similarly, manure from cattle non-dairy source also witnessed linear growth from 1961 until 1994 after which the utilization decreased slightly and kept oscillating till 2010 before experiencing a sharp increase to 2011 and this increase continued in a linear form until 2021.

The utilization of manure from meat-type chicken in Nigeria witnessed a linear growth from 1961 until 1989 before witnessing a quadratic growth until 1997 having its deep in 1994. This further witnessed another quadratic growth until 2010 with a deep in year 2000 which implies that the minimal utilization within this quadratic growth period was in year 2000. Another quadratic growth was also witnessed between 2010 and 2017 with its minimal deep in year in 2014 before further declining till 2021.

The utilization of manure from egg-type chicken also witnessed an initial increase from 1961 until 1987 before decreasing sharply until 1989 and further increasing linearly until 1994 and sharply decreasing to about 6million kg in 1997. This linear growth was further witnessed until 2014 before decreasing between 2014 and 2015 and the growth kept oscillating until 2021.

Result of Dynamic Ordinary Least Square (DOLS) Technique for trend Analysis

The cumulative and instantaneous growth in cattle manure utilization was achieved using the Ordinary Least Square technique. The linear functional form revealed best fit with R-square value of 94.38% and 92.56% for cattle manure utilized from the dairy and non-dairy sources respectively. This implies that variations in the dependent variables are explained by 94.38% and 92.56% of variations in the trend. An instantaneous growth of 2.05% and 1.76% were recorded for the various cattle manure sources respectively. Similarly, the cumulative growth of 4.8% and 4.1% accounted for manure utilization sourced from dairy and non-dairy cattle sources. This increment in cattle manure usage should be due to its large adoption by farmers and this is in consonance with [7] who noted that use of cattle manure significantly increases productivity of maize.

The utilization of broiler and layer chicken manure accounted for an R-square of 38.36% and 93.83% respectively for the linear functional form which implies is the best fit for the study. An instantaneous growth of 1.45% and 3.17% were recovered for both sources over the years. Similarly, cumulative growth rates of 3.4% and 7.6% were recorded for both sources respectively. This implies that there has been considerable increase in the utilization of chicken manure over the years compared to other animal sources; and this could be due to various advocacies for increased adoption of organic fertilizer use, which is more environmentally friendly compared to the inorganic forms. This is in agreement with [8] who noted that the need for utilization of poultry manure has overtaken that of other crops.

Forecast of Manure Utilization

The Study forecasted an increase in cattle manure utilization to 17,631,092 kg and 16,975,131kg in dairy and non-dairy sources respectively by the year 2031. This implies a higher growth from the dairy sources than the non-dairy sources. This could be because dairy cattle are well fed and do not roam about hence more manure could be obtained for agricultural utilization unlike in the non-dairy sources.

Similarly, a forecast of chicken manure utilization of 4,167,024.8kg and 22,207,680kg from broiler and layer sources respectively by the year 2031. This implies a higher growth from the layers compared to the broilers which may be because layers are kept for longer period of time and hence more manure could be received from them.

CONCLUSION

The manure utilization in Nigeria has been on the increase but chicken manure was being utilized more compared to cattle manure. Farmers could practice intensive systems such as ranching of cattle to make manure more available for agricultural uses. Higher awareness on the importance of organic manure compared to inorganic sources should be engaged to promote the adoption of organic fertilizer in Nigeria.

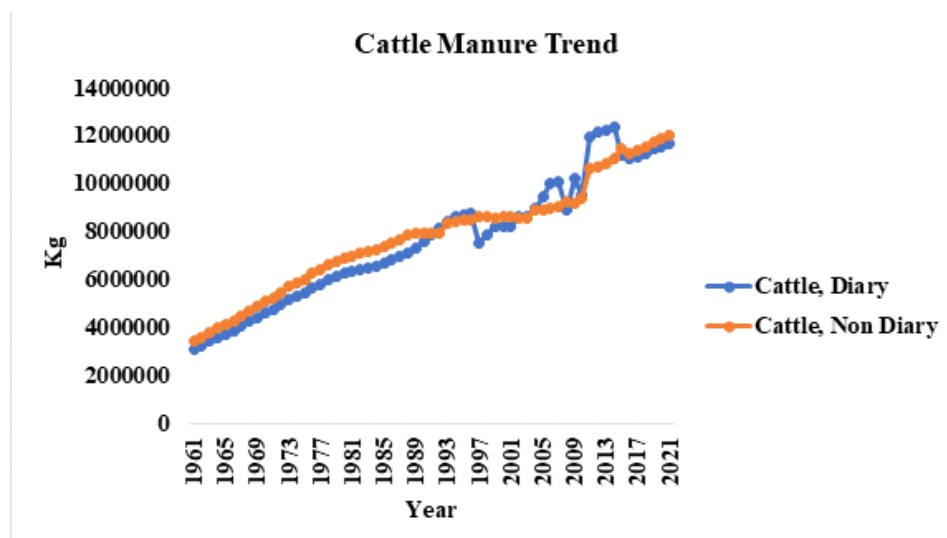


Figure 1: Trend of Cattle manure utilization in Nigeria

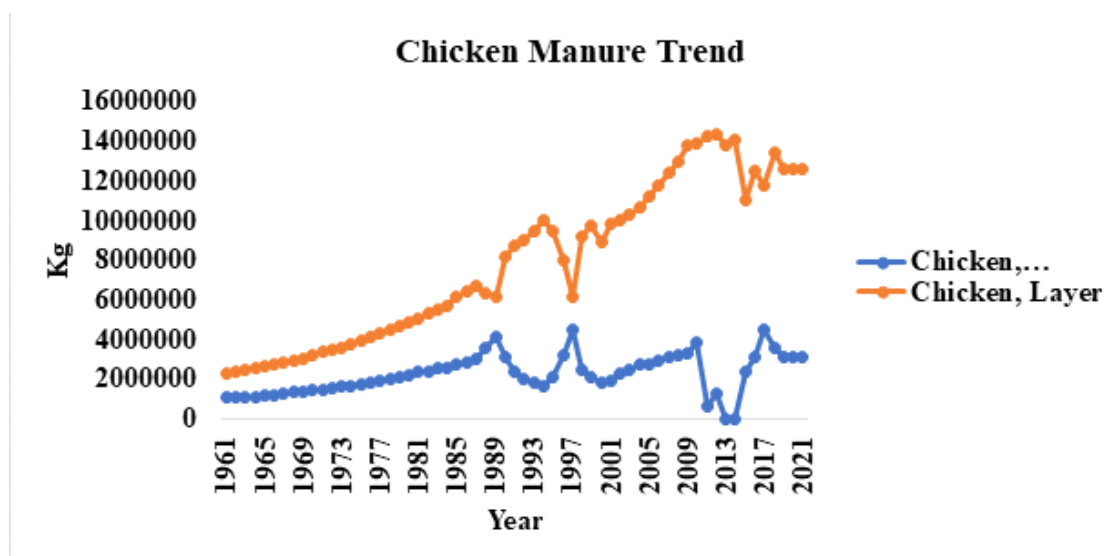


Figure 2: Trend of Chicken manure utilization in Nigeria

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THE PARADIGM SHIFT IN SUSTAINABLE AGRICULTURE: INTEGRATING CONSERVATION PRACTICES IN ORGANIC FARMING (A REVIEW)

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ABSTRACT

This paper investigates the adoptable changes in sustainable agriculture, with a specific focus on incorporating conservation methods in organic farming. The study looked into the framework of evolving conservation practices in organic farming. Analyzing a thorough literature review on sustainable agriculture, encompassing research on conventional/traditional, conservation, and organic methods, this study combines findings to grasp the transformation of the paradigm. In the past, traditional farming methods were common, but worries about their impact on the environment and their sustainability have caused a move towards organic practices. The research investigates the reasons for implementing conservation methods in organic agriculture, the barriers faced, and the possible advantages of making the shift, while promoting sustainable agriculture. The study recommends that in order to take advantage of incorporating conservation practices in organic farming, various stakeholders in the agricultural sector, agricultural organizations, and policymakers need to focus on providing training programs for farmers to educate them on the latest research and innovations in conservation agricultural practices within organic farming. In conclusion the importance awareness creation becomes paramount to educate both farmers and customers about the advantages of organic practices and the lifestyle of consuming organic products, respectively.

Keywords: Conceptual Framework, Conservation Practices, Organic Farming, Sustainable Agriculture

INTRODUCTION

With the projected increase in the global population to reach 9 billion by 2050, there will be a greater demand on the agricultural industry [1]. Sustainable agriculture offers a practical option that seeks to fulfill food needs while also safeguarding ecosystems, rural economies, and overall societal welfare [2]. It plays a leading role in tackling worldwide worries related to food production, environmental effects, and the health of ecosystems in the long term. Conventional agricultural methods have been the foundation of worldwide food production for many years. Yet, the growing environmental issues and the necessity for strong farming methods have caused a change in thinking towards organic techniques [3]. Hitherto, traditional farming has relied heavily on the extensive application of artificial fertilizers with its attendant detriment effects on the environment.

Conservation agriculture mainly aims at preserving the soil and minimizing soil disturbances, whereas organic farming has a wider focus on limiting synthetic inputs and maintaining ecological balance [4]. Conservation farming techniques enhance soil health while reducing nitrogen and green-house gas emissions to a minimum [5]. This research aims to develop a conceptual framework to examine how conservation farming methods contribute to sustainable agricultural productivity by specifically examining the transition from traditional to organic practices. By examining drives/motivational factors, barriers, and rewards/benefits, the study aims to enhance the framework for a comprehensive changing environment in sustainable farming.

Incorporating Conservation Practices in Organic Farming

It is essential to understand conservation practices in organic farming in order to promote sustainable agriculture. Figure 1 shows that farmers are motivated to improve environmental

stewardship, biodiversity, and soil health in organic farming systems by incorporating conservation practices. This all-encompassing method has potential outcomes for the future, offering strong ecosystems, enhanced human well-being, and financial success. Advantages consist of decreased chemical residues in food, improved soil fertility, and entry to high-end markets. Nevertheless, obstacles like start-up expenses and lack of expertise need to be overcome in order to fully utilize the benefits of conservation methods in organic agriculture.

Need for Incorporating Conservation Methods in Organic Farming

The transition from traditional to organic methods in agriculture is a significant change driven by various factors like environmental and health concerns, as well as a growing consumer desire for organic products. (Fig. 1). This change represents a dedication to growing agricultural produce in alignment with the environment, highlighting sustainable methods that support ecological strength, protect human well-being, and cater to a more mindful customer base.

The shift towards sustainable agriculture is driven by a common understanding of the limitations and negative impacts associated with conventional farming methods. Studies [6,7] have shown that environmental issues such as ozone layer depletion, climate change, erosion, soil degradation, water pollution, and biodiversity loss, have led to a reevaluation of farming practices. The wish to reduce these environmental effects, along with concerns for health, has driven farmers and policymakers to explore different methods based on their sustainability.

Economic factors also play a role in the reasons for shifting to sustainable farming practices. Despite the upfront expenses and difficulties that may arise, the possibility of sustainable economic success in the long run, increased market potential, and decreased dependence on costly resources appear as strong motivators. The main goal is to establish a supportive atmosphere for implementing sustainable agricultural methods.

It is crucial to include conservation practices in organic farming for sustainable agriculture. Organic farming aims to reduce the use of synthetic inputs, while incorporating conservation practices can further improve its ecological influence. Actions like rotating crops, planting cover crops, and minimizing tillage help improve soil quality, diversify ecosystems, and conserve water. This integration supports environmental stewardship and enhances the sustainability of organic farming systems by promoting resilient ecosystems and reducing environmental degradation linked to conventional agriculture.

4. Anticipated Developments in Sustainable Agriculture: Future Prospects and Trends

As the world strives for sustainable and resilient food systems, the future of agriculture is shaped by technological advancements, environmental awareness, and changing conditions [8]. Precision agriculture optimizes resource use, while agro-ecology and regenerative practices emphasize biodiversity and soil health [9]. These solutions offer eco-friendly pest management, and digital technologies that enhance efficiency. Anticipated shifts towards circular food systems, climate-resilient crops, and soil health underscore a promising future for sustainable farming.

5. Challenges in Implementing Conservation practices in Organic farming

Transitioning to conservation practices within organic farming presents hurdles for farmers, notably the economic burden [10]. Organic methods demand substantial upfront investments and higher ongoing costs, including pricey organic inputs and certification fees. The transition period from conventional to organic practices brings reduced yields and vulnerability to pests. Addressing these issues requires educational initiatives, training programs, and infrastructure investments facilitated by agricultural institutions and research organizations.

Moreover, successful implementation of conservation practices relies heavily on knowledge and expertise. There exists a wide range of knowledge gaps in the farming techniques, controlling pests, and maintaining soil fertility for organic farmers. Insufficient information and direction can hinder the implementation of optimal practices, leading to less than ideal results during the transition into organic farming.

Furthermore, infrastructure challenges play a pivotal role in the adoption of conservation practices within organic farming. Conventional farming infrastructure, optimized for industrial agriculture needs, may not align with organic cultivation methods. This requires making changes to infrastructure, like irrigation systems and storage facilities, in order to meet the needs of conservation-minded farming practices.

6. Possible advantages of adopting conservation practices in organic agriculture

The shift from traditional to organic farming methods offers various advantages in terms of environmental sustainability, human health, and economic prosperity. Organic farming focuses on natural methods, shunning artificial pesticides and fertilizers while enhancing biodiversity and soil fertility. Techniques such as crop rotation and agroforestry help protect and improve soil quality by decreasing the amount of chemicals flowing into water sources. Moving towards organic methods decreases the presence of artificial chemicals in food, decreasing health hazards and providing increased nutritional benefits. Although there may be higher upfront expenses, organic farming shows economic feasibility in the future, due to the higher prices and increasing consumer interest in organic products. Access to specialized markets and potential for exporting also improve economic outlook. In general, organic farming provides a hopeful route to a future that is more resilient, health-oriented, and economically sustainable.

7. Conclusion and Recommendation

In summary, the extensive advantages of adopting conservation practices in organic agriculture cover various aspects such as environmental sustainability, human well-being, economic sustainability, and market prospects. Organic farming provides a hopeful route to a sustainable future, emphasizing biodiversity, soil health, and natural processes in line with environmental stewardship and social responsibility principles. The study recommends that policymakers, agricultural institutions, and stakeholders need to focus on investing in education and training programs for farmers, supporting research and innovation projects specifically for organic farming, and enhancing policy measures.

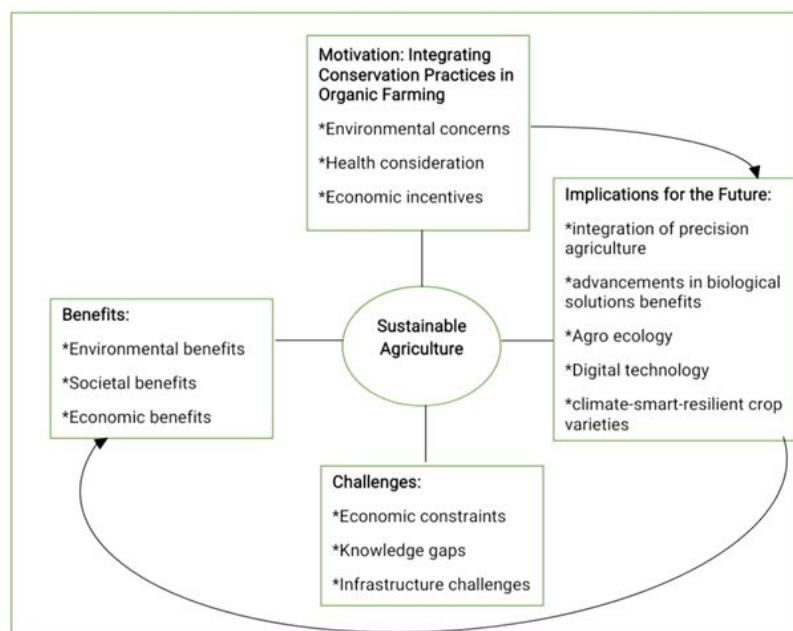


Figure 1: Conceptualizing Conservation Practices in Organic Farming

Source: Author (2024)

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INFLUENCE OF PLANT SPACING AND MANURE APPLICATION RATES ON GROWTH AND YIELD OF CABBAGE (*Brassica oleracea* var. *capitata*)

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ABSTRACT

Cabbage (*Brassica oleracea*) is an important vegetable crop cultivated worldwide, valued for its nutritional content and culinary versatility. Despite the potential benefits of organic manure application in cabbage production, the optimal application rate that maximizes crop performance remains uncertain. Our experiments at the Federal University Oye-Ekiti, Ekiti State, Nigeria, was conducted to determine the effect of plant spacing and organic manure application rates on growth and yield of cabbage. The results showed that except in the plant height and canopy spread wider spacing did not significantly affect plant growth. The plant height showed significant difference among the manure treated plants as there was significantly taller plant height, stem height, number of leaves for the plants that received 15t/ha compared to those treated with 10t/ha while the control (no manure application) had significantly lower growth responses. The growth of cabbage observed by the bigger ball heads showed the height and width of ball head, as the main growth parameters contributing to the yield quality of the produce. However, at the final harvest significantly heavier fresh weights though not different from 10t/ha was observed compared to the lower yield observed for the control. In conclusion, cultivation of cabbage at 50 cm x 40 cm spacing and application of 15 t/ha was observed as optimum for maximum growth and yield of cabbage.

Keywords: cabbage, pacing methods, manure application rates, growth response

INTRODUCTION

Cabbage, a widely consumed vegetable belonging to the cole crop family, the Brassicaceae family, has a long history of global cultivation due to its nutritional richness [1, 2, 3, 4]. The edible part, known as the ball head, consists of compacted layers of leaves with diverse sizes, colors, and textures. Recognized for its anti-inflammatory properties, immune-boosting effects, and promotion of healthy digestion, cabbage is prepared in various ways, including stewing, shredding, steaming, pickling, fermenting, boiling, sautéing, or being consumed raw [5]. Cabbage has been domesticated for approximately 2000 years [6]. It is a multi-layered vegetable predominantly cultivated in India, China, North America, and certain African regions like Malaysia, Tanzania, and Nigeria [7]. In Nigeria, cabbage is a common crop, consumed both raw and cooked for its vitamin and mineral content [2]. Global production of cabbages was estimated at 21.8 million tonnes, with China being the highest producer having 47% of the World total production. Other major producers include India with 9.0 million metric tonnes, Russia 3.5 million metric tonnes. However, in Nigeria cabbage is mostly cultivated in the Northern parts where cabbage production in 2016 grew from 2.7 million to 14.3 million tonnes [8].

Achieving healthy cabbage growth and yield necessitates the application of nutrients in the correct proportion [9]. The choice of manures in crop cultivation influences the nutritional output, with differences observed between organic manure application rates and fertility of the soil [10,11]. The recommended manure rates of application for annual and biennial crops ranged from 5 t/ha to 10 t/ha depending on crop type [12, 13]. The applications of organic manures perform almost the same or better than NPK fertilizer and poultry dung seemed to be the best among the organic manures applied [14]. The addition of organic fertilizers improves soil porosity, moisture content, and water-holding capacity, while mitigating soil compaction and reducing bulk density [15]. More so, the organic matter introduced through these sources benefits soil quality by contributing to humified fractions, serving as the most stable reservoir of organic carbon that aids in stabilizing soil structure [7].

Despite the potential benefits of organic manures, the specific effects of these fertilizers on cabbage growth and yield are not fully understood. This study was therefore aimed to investigate the influence of organic manure on the growth and yield of cabbage, with the goal of identifying the optimal organic manure for cabbage production.

MATERIALS AND METHODS

The experiment was conducted at the Nursery Section of the Tree Crop Orchard of the Federal University Oye-Ekiti, Ikole campus (7°79'N) and latitude 5°49'E). The vegetation of the location is humid rain forest; it has distinctive climatic condition of raining season and dry season. Cabbage seeds were purchased from seed merchants. Manure was sourced from Ekiti State Agricultural Development Program (ADP). The field was ploughed and harrowed, and beds of 2 m x 10 m were constructed and demarcated into plots.

Seeds were sown and treatments imposed by application of manure. The beds were daily watered to field capacity. Botanical were used (precisely neem) to prevent insect pests and rodents. Fire tracing was put in place. Wire mesh was installed for perimeter fencing to prevent rodents and insect attack, sheds were also constructed for shade to young plants to prevent direct sunlight.

The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replications. The treatments included four levels of manure application rates at 10 t/ha and 15 t/ha and the control of zero or no manure. The spacing types adopted included wider spacing at 50 cm x 50 cm (40,000 plants/hectare), moderately wide spacing at 50 cm x 40 cm (50,000 plants/hectare), and closer spacing at 50 cm x 30 cm (66,000 plants/hectare),

Data collection was done at weekly intervals after application of manure by measurement of the following plant parameters, which included Plant height (cm), Numbers of leaves, Root length (cm), Root girth (cm) and yield (g/plant) or kg/ha. The collected data were subjected to analysis of variance (ANOVA) and Means were separated by using least significant difference (LSD) at 5% probability.

RESULTS AND DISCUSSION

Comparing the nutrient contents in the soil and manure as shown in Table 1, it is evident that the manure's high organic carbon and nutrient levels significantly enhance soil fertility. This improvement in soil quality led to better nutrient uptake and growth in the treated plots. The enhanced organic matter from the manure improves the soil's water retention capacity and nutrient availability, providing a more conducive environment for plant growth. This increased fertility aligns with the observed growth parameters and proximate analysis results, where treated plots exhibited higher moisture content, improved crude protein levels, and increased mineral uptake.

The plant height measured from the ground to the tip of the plant as shown in Table 2 showed no significant difference, but eventually wider spacing (50 cm x 50 cm) had significantly taller plants compared to both closer (50 cm x 30 cm) and moderately spaced plants (50 cm x 40 cm) that were not different in response. However, for the stem height measured from the ground level to the neck below the ball head had an initial taller response for the 50 cm x 50 cm spacing though not different from the 50 cm x 40 cm spacing but eventually there was no significant difference among the spacing methods. Notwithstanding, the number of leaves was not significant different for the different spacing methods. This indicated that the taller plant height was due to the corresponding bigger ball head of the wider spaced plants, while the stem height at the neck of the plant holding the ball head and the numbers of leaves were not different. Thus, except in the plant height and canopy spread wider spacing did not significantly affect plant growth.

The plant height showed significant difference among the manure treated plants as there was significantly taller plant height, stem height, number of leaves for the plants that received 15 t/ha compared to those treated with 10t/ha while the control (no manure application) had significantly lower growth responses. However, for the canopy spread, although there was no significant difference observed initially nonetheless there was eventually wider ball head observed for the 10t/ha and 15t/ha which were not different in response but were significantly wider compared to the control which had smaller ball heads. This indicated that growth of cabbage observed by the bigger ball heads showed the height and width of ball head, as the main growth parameters contributing to the yield quality of the produce.

In the yield harvest as shown in Table 3, there was no significant difference in fresh and dry weight at the initial and final stages of growth of cabbage planted at the different spacing methods. However, significant difference was observed in plant response to manure application rates. The fresh weights observed at initial growth stage showed significantly heavier harvest for plants treated with 15t/ha which was not different from the control but was significantly heavier than plants treated with 10t/ha. However, at the final harvest significantly heavier fresh weights though not different from 10t/ha was observed compared to the lower yield observed for the control. The dry weight showed a no significant response at the initial growth stage among treatments, but a heavier ball head of plants treated with 15t/ha though not different from 10t/ha compared to lower yield of the control plants. This response showed cabbage as a nutrient demanding crop and that higher manure applications rate command higher yield compared to lower manure rate or control. Hence the higher the manure rate the higher the yield response. The lower fresh weight at the initial growth stage for plants that received 10t/ha which eventually improved at the final harvest could be due to nutrient antagonism but not observed at the higher manure rate.

CONCLUSION

In conclusion, the production of cabbage using spacing methods with the attendant wider rooting volume for widely spaced plants could positively influence moisture capture alongside nutrient uptake and proximate content but had no effect on cabbage growth responses. Spacing of cabbage did not seriously affect yield in the per plant response but when replicated will enhance yield at the relative plant population per hectare. However, cabbage responses to manure application rate showed the crop as nutrient demanding which tend to improve at higher application rates. The cultivation at higher manure rates should be adopted by growers for profitable and sustainable production.

Table 1: Soil and Manure Composition Analysis

PARAMETERS	SOIL	MANURE
Organic Carbon (%)	1.09	18.64
pH 1:2 (water)	6.02	7.15
Nitrogen (%)	0.11	2.52
Available Phosphorus (mg/kg)	12.12	0.85
Calcium (Cmol/kg)	3.70	36.18
Magnesium (Cmol/kg)	1.06	16.74
Potassium (Cmol/kg)	0.20	38.20
Sodium (Cmol/kg)	0.015	---
Exchanged Acidity	0.90	---
Particle size analysis		
Sand %	85.4	---
Silt %	7.0	---
Clay %	7.6	---
Textural class	Loamy Sand	---

Table 2: Plant growth of Cabbage in response to plant spacing and manure application rates

Treatments	Plant height (cm)		Stem height (cm)		Number of leaves	
	3	5	8	16	8	16
Plant Spacing						
CPS	14.11	17.48	8.78	15.29	19.78	33.06
MPS	15.37	19.21	9.37	16.68	21.11	33.11
WPS	16.75	21.81	10.1	15.73	19.61	32.11
LSD A	ns	2.22	1.23	ns	ns	ns
Manure rate						
Control (0 t/ha)	11.32	14.93	6.77	10.95	13.83	25.50
Moderate (10 t/ha)	15.51	20.17	9.60	17.00	21.44	34.89
Higher (15 t/ha)	19.40	23.40	11.9	19.74	25.22	37.89
LSD B	2.65	2.22	1.23	1.48	3.07	3.00
LSD A x B						

Note: CPS = Close plant spacing, MPS = Moderate plant spacing, WPS = Wider plant spacing
 Closer spacing = 50cm x 30cm, Moderate spacing = 50cm x 40cm, 50cm x 50cm = Wider spacing

Table 3: Plant growth and yield of Cabbage in response to plant spacing and manure application rates

Treatments	Canopy spread (cm)		Fresh Yield (g/plant)		Dry Weight Yield (g/plant)	
	8	16	wk1	wk3	wk1	wk3
Plant Spacing						
CPS	30.32	41.22	13.02	48.46	2.73	9.94
MPS	33.72	46.37	14.53	56.39	2.94	10.71
WPS	33.33	47.70	13.14	59.77	2.49	13.19
LSD A	Ns	6.07	ns	ns	ns	ns
Manure rate						
Control (0 t/ha)	20.30	36.62	12.33	24.47	2.12	5.57
Moderate (10 t/ha)	36.32	47.27	8.91	54.68	2.21	12.37
Higher (15 t/ha)	40.76	51.40	19.46	85.48	3.83	15.91
LSD B	5.91	5.06	7.26	34.12	ns	8.92
LSD A x B						

Note: CPS = Close plant spacing, MPS = Moderate plant spacing, WPS = Wider plant spacing
 Closer spacing = 50cm x 30cm, Moderate spacing = 50cm x 40cm, 50cm x 50cm = Wider spacing

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INFLUENCE OF PLANT SPACING AND MANURE APPLICATION RATES ON NUTRIENT AND PROXIMATE CONTENT OF CABBAGE (*Brassica oleracea* var. *capitataa*)

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ABSTRACT

Cabbage (*Brassica oleracea*) is a highly nutritive vegetable crop valued for its nutritional content and culinary versatility. Organic manure application has great influence on crop nutritive content. However, the optimal application rate for maximum proximate and nutritive content remains uncertain. Our experiments at the Federal University Oye-Ekiti, Ekiti State, Nigeria, was conducted to determine the effect of plant spacing and organic manure application rates on nutrient content and proximate content of cabbage. The results showed that there was lower K, Na, Ca, Mg, Fe, Mn and P for the wider spaced plants, and lower Na, Fe and Mn for the closer spaced plants compared to the moderately spaced plants. The closer spacing had lower Ash, Fat and protein content only and higher fibre content; the moderate spacing had lower moisture and fibre content but higher Ash, protein and carbohydrate, while the wider spaced had lower fibre and carbohydrate but higher fat and protein. In conclusion, higher balanced nutrient availability occurred at 15t/ha and lower balanced nutrient availability at the control while nutrient antagonism was observed at 10 t/ha. The higher balanced nutrient availability at 15t/ha and lower balanced nutrient availability at the control afford the plants more uptake of essential nutrients for growth and crop yield.

Keywords: cabbage, pacing methods, manure application rates, growth response

INTRODUCTION

Cabbage is nutritionally dense, containing fiber, essential minerals (Ca, P, and K), and vitamins (C, K, A, and folate) [1]. Recognized for its anti-inflammatory properties, immune-boosting effects, and promotion of healthy digestion, cabbage is prepared in various ways, including stewing, shredding, steaming, pickling, fermenting, boiling, sautéing, or being consumed raw [2]. Global production of cabbages was estimated at 21.8 million tonnes, with China being the highest producer having 47% of the World total production. Other major producers include India with 9.0 million metric tonnes, Russia 3.5 million metric tonnes. However, in Nigeria cabbage is mostly cultivated in the Northern parts where cabbage production in 2016 grew from 2.7 million to 14.3 million tonnes [3].

According to [4], season had significant effect on nutrient release from manure causing similar residual effect performance on plants growth and yield. Additionally, manure sources differed in their rates of mineralization and the nutrients release which is slower with cow dung compared to poultry manure, but which got better with the season of application [4]. The type of feeds and nutrients present in the feed significantly affects the nutrients released by these manures from animal waste [5]. Research studies indicate that the availability of plant nutrients influences the presence of phytochemical constituents and secondary metabolites in plants [1]. However, [3] reported that analysis of quantitative phytochemicals revealed more of phenolics, alkaloids and flavonoids were present in cabbage grown with organic manure than in inorganic fertilizer. Higher carbohydrate in contrast sugar as metabolic indicator showed the plant as operating in dormant state probably due to nutrient antagonism effect on crop response. Sugars contribute to plant immunity, with the so-called “sweet immunity” concept inferring that sugar metabolism and signaling can boost the defense responses of plants [6]. Sugars play an important role in plant defense mechanisms to various abiotic and biotic stress factors, where saccharides such as sucrose, glucose, fructose, and trehalose represent metabolic signaling molecules in host plant cells [7, 8, 9, 10, 11]. The higher protein and carbohydrate of 10t/ha showed good quality for consumption, higher moisture for 15t/ha showed succulence, higher fibre showed good tensile strength of produce. Despite the corresponding lower yield of the plant in control plot the higher fat and protein showed that cabbage with or without nutrient application can still be nutritive.

Despite the potential benefits of organic manures, the specific effects of these fertilizers on nutrient content and proximate content of cabbage are not fully understood. This study was therefore aimed to investigate the influence of organic manure on nutrient content and proximate content of cabbage, with the goal of identifying the optimal organic manure for cabbage production.

MATERIALS AND METHODS

The experiment was conducted at the Nursery Section of the Tree Crop Orchard of the Federal University Oye-Ekiti, Ikole campus (7°79'N) and latitude 5°49'E). The vegetation of the location is humid rain forest; it has distinctive climatic condition of raining season and dry season. Cabbage seeds were purchased from seed merchants. Manure was sourced from Ekiti State Agricultural Development Program (ADP). The field was ploughed and harrowed, and beds of 2 m x 10 m were constructed and demarcated into plots.

Seeds were sown and treatments imposed by application of manure. The beds were daily watered to field capacity. Botanical were used (precisely neem) to prevent insect pests and rodents. Fire tracing was put in place. Wire mesh was installed for perimeter fencing to prevent rodents and insect attack, sheds were also constructed for shade to young plants to prevent direct sunlight.

The experiment was arranged in a Randomized Complete Block Design (RCBD) with four replications. The treatments included four levels of manure application rates at 10 t/ha and 15 t/ha and the control of zero or no manure. The spacing types adopted included wider spacing at 50 cm x 50 cm (40,000 plants/hectare), moderately wide spacing at 50 cm x 40 cm (50,000 plants/hectare), and closer spacing at 50 cm x 30 cm (66,000 plants/hectare),

Data collection was done at weekly intervals after application of manure by measurement of the following plant parameters, which included Plant height (cm), Numbers of leaves, Root length (cm), Root girth (cm) and yield (g/plant) or kg/ha. The collected data were subjected to analysis of variance (ANOVA) and Means were separated by using least significant difference (LSD) at 5% probability.

RESULTS AND DISCUSSION

The soil and manure as shown in Table 1 revealed that the manure's high organic carbon and nutrient levels significantly enhance soil fertility. The improved in soil quality led to better nutrient uptake and growth in the treated plots. This increased fertility aligns with the observed nutrient uptake and proximate content in plants, where treated plots exhibited higher moisture content, improved crude protein levels, and increased mineral uptake.

In the nutrient uptake response to plant spacing as shown in Table 2, it was observed that there was lower K, Na, Ca, Mg, Fe, Mn and P for the wider spaced plants at 50 cm x 50 cm, and lower Na, Fe and Mn for the closer spaced plants at 50 cm x 30 cm compared to the moderately spaced plants at 50 cm x 40 cm. This indicated that the more lower nutrient uptake observed for wider spaced plants compared to other spacing could be due to nutrient diversion into growth and development rather than into cellular content. The lower K, Ca, Mg, Fe, Mn and P observed for plants with 10t/ha, and lower K, Na and P for control plants compared to higher and maximum nutrient uptake as observed in the wider spaced plant although with lower Ca and Mg could have effect on the firmness and green colouration. This indicated that wider spacing provided maximum rooting volume for nutrient uptake in the absence of nutrient antagonism observed in 10t/ha. The higher balanced nutrient availability at 15t/ha and lower balanced nutrient availability at the control afford the plants more uptake of essential nutrients for growth and crop yield.

In the proximate content of harvested produce as shown in Table 3, the closer spacing had lower Ash, Fat and protein content only and higher fibre content; the moderate spacing had lower moisture and fibre content but higher Ash, protein and carbohydrate, while the wider spaced had lower fibre and carbohydrate but higher fat and protein. This indicated that higher cellular deposition and development resulted in Ash and carbohydrate. Higher fibre of closer spacing indicated firmness, higher fat and protein but lower fibre of

wider spaced showed the succulent and higher nutritive content nature of the produce. The lower carbohydrate and lower nutrient uptake indicated metabolic activities consuming the photosynthates as metabolites and nutrient elements in the active growth and development which both combined to provide the needed nutritive content of fat and protein. The lower moisture, ash, fat and fibre was observed for plant that received 10t/ha, lower moisture and lower fibre and lower carbohydrate was observed for control, while lower ash, fat, protein and carbohydrate was observed for plants that received 15t/ha.

CONCLUSION

In conclusion, the production of cabbage using spacing methods with the attendant wider rooting volume for widely spaced plants could positively influence moisture capture alongside nutrient uptake and proximate content but had no effect on cabbage growth responses. Spacing of cabbage did not seriously affect yield in the per plant response but when replicated will enhance yield at the relative plant population per hectare. However, cabbage responses to manure application rate showed the crop as nutrient demanding which tend to improve at higher application rates. The cultivation at higher manure rates should be adopted by growers for profitable and sustainable production.

Table 1: Soil and Manure Composition Analysis

PARAMETERS	SOIL	MANURE
Organic Carbon (%)	1.09	18.64
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Exchanged Acidity	0.90	---
Particle size analysis		
Sand %	85.4	---
Silt %	7.0	---
Clay %	7.6	---
Textural class	Loamy Sand	---

Table 2: Mineral nutrient uptake of Cabbage in response to plant spacing and manure application rates

Treatments	K (Mg/100g)	Na	Ca	Mg	Fe	Mn	P
Plant Spacing							
CPS	491.44	21.70	187.50	51.70	105.39	9.35	142.07
MPS	363.99	24.25	187.50	59.80	328.43	25.12	130.95
WPS	236.54	18.64	112.50	39.55	159.32	1.76	105.56
Mean	363.99	21.53	162.50	50.35	197.71	12.08	126.19
Manure rate	313.01	16.60	225.00	73.06	220.59	23.36	109.52
Control (0 t/ha)	262.03	22.72	150.00	43.15	186.27	7.01	112.17
Moderate (10 t/ha)	465.94	20.34	175.00	57.55	209.15	17.13	140.21
Higher (15 t/ha)	346.99	19.89	183.33	57.92	205.34	15.83	120.63
Mean							

Note: CPS = Close plant spacing, MPS = Moderate plant spacing, WPS = Wider plant spacing
Closer spacing = 50cm x 30cm, Moderate spacing = 50cm x 40cm, 50cm x 50cm = Wider spacing

Table 3: Proximate content of Cabbage in response to plant spacing and manure application rates

Treatments	Moisture (Percent)	Ash content	Crude Fat	Crude Fibre	Crude Protein	Carbohydrates
Plant Spacing						
CPS	83.56	1.15	2.29	2.43	2.71	7.87
MPS	80.78	2.43	2.54	1.94	3.32	8.99
WPS	84.13	2.00	2.75	1.71	3.32	6.08
Mean	82.82	1.86	2.53	2.03	3.12	7.65
Manure rate						
Control (0 t/ha)	82.41	2.96	3.69	1.55	3.67	5.72
Moderate (10 t/ha)	81.65	2.01	2.30	1.84	3.32	8.87
Higher (15 t/ha)	83.99	1.71	2.75	2.21	2.91	6.43
Mean	82.68	2.23	2.91	1.87	3.30	7.01

Note: CPS = Close plant spacing, MPS = Moderate plant spacing, WPS = Wider plant spacing
 Closer spacing = 50cm x 30cm, Moderate spacing = 50cm x 40cm, 50cm x 50cm = Wider spacing

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ANALYSIS OF AGROFORESTRY FARM PROFITABILITY AND POTENTIAL ECONOMIC VALUE OF CARBON SEQUESTERED BY AGROFOREST LAND IN OYO STATE, NIGERIA

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ABSTRACT

The potentials of agroforestry farming are yet to be fully exploited for carbon sequestration, increased crop and farmers' income. This study estimates the agroforestry farm profitability and potential economic value of carbon sequestered by agroforest land in Oyo State, Nigeria. A three-stage sampling procedures were adopted to select 346 agroforestry farmers involved in one agroforestry practice or the other. *Kobotool* and field observation were used in collecting primary data for the 2022 cropping season. Descriptive statistics and the Net Present Value (NPV) statistics were used for the data analysis. The potential net economic value of carbon sequestered in the study area was ₦7,246.37 (\$9.18) per ha. The results indicated that agroforestry practices in the study area have a huge capacity to sequester carbon and in the long run, generate additional income for smallholder farmers. Although, carbon revenues drops at 0.2-0.3% of NPV, however, carbon payments can still generate substantial revenue for farmers especially when carbon payments are combined with other payments for environmental services provided by agroforestry. Agroforestry practice was adjudged to be profitable with the net farm income of agroforestry farmers as ₦237,966.68 (\$311.12) in the last production season. Furthermore, the returns on investment were said to be at 0.63. Despite significant results recorded from agroforestry practices, there is a greater need to create better awareness among farmers on the carbon sequestration and carbon credit generating potential of agroforestry by relevant agencies of

INTRODUCTION

The craving for increased agricultural production has been under tremendous strain due to rapid population expansion, forest degradation, and indiscriminate usage of agricultural land (1). By 2050, the demand for food will go up by 60% around the world and 100% in developing countries including Nigeria (1). Therefore, adopting agroforestry, a climate-smart farming strategy, is necessary to maximize output and productivity (2). There is also little knowledge of the tremendous advantages offered by agroforestry practices, which can help millions of homes stuck in poverty. According to, (3), Agroforestry is generally referred to as land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboo, etc.) are intentionally used on the same land areas or units with crops and animals, in some form of spatial arrangement or temporal sequence. agroforestry systems in Nigeria include home gardens or traditional agroforestry system (TAS), Taungya farming, integrated Taungya, improved fallow in shifting cultivation, Alley-cropping (hedge row intercropping), and alley farming; others include Shelterbelts, windbreaks, multipurpose trees on cropland, and trees in social conservation.

Carbon sequestration is the process of taking carbon out of the atmosphere and storing it in different parts of the ecosystem. Trees on farms can sequester and store a lot of carbon (4). The amount of carbon sequestration can be estimated based on different tree species and their growth patterns. It's estimated that carbon capture and storage could reduce global Greenhouse Gas (GHG) emissions by 14% by 2050, with a total of 120 billion tons of carbon dioxide captured and stored between 2015 and 2050 (5).

The greatest role of agroforestry about climate change is perhaps in mitigating the emissions of carbon dioxide by productively sequestering carbon from the atmosphere. Carbon can sequester in two parts through agroforestry systems: aboveground and belowground. Carbon sequestration in agroforestry systems occurs in above-ground biomass, i.e., stem, branch, and foliage, and in belowground biomass, i.e., roots, and in soil.

However, there is little knowledge of the tremendous advantages offered by agroforestry practices, which can help millions of rural homes stuck in poverty. Therefore, there is a need for a global agroforestry transformation to mobilize science and resources to remove the socio-economic, ecological, and political barriers to the widespread adoption of agroforestry innovations, and thereby aid in achieving the sustainable development goals, SDGs (6).

The majority of smallholder agroforestry farmers in rural areas are unaware of the Kyoto Protocol, which might allow them to participate in the international carbon markets and increase the profitability of agroforestry. To allow developing countries to trade in GHG emission reductions, (7), and enhance their income, this has been presented as two market-based approaches. Despite the above-elicited literature attempting to address some of these gaps in Nigeria, there is not so much literature covering the value of carbon sequestered and potential carbon credits of agroforestry farmlands in Southwest Nigeria. Therefore, the study aims to estimate the potential economic value of carbon sequestered by agroforest land and analyze the profitability of selected agroforestry practices among farming households in Oyo State, Nigeria.

RESEARCH METHODOLOGY

The study was carried out in Oyo State in the Southwestern part of Nigeria. The State covers approximately an area of 28,454 square kilometers and is ranked 14th by size in Nigeria (8). Agriculture is the main occupation of the rural people of Oyo State (9). The climate in the state favors the cultivation of crops like maize, yam, cassava, millet, rice, plantains, cocoa, palm produce, and cashews (10). Most farmlands are cropped with fruit trees making the potential of agroforestry in the study area a huge one with a great impact on climate change mitigation and carbon sequestration.

Multi-stage sampling procedure was used to select the respondents from the study area. The first stage involved sampling of the total population of all four agro-ecological zones in Oyo state since due to a dominance of farmers mostly involved in agroforestry. The second stage involved the random selection of Local Government Areas (LGAs) also known as blocks from the selected zones. Three LGAs each were selected from Ibadan/Ibarapa and Saki zones while two LGAs each were selected from both Oyo and Ogbomoso zones. The selection was done based on the proportion of the number of LGAs in each of the selected zones. The third stage was the random selection of two communities in each LGA, making a total of twenty (20) communities in all. In the fourth and final stage, farming households who are into one form of agroforestry or the other were randomly selected using the Yamane scientific formula for calculating sample size. A sample size determination using $\geq 10\%$ is highly recommended when the sample size is relatively large (11). However, 9% was used for reasons due to financial constraints.

The scientific formula which was given by (12), was used to select the sample size at a 95% confidence level.

$$n = \frac{N}{1 + N(\alpha^2)} \dots\dots\dots(1)$$

Where: n = sample size, N = Sample frame (A sample frame of lists of farmers was obtained from ADP, Oyo State), and α^2 = precision level (0.05).

Primary data were collected and used for this study. Required information for the 2022 farm production season on socio-economic and institutional characteristics of agroforestry farmers, agroforestry farming operations and practices were collected using a structured questionnaire on the Kobo toolbox application. The use of the *Kobotool* app was preferred because it ensures the accuracy of collection and capturing of data. The questionnaire was administered to agroforestry farming households in the selected communities in Oyo State. The amount of carbon sequestered was calculated using the formula obtained from (13).

Data collected were analyzed using the net present value and budgetary techniques. Net present value was used to estimate the potential economic value of carbon sequestered by agroforest land in the study area. Budgetary analytical tools like Gross Margin (GM) and Returns on Rate of Investment (RORI) was used to determine the profit of agroforestry production to farmers in the study area (14).

$$GM = TR - TVC \dots \dots \dots (2)$$

Where: GM = Gross margin (N), TR = Total Revenue (N) given as $P_y.Y$.

Where: P_y = price/ unit of product from any agroforestry system practiced and Y = output (kg).

TVC = Total Variable Cost in (N).

$$\text{Net farm income (NFI)} = GM - TFC; \dots \dots \dots (5)$$

Where; TFC = Total Fixed Cost.

Results and Discussion

Socioeconomic and institutional characteristics of agroforestry farmers

Results are as described in Table 1. The male category had the majority (82.4%) of agroforestry farms, 33.8% had primary education, over half (60%) of the farmers have formal education with mean age of 52 years and standard deviation of 9.9 years. Furthermore, majority of the respondents were married (91.3%), have a relatively sizable household size of an average of 7 members and more than 10 years of experience in agroforestry practice and 47.1 %, have been in cooperative for about 10 years. The results are comparable with the studies of (14; 15), on socioeconomic profile of agroforestry farmers in Kaduna and Ogun States, respectively.

Potential economic value of carbon sequestered by agroforest land

The Net Present Value (NPV) of carbon sequestered in the study area using the current interest rate of 18% obtained from the Central Bank of Nigeria, (2023) is shown in Table 2. Findings reveal that the total carbon sequestration potential was 31.25 tons of carbon. However, the NPV of carbon sequestered in the study area is greater than zero with the value ₦6,772,537.60 (\$8514.31). With a total hectare of 945 ha under this research, the NPV of carbon per ha stood at ₦7,246.37 (\$9.18/ha). The results are comparable with findings of (14), on carbon sequestration, allocation, and ecosystem storage in a grassed vineyard.

Cost-return analysis of agroforestry practices in the study area

The net farm income (profit), profitability index, and rate of investment returns were all calculated and reported in Table 3. The findings indicated that the agroforestry farmers spent a total of ₦129,880.92 on variable costs comprised of cost on labor, seeds, and seedlings, compost made from forest drops, and manure, and very often inorganic fertilizer. This also shows that the net farm income of agroforestry farmers was ₦237,966.70 in the last production season which indicated that agroforestry is profitable and a successful business in the study area. This agrees with the work of (14), who also posited that agroforestry was highly profitable in his research on economic evaluation of agroforestry practices in Ogun state, Nigeria. The resulting gross margin ratio of 0.658 means that for every Naira invested in agroforestry production per hectare, 658 kobo were used to cover interest, profits, taxes, depreciation, and other costs. A lower operating ratio is considerably preferred, and the smallholder agroforestry farmers' 0.342 operating ratio shows that they were efficient in their use of resources. This suggested that the cost of output sold and other running costs were covered by 34.2% of the profits from agroforestry production. This is consistent with findings of (15).

CONCLUSION AND RECOMMENDATIONS

Based on the findings from the study it is therefore concluded that agroforestry practices have huge potentials for carbon sequestration, generate carbon credits for farmers and also improve food security through increased profitability. With the significant effect carbon sequestered on agroforestry farms which is connected to carbon sequestration and improved profitability, it becomes imperative to continue educating farmers on the importance of practicing agroforestry.

Agroforestry programs dedicated to creating better awareness among farmers on the carbon sequestration and carbon credit generating potential of agroforestry should be mounted by relevant agencies of government such as the Ministry of Environment.

Table 1: Socioeconomic characteristics of agroforestry farmers

Variables	Dominant indicators	F	%	Mean	Stadev
Gender	Household head that were male	285	82.4	na	na
Age	Respondent between 21 -60 years	286	96.6	52.6	9.9
Education	Minimum of primary education	117	33.8	na	na
Per household size	Respondent with 1-10 persons	313	90.5	6.8	3.0
Agroforestry practice	Respondent with 1-20 years	267	77.2	16.7	10.9
Marital status	Married respondent	316	91.3	na	na
Extension visit	Minimum of one contact	296	85.6	3.5	0.8
Cooperative	Minimum of 10 years	163	26.6	7.4	0.4
Credit access	Access	225	65.0	na	na
Occupation	Farming and others	259	74.9	na	na
Agroforestry type	Agrisilviculture	219	63.3	na	na
Land acquisition	Inherited	230	66.5	na	na
Agroforestry farm size	Farm size between 0.2-2.1	205	59.3	2.7	2.8

Note: Computation from field survey, 2023

Table 2: Net Present economic value of Carbon sequestered in the study area

*Cseq veg (kg)	*Cseq soil(kg)	Total *Ceq (Kg)	Total CO ₂ eq (Kg)	Conversion (ton)	NPV (\$)	NPV per ha (\$/ha)
6757.16	1756.91	8514.07	31,246.64	31.25	8680.56	9.18

Note that *Cseq veg (kg) –Carbon sequestered in trees, Cseq soil(kg)- C sequestered in soil, Ceq-(Carbon equivalent), CO₂eq–(Carbon dioxide equivalent)

Source: Field Survey, 2023

Table 3: Costs and returns analysis of agroforestry practices in the study area

Description (per household)	Amount (?)
Total variable costs (TVC)	129,880.92
Total fixed cost (TFC)	12,286.76
Total cost	142,167.70
Total revenue from tree produce	131,447.10
Total revenue from crop component	247,911.70
Total revenue	379,358.80
Annual net farm income(profit)	237,966.70
Gross margin ratio	0.658
Operating ratio (TVC/TR)	0.342
Profitability index (NFI/TR)	0.63
RORI = PI*100	63

Source: Field Survey, 2023

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ASSESSMENT OF INDIGENOUS KNOWLEDGE APPLICATION OF PESTICIDAL PLANTS AMONG YAM FARMERS IN OHAUKWU, EBONYI STATE NIGERIA

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ABSTRACT

A study was conducted to assess the indigenous knowledge on the use of Pesticidal Plants (PPs) by ADP Contact yam Farmers (CF) in Ohaukwu, Ebonyi State Nigeria. Sixty selected CF in Ohaukwu Extension block were administered each with structured questionnaire enquiring the farmers' knowledge and experience on use of PPs for control of various pests of yam. Purposive random sampling technique was adopted. Data were analyzed using descriptive statistics. Results indicated that 68.3 and 31.7% of the respondents were male and female, respectively. More than 60% of the respondents had at least basic junior secondary education, while 23.3% of them had no formal education. Majority of the farmers (61.7%) cultivated farm size estimated at ≤ 4.5 hectares. About 41.7% of the farmers affirmed knowledge and use of PPs for various applications: control of crop insect pests (26.7%), household pests (8.0%), vertebrate pests (5.0%), crop diseases (3.3%), weeds control (1.7%) and other unspecified pests (3.3%), while 51.7% indicated no idea of PPs. Relative frequency (%) distribution of eleven PPs identified and explored by the farmers included: *Azadirachta indica* (22.03), *Nauclea diderrichii* (15.25), *Carica papaya* (11.84), *Sarcocephalus latifolius* (6.78), *Allium sativum* and *Urtica dioica* (1.69, each). Effectiveness of PPs in pest management reports ranged from: high (16.7%), moderate (20.0%), low (3.3%), very low (1.7%) and no idea (58.3%). Moreover, 83.3% of the farmers admitted no negative effect experience in the use of PPs. In conclusion, it was observed that most farmers in Ohaukwu were not fully aware of the potential of PPs as alternative control strategy for managing pest challenges in yam production in their locality.

Key words: Crop protection, indigenous knowledge, organic farming, pesticidal plants, southeast Nigeria, yam production.

Keywords: Agroforestry, crop production, Carbon sequestration, Economic value, Profit

INTRODUCTION

Studies have shown the roles rural communities and many other parts of developing continents play in generating knowledge and devising mechanisms to conserve their natural resources through science based researches, innovation and exchange of ideas [1,2]. Although fewer of these indigenous knowledge are documented in literatures, yet, they are valuable bodies of experience which provide insights on how rural communities interact with the changing environment particularly its flora and fauna resources [3]. Indigenous knowledge is a potential rich source of innovations and ideas capable of maintaining sustainable agriculture through provision of a theoretical framework within the scope of farmers' practices and decision making process [4,5]. Traditionally, many farmers in the developing countries manage field and storage crop pests using indigenous cultural controls, yet little information about accessibility to such practices avail the other end users [6].

In Nigeria, pests constitute one of the most pressing constraints to crop productivity, and the farmers, through their acquired expertise in indigenous knowledge on pest control have found that naturally occurring phytochemicals of plant origin (botanical pesticides) contain bioactive substances. Such bioactive substances are used in fresh or processed form to control, destroy, mitigate, prevent or repel the activities and negative effects of agricultural pests [3, 7].

Yam (*Diocorea spp*: Discoreaceae) is an important staple tuber crop of Nigeria and other sub-Saharan African countries. In many yam growing communities in Nigeria, yams play a vital role in the socio-cultural belief of the people especially during traditional festivals [8]. Until recently, studies on pest management by small scale yam farmers using indigenous knowledge have been scanty or not well documented in the humid agroecological zone of Nigeria in particular [9]. More so, scientific literatures on the extent to which yam growers explore the botanicals and their effectiveness on the targets (pests) have proved difficult to be determined.

The objectives of this present study were to: determine the socioeconomic characteristics and distribution of yam farmers in Ohaukwu Local Council Area, Ebonyi State, Southeast Nigeria; to assess the farmers' awareness of pesticidal plants and its use in yam crop protection within their locality; to identify and characterise pesticidal plants mentioned by the farmers; and to evaluate their experience in the effectiveness of pesticidal plants for controlling pest menace in yam production.

METHODOLOGY

The research was carried out between May and August, 2023 at Ohaukwu Council Area of Ebonyi State Southeast Nigeria. The Council area occupies the northern axis of Ebonyi State and it is bordered in the east by Ebonyi, southward by Ezza North, west by Ishielu Council Areas and in the north by Benue State. Ohaukwu is typical of tropical derived savanna climate with mean annual rainfall of between 1500mm-2500mm and annual temperature of between 18 °C - 42°C, and mean relative humidity of 65%. It is more of a semi-urban agrarian community with most of the dwellers actively engage in farming as full or part time occupation. Existing structures of the Agricultural Development Programme (ADP) located at the Council Area including; extension blocks and circles were used in reaching out to the targets contact farmers. Using purposive random sampling technique, sixty (n=60) copies of structured questionnaire developed and validated by Agricultural Extension officers in the Department of Agricultural Extension and Management, Federal College of Agriculture, Ishiagu Ebonyi State, were self - administered to the selected ADP contact farmers who constituted the respondents. The questionnaire sought to obtain information on farmers' socio-demographic profile, knowledge/experience on the use of pesticidal plants in their yam farming activities and other relevant areas of applications including the observed side effects of the applied botanicals. Completed questionnaires were returned for validation. Data collected were analysed using descriptive statistics and relative frequency (%) distribution [10, 11]. A list of pesticidal plants mentioned by the respondents during the field survey was compiled and the floristic information about pesticidal plants were identified down to their species level using [12] and [13]. Thereafter, plant's growth habits were characterized according to methods described by [10]. Family names, genus and species names of the plants were also verified for current nomenclature from the previous scholars [14] and [12].

RESULTS AND DISCUSSION

The socio-demographic characteristics and distribution of the respondents in Ohaukwu Council Area of Ebonyi State is as shown in Table 1. The respondents comprised of 68.3% male and 31.7% female. About 50% of the farmers were within the active age groups of 21 – 50 years, while the remaining segments were above 50 years of age. These patterns of distribution could be attributed to the peculiarity of the survey area as an agrarian rural community where traditional farming practices are the order of the day and in which yam cultivation is associated with socio-cultural status of married heads of households who engage in its production. This observation corroborated with the prevailing traditional farming system in Igbo speaking area of southern Nigeria where yam is regarded men's crop [15]. The distribution of the respondents' age brackets which showed that half of the sampled population were within the relatively older farming folks, agreed with the belief system about yam production as crop for older generation. Moreover, about 36.6% of the respondents had no formal education or at least attempted primary school, while more than 60% had secondary and/or tertiary education experience. The greater percent of the farmers possessing at least secondary education must have contributed to their ability to perform certain technical tasks such as sprayer calibration, preparation of botanical pesticides and documentation of pesticidal plants in use [16]. Sharma *et al.* [17] who reported that education greatly influence the behavioral pattern and dispositions of individual farmer towards the adoption of agricultural related innovations support the present observations. Majority of the farmers (61.7%) cultivated farm size estimated at about ≤ 4.5 ha, whereas respondents with cultivable land area estimated at 9 ha (200 plots equivalent) belonged to the group of farmers under 23.3%. (Table 1).

Among the respondents only 42.0% of the farmer affirmed knowledge and use of pesticidal plants for various applications: control of crop insect attacks (26.7%), household pests (8.0%), vertebrate pests (5.0%), crop diseases (3.3%), weeds control (1.7%) and management of other unspecified pests (3.3%), while 51.7% indicated no idea about pesticidal (Table 1). The relative frequency distribution (%) of eleven pesticidal plants identified and used by the respondents is displayed in Table 2. Effectiveness of pesticidal plants in pest management reports ranged from: high (16.7%), moderate (20.0%), low (3.3%), very low (1.7%) and no idea (58.3%). Hence, about 83.3% of them reported no negative effect experience in the use of pesticidal plants. Most of the pesticidal plants listed by the farmers, Neem (*A. indica*) in particular, have been reported with similar applications and benefits [18,19].

CONCLUSION

Majority of the ADP contact yam farmers in Ohaukwu Council Area of Ebonyi State were smallholders, although most possessed basic formal education. Eleven pesticidal plants used by the farmers for various aspects of yam crop protection were identified for further specific detail investigation. However, some of the respondents in the study locality expressed ignorance about the opportunities and benefits these pesticidal plants offer as safer alternative for management of pest challenges than conventional synthetic pesticides. Arising from this observation, further intervention or researches by interested stakeholders local agricultural extension agents and relevant organizations should address the critical gap from the present study.

Table 1: Socio-demographic Profile of Yam Farmers and their Awareness about Pesticidal Plants in Ohaukwu, Ebonyi State

Variable	Sub-group	Percent (%)
Gender:	Male	68.3
	Female	31.7
Age group (years):	21 – 30	11.7
	31 – 40	18.3
	41 – 50	20.0
	51 – 60	30.0
	61 and above	20.0
Educational level:	No formal education	23.3
	Primary school	13.3
	Junior secondary	11.7
	Senior secondary	28.3
	Tertiary education	23.3
Farm size (plot)†:	1 – 50	26.7
	51 – 100	35.0
	101 – 150	15.0
	151 – 200	23.3
	Aware	42.0
Awareness about Pesticidal Plants:	Not aware	58.0
	Control of crop insect attacks	26.7
Various applications of PPs:	Vertebrate pests (snake, etc)	5.0
	Crop diseases	3.3
	Household pests	8.0
	Weeds control	1.7
	Other unspecified pests	3.3
	No idea	51.7

Source: Field Survey (2023); †One plot = 450m² = 0.045ha. PPs = Pesticidal Plants.

Table 2: Relative Frequency (RF) Distribution of Pesticidal Plants Identified and Used by the Selected Farmers in Ebonyi State

Common Name	Scientific Name	Family Name	Plant habit	RF (%)
Garlic	<i>Allium sativum</i>	Amaryllidaceae	ABL	1.69
Oil palm	<i>Elaeis guineensis</i>	Arecaceae	PBL	20.34
Paw paw	<i>Carica papaya</i>	Caricaceae	ABL	11.84
Bitter kola	<i>Garcinia kola</i>	Clusiaceae	PBL	5.08
Neem	<i>Azadirachta indica</i>	Meliaceae	PBL	22.03
Elephant grass	<i>Pennisetum purpureum</i>	Poaceae	ABL	3.39
Spear grass	<i>Imperata cylindrical</i>	Poaceae	ABL	1.69
Lemon grass	<i>Cymbopogon citratus</i>	Poaceae	PG	6.78
African peach	<i>Sarcocephalus latifolius</i>	Rubiaceae	PBL	6.78
Uvuru	<i>Nauclea diderrichii</i>	Rubiaceae	ABL	15.25
Stinging nettle	<i>Urtica dioica</i>	Urticaceae	ABL	1.69
Wood ash	-	-	-	3.39

Source: Field Survey (2023). Legend: ABL = Annual broad leaved, PBL = Perennial broad leaved, PG = Perennial grass

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EFFECT OF TORREFACTION ON ENERGY-RELATED PHYSICAL-CHEMICAL PROPERTIES OF YAM PEEL

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ABSTRACT

Torrefaction pretreatment is a mild form of pyrolysis that has the potential to produce a high-quality raw material for making biofuel that serves as a replacement for coal in the bioenergy industry. Torrefaction was conducted on yam peel at various temperatures of 250°C, 270°C, and 300°C with retention times of 30 mins, 60 mins, and 90 mins in an inert environment. Torrefaction process produces a solid carbon, commonly known as biochar. In this study, torrefaction characteristics were investigated to observe its effects on the thermal and physiochemical properties of the product. During the torrefaction process, a significant mass loss associated with the decomposition of hemicellulose was observed. The hemicellulose content, lignin drastically reduced and the cellulose content was reduced. This led to an improvement in the higher heating value (HHV), hydrophobicity, bulk and particle density. Torrefaction pot was used as our reactor in this case. The thermogravimetric analysis conducted showed that the torrefaction of yam peel slightly reduced its thermal stability as temperature increases. The result showed that torrefaction of sundried yam peels has transformed the biomass into a more homogeneous, energy-dense and stable fuel source with improved combustion characteristics, making it a promising option for renewable energy production.

Keywords; Surface morphology, thermal stability, calorific value, underutilized agricultural residue, proximate analysis.

INTRODUCTION

Torrefaction is a promising technology for upgrading the fuel properties of biomass. In this study, torrefaction of Licorice residue (LR) at temperatures of 210, 240 and 280°C resulted in an increase in the higher heating value (HHV) of the torrefied samples by 8.1-39.5% compared to untorrefied LR [1]. According to the Food and Agriculture Organization (FAO), yams are a staple food for millions of people, particularly in sub-Saharan Africa, Asia and the Caribbean. The processing of yams, however, generates substantial amount of peel waste, often overlooked and underutilized. This study aims to systematically explore the impact of torrefaction on the physicochemical properties of yam peel, assessing changes in composition, structure, and thermal behaviour. By elucidating these transformations, we aim to contribute valuable insights into the feasibility of utilizing torrefied yam peel as a sustainable feedstock for energy applications, thereby addressing both energy and waste management challenges in an integrated manner. Through this exploration, we hope to unlock the untapped potential of yam peel as a renewable energy resource and contribute to the broader discourse on sustainable bioenergy solutions[2].

MATERIALS AND METHODS

Collection and preparation for biomass

Yam peels were obtained from Oye market located at Oye- Ekiti, Ekiti State Nigeria. The yam peel was taken to Industrial Chemistry Laboratory in the Federal University Oye-Ekiti, Ekiti State, Nigeria for analysis. The yam peels were sun-dried for five days and grounded into smaller particles, before torrefaction in the torrefaction pot at various temperatures of 250, 270 and 300°C [3].

Volatile matter

One gram of sieved sample was introduced into pre-weighed platinum crucible, covered with lid and placed into the furnace at 105°C in order to determine the weight of the heated yam peels sample. Thereafter it was heated to 950°C and maintained at that temperature for about seven (7) minutes. The weight of the heated sample was recorded after cooling in the desiccators. Thus the volatile matter was calculated using the equation below.

$$VM = (P_s - P_v) / P_s \times 100$$

Where, VM is the volatile matter, P_s is the weight of yam peel after subjecting to 105°C, P_v is the weight of the charcoal after subjecting to 950°C.

Ash content

One gram of the sieved sundried-sample was introduced into a pre-weighed platinum crucible, placed into the furnace at 950°C and was allowed to burn completely to a constant weight. The loss in weight was recorded and the ash content was calculated using the equation below [4,11].

$$AC = \left(\frac{P_a}{P_v} \right) \times 100$$

Where, AC is the ash content; P_a , the weight of the sun-dried yam peel; P_v , the weight of the yam peel after subjecting to 950°C [14].

Fixed carbon (FC)

The Fixed Carbon (FC) was calculated by subtracting the sum of volatile matter (VM) and ash content (AC) from 100. The carbon content is usually estimated as a “difference”, i.e. all the other constituents are deducted from 100 as percentages, and the remainder is assumed to be the percentage of fixed carbon. This was determined using the formula below: [5].

$$FC = 100\% - (MC\% - AC\% - VM)$$

Higher Heating Value (HHV) analysis of torrefied yam peels.

It includes the heat energy released during combustion and the energy required to convert the resulting water vapour to liquid state (latent heat of vaporization). Calculating the HHV involves measuring the heat produced when a given amount of the fuel is burned under controlled conditions [12].

The formula to calculate higher heating value (HHV) from proximate parameters is $HHV = 0.333 * (FC + 9 * HM)$ [8].

CHNOS analysis of torrefied yam peels.

CHNOS analysis is an essential analytical technique that delves deep into the elemental makeup of substances, casting a precise spotlight on the quantification of carbon (C), hydrogen (H), nitrogen (N), oxygen (O), and sulphur (S) within samples [9, 10]. The C, H, N, S and O concentrations can be calculated from proximate parameters, using the formulas below:

Carbon content (C): $C = 100 - (FC + VM + AS)$

Hydrogen content (H): $H = 100 - (FC + VM + AS + O + N + S)$

Nitrogen content (N): $N = \%NO * 14 / 46$

Sulphur content (S): $S = \%SO * 32 / 64$

Oxygen content (O): $O = 100 - (C + H + N + S + Ash)$. [11].

RESULTS AND DISCUSSION

Proximate Analysis

The raw yam has moisture content of 10.1%, and an ash content of 1.72%. When the sundried yam sample was torrefied at 250 °C, the moisture content reduced to 8.16%. It can be observed that the volatile matter and fixed carbon reduces as temperature increases. The ash content, however, was almost constant. It can also be observed that the highest values of fixed carbon were obtained for torrefaction at 250 °C, and specifically this was when the yam peels sample is about to be torrefied [6,17].

FTIR analysis of sundried and torrefied yam peels

FT-IR spectra were taken to determine the functional groups of the biomass components and raw materials, as given in Figure 2.

The FTIR spectrum of sundried yam peel showed the phenolic O–H stretch which was seen at a

wavenumber 3280.1 cm^{-1} , and the observed wavelength of 2922.2 cm^{-1} can be attributed to the presence the alkane functional group (CH_3 , CH_2 & CH_2 or 3 bands).

The stretching frequency of the $\text{C}\equiv\text{C}$ bond was observed at 2117.1 cm^{-1} , the primary mode associated with $\text{C}\equiv\text{C}$ bonds is the stretching vibration of the carbon-carbon triple bond. This stretching mode occurs at higher wavenumbers (frequencies) compared to single and double bonds. A sharp and intense peak was observed in this region[16].

The spectrum of torrefied yam peels depicted at the bottom in Figure 2 shows the Fourier Transform Infrared (FTIR) spectrum. The vibration that causes O-H stretching is responsible for the phenolic O-H stretch, which was seen at a wavenumber of 3153.3 cm^{-1} [7].The functional groups of sundried yam peels are more than torrefied yam peels, this is as a result of the effect of temperature [17].

Figures 3, 4, 5 and 6 respectively show the thermogravimetric trends and differential thermogravimetric curves for sundried and torrefied yam peels samples respectively, whereas the DTG profiles revealed more significant differences [14,15].

The release of weakly bonded water molecules and hydrolysis was first observed at a stage called the evaporation or dehydration stage. The thermal curves showed that torrefied materials have an initial decomposition temperature of 780°C [10, 13].

Higher Heating Value (HHV) analysis of torrefied yam peels.

The initial higher heating value of sundried yam peels was 25.61, when the sundried yam peels was subjected to temperatures of $250, 270$ and 300°C , the higher heating value increases to 41.56, 45.37 and 53.17 respectively, the results showed that the higher the temperature, the greater the higher heating value and the more stable fuel source biomass becomes. [12].

CHNOS analysis of torrefied yam peels.

Table 2 above explained the carbon, hydrogen, oxygen, nitrogen and sulphur contents of torrefied yam peels at different temperatures [9, 10].

CONCLUSION

The experiment shows that the occurring decomposition reactions of yam peel at varying temperature levels cause the biomass to become completely dried and loose its fibrous structure. The torrefied biomass steadily changes colour from brown to dark-brown, then to black, as it approaches the properties of coal. These changes make torrefied biomass very attractive for combustion and gasification applications. The biomass partly decomposes during the process giving off various types of volatiles, which result in the loss of mass and chemical energy to the gas phase.

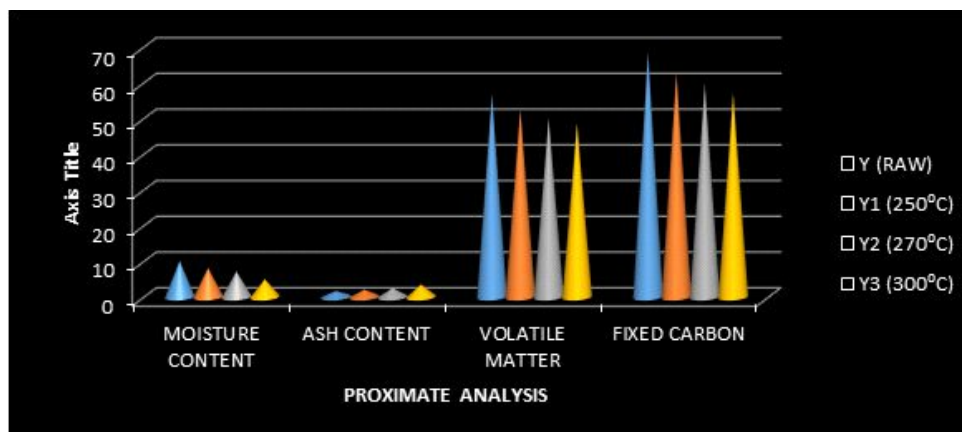


Figure1: Pictorial of proximate composition of sundried and torrefied yam peels samples

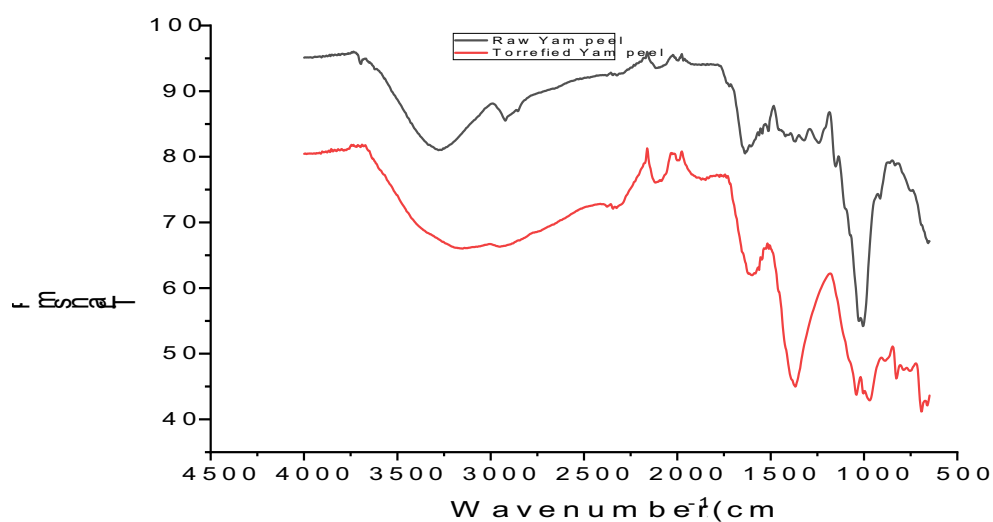


Figure 2: FTIR spectra of sundried (SY) and torrefied yam peels samples (TY).

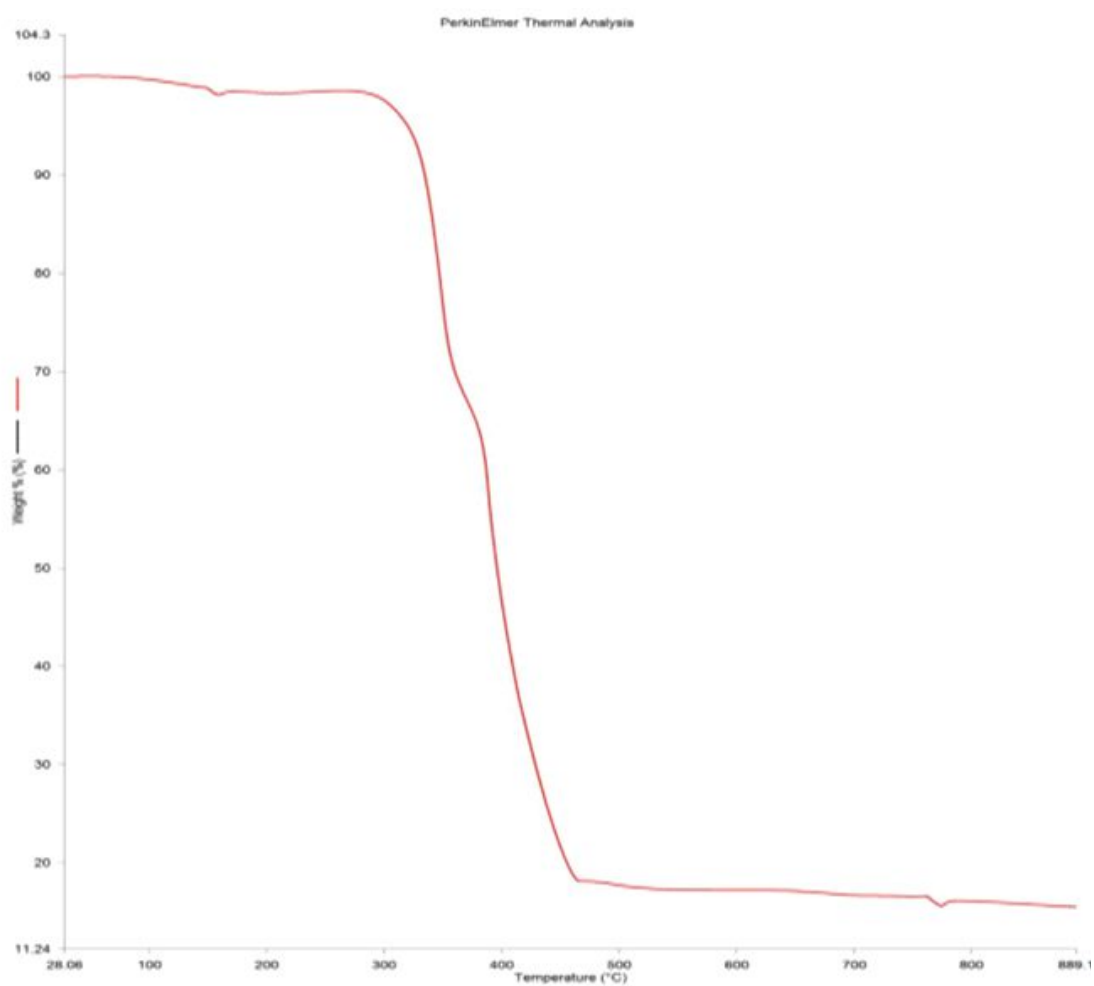


Figure 3: TGA of torrefied yam peels sample (TY)

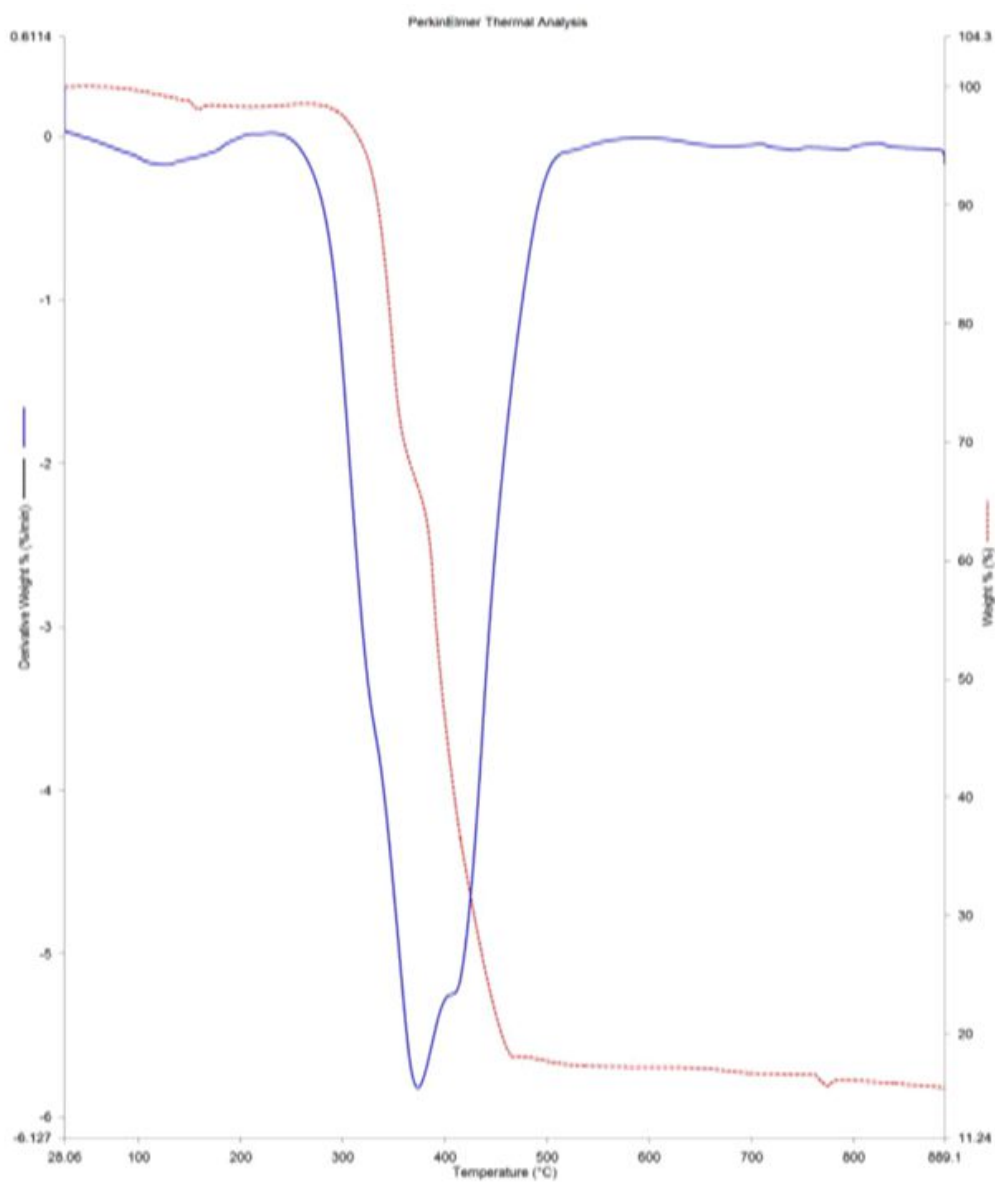


Figure 4: DTG of torrefied yam peels sample (TY)

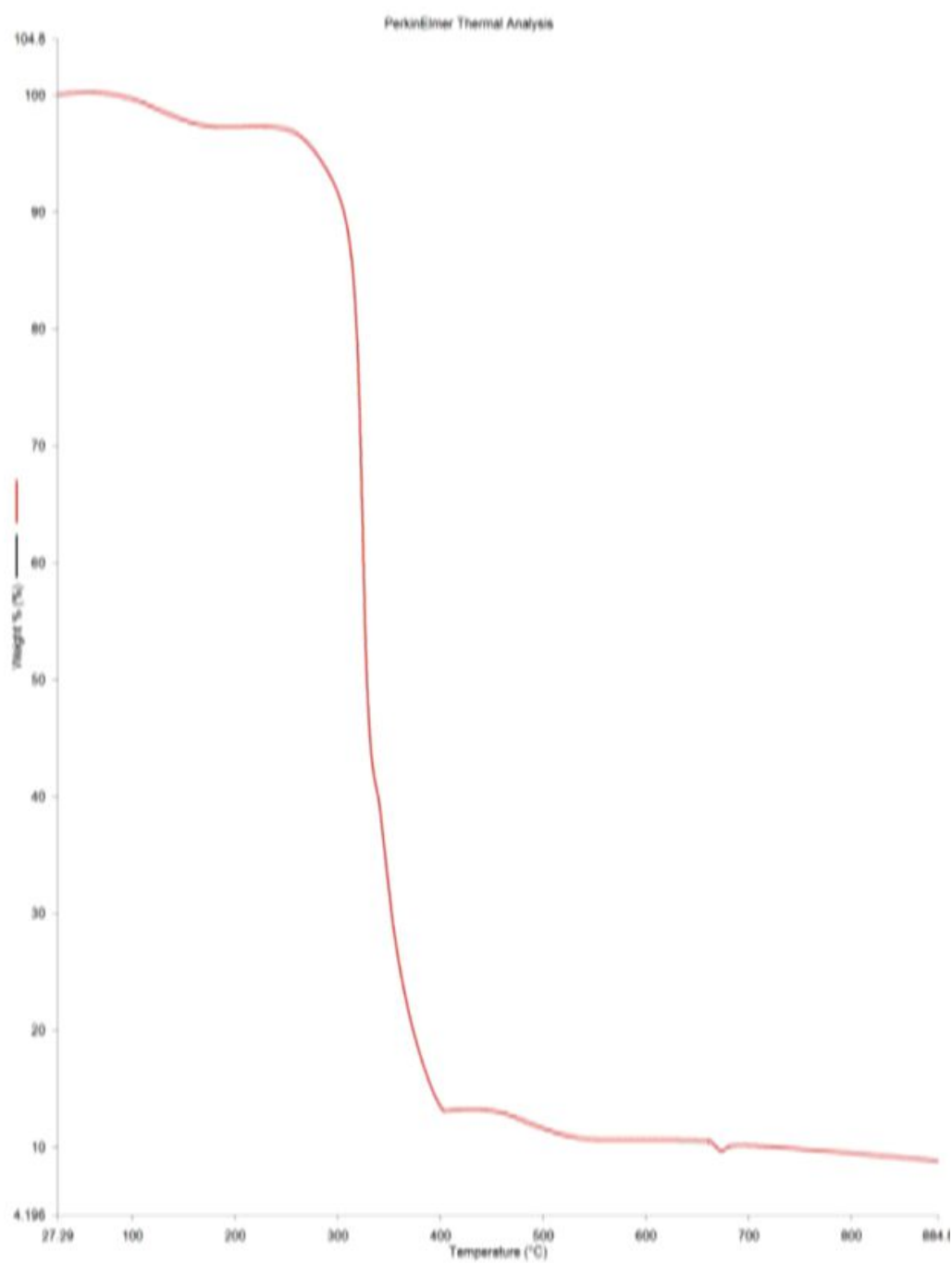


Figure 5: TGA of sundried yam peels sample (SY)

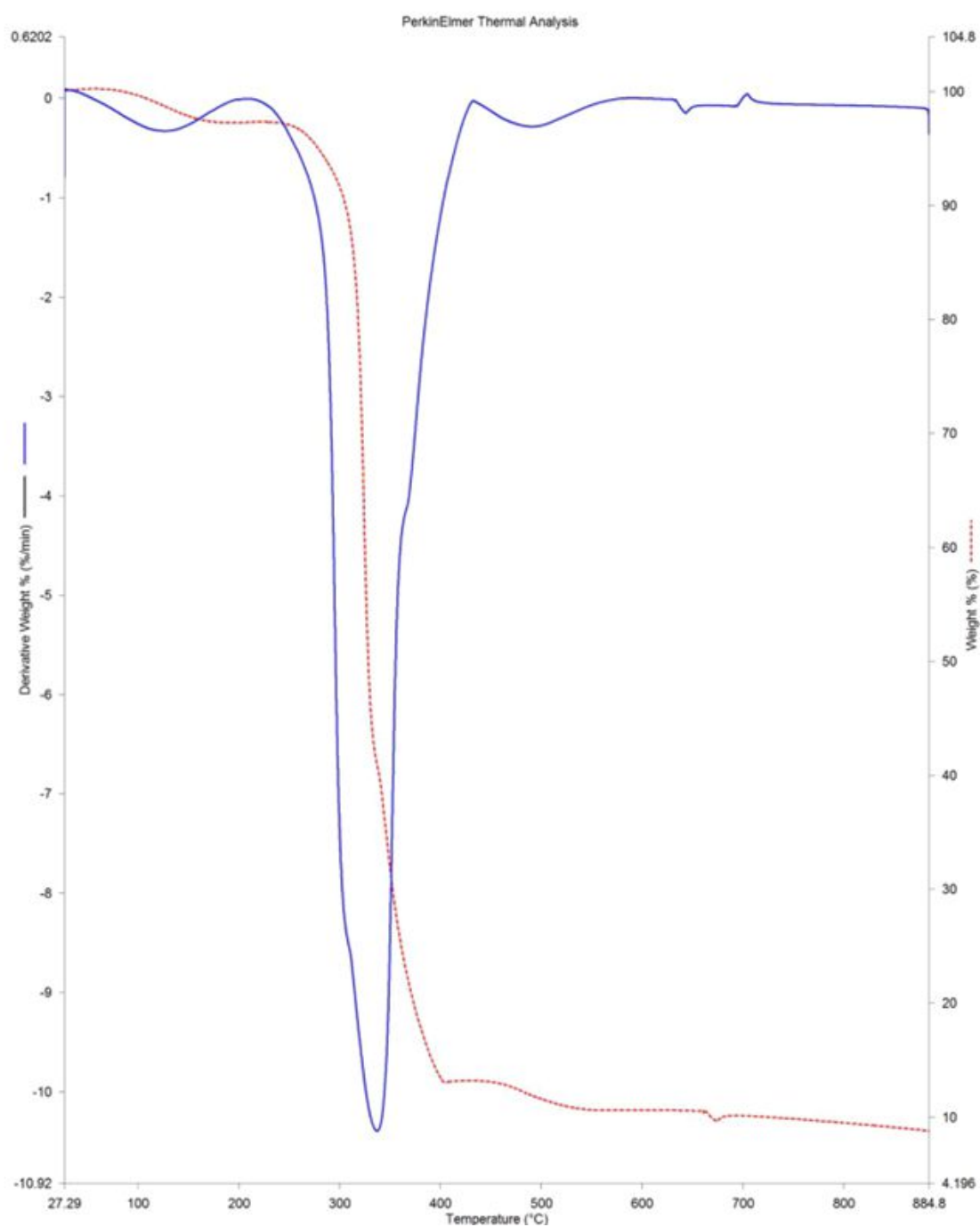


Figure 6: DTG of sundried yam peels sample (SY)

Table 1: The higher heating value of sundried and torrefied yam peels

S/N	TEMP (°C)	HHV
1	Y(sundried)	25.61
2	YI(250)	41.56
3	Y2(270)	45.37
4	Y3(300)	53.17

Table 2: The carbon, hydrogen, nitrogen, oxygen & sulphur content of torrefied yam peels at different temperatures

S/N		Result (C sundried)	CI (250°C)	C2 (270°C)	C3 (300°C)
1	C	44.52	43.45	47.60	46.72
2	H	5.03	5.27	5.33	5.38
3	O	41.69	36.48	36.71	38.05
4	N	8.50	14.60	10.16	9.65
5	S	0.20	0.20	0.20	0.20

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DEVELOPMENT AND EVALUATION OF NUTRITIONAL QUALITY OF EXTRUDED FLAKES FROM MALTED AND UNMALTED MAIZE (*Zea mays* L.) FORTIFIED WITH PUMPKIN (*Cucurbita maxima*) PULP FLOUR

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ABSTRACT

This research evaluates the quality of extruded flakes from malted and unmalted maize, fortified with pumpkin pulp. Maize was cleaned, dried and milled to give unmalted flour, while for malted, maize were cleaned, steeped in water and allowed to germinate. Germinated maize was dried, winnowed and milled. Pumpkin fruits were washed, peeled and cleaned of fibrous core and seeds. The pulp was sliced, dried and milled. Unmalted and malted maize flour was combined with pumpkin flour to give YMP2 (95:0:5), YMP3 (90:0:10), YMP4 (0:95:5), YMP5 (0:90:10), YMP6 (90:5:5), YMP7 (80:10:10), YMP8 (70:15:15) respectively, while YMP1 (100% unmalted) served as control. Flour were mixed with ingredients to form a good textured dough and extruded using a twin-screw extruder. Extruded flakes were analyzed for proximate and mineral content using (standard AOAC methods), while sensory attributes were based on a 9-point hedonic scale. Proximate content showed significant differences ($p < 0.05$), as protein increased in YMP6 (5.15%) and YMP7 (5.67 %). Fat increased in YMP2 (2.48%), YMP7 (3.02%) and YMP8 (3.20%). Fibre increased in YMP2 (5.99%), YMP3 (6.78%), YMP6 (7.91%), YMP7 (6.69%) and YMP8 (8.76%). Ash increased in YMP3, YMP4, YMP6, YMP7 and YMP8. Calcium and magnesium were abundant in the flakes while iron, manganese and zinc (were fluctuating). Calcium increased in YMP2 (16.25mg/100g), YMP3 (15.85mg/100g), YMP6 (17.96mg/100g), YMP7 (16.01mg/100g) and YMP8 (14.89mg/100g). Magnesium was the most abundant mineral element with YMP6 (21.83mg/100g) having the highest followed by YMP7 (20.40 mg/100g). Highest iron content was observed in YMP6 (4.06mg/100g). There was no significant difference in manganese among samples. All the flakes were well accepted based on, sensory scores. The extruded flakes, samples YMP6 and YMP7 revealed higher protein, ash, fibre, calcium and magnesium content and were preferred in taste, aroma, texture and overall acceptability.

Key words: Extrusion, fortification, flakes, pumpkin, quality

INTRODUCTION

As generation changes, globalization increases with consumption of fast foods of high calorific values. Corn (*Zea mays* L.) is a cereal that serves important nutritional purpose around the world for production of food varieties such as canned corn, breakfast cereals and in the formulation of infant foods [1]. Pumpkin is a fruit vegetable with high vitamins and minerals, source of antioxidants; beta and alpha-carotene [2]. Pumpkin flour is an excellent source of beta-carotene, iron, ascorbic acid and protein [3], which can be useful in food systems. Pumpkin is a perishable crop and its characteristics change with time. Pumpkin's large size and weight cause transportation problems [4] as such processing it into more utilizable forms such as incorporating it into maize for production of flakes to improve overall food quality will be an advantage. The main objective of this work is to develop and evaluate the quality of extruded flakes from malted and unmalted yellow maize, fortified with pumpkin pulp flour.

MATERIALS AND METHODS

Quality maize (Samma-27) was purchased from International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, Nigeria, while mature pumpkin fruits were purchased from Oja Oba market, Ado Ekiti, Ekiti State, Nigeria. The maize samples were cleaned, dried in oven at 65 °C for 48 hrs and milled to give the unmalted flour samples [5], while the malted maize samples were cleaned, stepped in water and allowed to germinate for 96 hrs. The germinated grains was dried in oven at 65 °C for 48 hrs, winnowed and milled into flour [6]. The pumpkin fruits were washed, peeled and cleaned of fibrous core and seeds, while the pulp was then cut into thin slices, dried in oven at 65 °C for 48 hrs, and milled into flour [3]. The unmalted and malted maize flour was combined with pumpkin flour to give samples YMP2 (95:0:5), YMP3 (90:0:10), YMP4 (0:95:5),

YMP5 (0:90:10), YMP6 (90:5:5), YMP7 (80:10:10), YMP8 (70:15:15) respectively while YMP1 (100% unmalted maize flour) serves as control. The different flour samples were mixed with sugar (80g), salt (20g), milk flavour (30g) and water to get creamy dough, which was then extruded using a twin-screw extruder to obtain firm flakes [7].

Proximate determination of the flakes

Proximate content of the flakes were determined for moisture, protein, fat, ash and fibre, while carbohydrate content was calculated by difference [8]

Determination of mineral composition of the flakes

Mineral content of the flakes were determined for calcium, magnesium, iron, manganese and zinc using the atomic Absorption Spectrophotometer. The standard solution was prepared separately for each of the elements and values determined from atomic absorption Spectrophotometer [8].

Sensory evaluation of the produced flakes

Sensory qualities of the extruded flake samples were assessed by 20-panelists based on crumbliness appearance, colour, aroma, taste, texture and overall acceptability. The quality indices were assessed on a 9-point Hedonic scale from 1-extremely dislike to 9-like extremely [9].

Statistical analysis of data

Data collected were subjected to One Way Analysis of Variance (ANOVA) and the means were separated using Duncan's multiple range test (DMRT). Statistical Package for Social Science (SPSS, version 20) was used for the statistical analysis.

RESULTS AND DISCUSSION

Proximate composition of the extruded flakes

The results of proximate composition of extruded flakes are shown in Table 1. There was significant difference at ($p < 0.05$) among the samples. The moisture content fluctuates in samples YMP 2 (5.20%), YMP3 (5.30%), YMP6 (5.72%) and YMP8 (5.15%) compared to the control sample YMP1 (4.75%). Protein content increased in samples YMP1 (4.85 %) to sample YMP7 (5.67 %). Fat content also increased in samples YMP1 (1.90 %) to sample YMP7 (3.02%) and YMP8 (3.20%). Fibre contents increased from samples YMP1 (5.65 %) to YMP6 (7.91 %), YMP7 (6.69 %) and YMP8 (8.76 %), thereby rating sample YMP8 (8.76%) as the highest fibre content among all the samples. Ash content fluctuates, but increased in samples YMP1 (3.80 %) to YMP6 (5.24 %), YMP7 (4.75 %), and YMP8 (5.25%). Carbohydrate content reduced in samples YMP6 (74.11%), YMP7 (75.72%) and YMP8 (74.24%), whereas, there was an increase in sample YMP 4 and sample YMP 8 compared to sample YMP 1. The significant differences observed in the proximate results could be due to the different combinations of the composite flours used in production of the flakes.

Mineral content of extruded flakes

The mineral composition of extruded flake samples are shown in Table 2. The results showed that the macro minerals, calcium and magnesium were more abundant in the produced flake samples, while iron, manganese and zinc were found in small quantities in all samples. Calcium increased in samples YMP2 (16.25mg/100g), YMP3 (15.85mg/100g), YMP6 (17.96mg/100g) and YMP7(16.01 mg/100g) . Magnesium increased in YMP 2(18.35mg/100g), YMP 4(19.95mg/100g), YMP 7(20.40mg/100g) and YMP 8(18.20mg/100g). There was an increase in Iron content of samples YMP 4(4.00mg/100g), YMP 5(2.86mg/100g), YMP 6(4.06mg/100g) and YMP 8(4.25mg/100g). Manganese content increased in samples YMP 3(0.09mg/100g), YMP 5(0.10mg/100g), YMP 7(0.11mg/100g) and YMP 8(0.11mg/100g). Also the Zinc content of the samples increased in samples YMP 5(0.36mg/100g) and YMP 6(0.75mg/100g). There was no significant difference in manganese content.

Sensory evaluation of the extruded flakes from

The mean sensory scores of the extruded flake samples are presented in Table 3. All flake samples were accepted based on mean replicate scores. Sample YMP4 was least preferred in taste, aroma and colour, with an overall acceptability value of 5.67. Sample YMP6 had the highest score preference in taste (7.67), aroma (7.40), colour (7.77) and texture (6.67) and crumbliness (6.87). Samples YMP6 and YMP8 had similar highest score preferences in taste, texture, crumbliness compared to the control sample YMP1. There were no significant differences ($P>0.05$) in overall acceptability of samples YMP6, YMP7 and YMP8, due to similar acceptability scores by the panelists. This shows that flakes produced from unmalted and malted maize, fortified with pumpkin pulp can be acceptable as a breakfast meal.

CONCLUSION

Extruded flakes from malted and unmalted yellow maize fortified with pumpkin pulp flour revealed high protein, ash, fibre, calcium and magnesium content in samples YMP6 and YMP7, which were preferred ahead of other samples in taste, aroma, texture and overall acceptability. This shows that unmalted and malted yellow maize flour fortified with pumpkin flour flakes could serve as an inexpensive source of nutrients and can play a role to reduce nutritional challenges especially in developing countries.

Table 1: Percentage proximate composition of extruded sampled flakes

Sample	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
YMP1	4.75 $\pm$ 0.26 ^d	4.85 $\pm$ 0.09 ^b	1.90 $\pm$ 0.13 ^c	3.80 $\pm$ 0.24 ^c	5.65 $\pm$ 0.24 ^{de}	79.04 $\pm$ 0.25 ^c
YMP2	5.20 $\pm$ 0.22 ^b	3.69 $\pm$ 0.16 ^d	2.48 $\pm$ 0.46 ^b	3.20 $\pm$ 0.24 ^d	5.99 $\pm$ 0.36 ^d	79.43 $\pm$ 0.25 ^c
YMP3	5.30 $\pm$ 0.28 ^b	4.25 $\pm$ 0.21 ^c	1.89 $\pm$ 0.05 ^c	5.13 $\pm$ 0.11 ^a	6.78 $\pm$ 0.24 ^c	76.65 $\pm$ 0.19 ^d
YMP4	4.26 $\pm$ 0.10 ^e	3.47 $\pm$ 0.47 ^e	1.15 $\pm$ 0.23 ^d	4.63 $\pm$ 0.17 ^b	5.13 $\pm$ 0.19 ^e	81.36 $\pm$ 0.61 ^a
YMP5	4.15 $\pm$ 0.24 ^e	3.09 $\pm$ 0.13 ^f	1.57 $\pm$ 0.10 ^{cd}	3.46 $\pm$ 0.08 ^d	5.41 $\pm$ 0.27 ^{de}	80.92 $\pm$ 0.37 ^b
YMP6	5.72 $\pm$ 0.29 ^a	5.15 $\pm$ 0.11 ^b	1.87 $\pm$ 0.11 ^c	5.24 $\pm$ 0.21 ^a	7.91 $\pm$ 0.15 ^b	74.11 $\pm$ 0.24 ^f
YMP7	4.15 $\pm$ 0.24 ^e	5.67 $\pm$ 0.39 ^a	3.02 $\pm$ 0.04 ^a	4.75 $\pm$ 0.08 ^b	6.69 $\pm$ 0.75 ^c	75.72 $\pm$ 0.90 ^e
YMP8	5.15 $\pm$ 0.12 ^c	3.40 $\pm$ 0.21 ^e	3.20 $\pm$ 0.46 ^a	5.25 $\pm$ 0.14 ^a	8.76 $\pm$ 0.24 ^a	74.24 $\pm$ 0.92 ^f

Table 2: Mineral composition (mg/100g) of extruded flakes

Sample	Calcium	Magnesium	Iron	Manganese	Zinc
YMP1	12.83 $\pm$ 0.01 ^e	16.43 $\pm$ 0.58 ^c	2.65 $\pm$ 0.03 ^d	0.09 $\pm$ 0.00 ^a	0.37 $\pm$ 0.00 ^c
YMP2	16.25 $\pm$ 0.00 ^b	18.35 $\pm$ 0.15 ^d	1.86 $\pm$ 0.00 ^f	0.09 $\pm$ 0.00 ^a	0.25 $\pm$ 0.00 ^d
YMP3	15.85 $\pm$ 0.01 ^c	13.80 $\pm$ 0.10 ^f	1.59 $\pm$ 0.00 ^g	0.11 $\pm$ 0.00 ^a	0.43 $\pm$ 0.00 ^b
YMP4	11.67 $\pm$ 0.59 ^f	19.95 $\pm$ 0.15 ^c	4.00 $\pm$ 0.01 ^b	0.09 $\pm$ 0.10 ^a	0.51 $\pm$ 0.00 ^b
YMP5	10.89 $\pm$ 0.00 ^g	15.43 $\pm$ 0.23 ^e	2.86 $\pm$ 0.01 ^c	0.10 $\pm$ 0.64 ^a	0.36 $\pm$ 0.75 ^c
YMP6	17.96 $\pm$ 0.00 ^a	21.83 $\pm$ 0.25 ^a	4.06 $\pm$ 0.05 ^b	0.06 $\pm$ 0.11 ^a	0.75 $\pm$ 0.46 ^a
YMP7	16.01 $\pm$ 0.02 ^b	20.40 $\pm$ 0.10 ^b	2.01 $\pm$ 0.01 ^e	0.11 $\pm$ 0.11 ^a	0.46 $\pm$ 0.39 ^b
YMP8	14.89 $\pm$ 0.00 ^d	18.20 $\pm$ 0.10 ^d	4.25 $\pm$ 0.01 ^a	0.11 $\pm$ 0.09 ^a	0.39 $\pm$ 0.44 ^c

Table 3: Sensory profile of extruded flakes

Sample	Taste	Aroma	Colour	Texture	Crumb l eness	Overall acceptability
YMP1	6.73 ±1.87 ^{ab}	6.67 ± 1.29 ^b	6.67 ±2.16 ^c	6.53 ±1.25 ^a	6.27 ±1.79 ^a	6.87 ±1.69 ^b
YMP2	6.27 ±2.12 ^{ab}	5.60 ±1.88 ^{b c}	7.27 ±1.33 ^b	6.00 ±2.42 ^b	5.33 ±2.38 ^c	6.47 ±2.00 ^b
YMP3	6.53 ±2.45 ^{ab}	6.27 ±2.37 ^b	6.00 ±1.89 ^e	5.20 ±2.59 ^c	5.80 ±2.62 ^c	6.53 ±2.29 ^b
YMP4	4.60 ±3.02 ^d	4.80 ±3.17 ^e	5.87 ±2.36 ^f	5.27 ±2.77 ^c	6.13 ±2.53 ^b	5.67 ±2.97 ^c
YMP5	5.53 ± 2.53 ^c	5.40 ±1.81 ^d	5.13 ±2.23 ^g	6.07 ±1.79 ^b	6.53 ±1.77 ^a	5.80 ±2.57 ^c
YMP6	7.67 ±1.39 ^a	7.40 ±1.35 ^a	7.77 ±1.13 ^a	6.67 ±1.05 ^a	6.87 ±1.25 ^a	7.47 ±1.55 ^a
YMP7	6.40 ±2.35 ^{ab}	6.53 ±1.59 ^b	6.20 ±1.57 ^d	6.60 ±1.45 ^a	6.07 ±1.98 ^b	7.40 ±1.50 ^a
YMP8	7.67 ±1.18 ^a	6.00 ±1.69 ^c	6.60 ±1.50 ^c	6.33 ±1.54 ^a	7.00 ±1.46 ^a	7.53 ±0.99 ^a

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EFFECTS OF COMPOSITE ALGAL SUPPLEMENTATION (*Spirulina platensis* and *Phaeodactylum tricornutum*) ON THE ZOO-TECHNICAL PERFORMANCE AND HEALTH PARAMETERS OF AFRICAN CATFISH (*Clarias gariepinus*)

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ABSTRACT

This study examined the effects of two microalgae namely *Spirulina platensis* and *Phaeodactylum tricornutum* supplementation in African catfish diets. Fish were fed five isonitrogenous and isocaloric diets containing 0mg/g of microalgae (control diet), 10mg/g of the algae mix, 20mg/g of the algae mix, 30mg/g of the algae mix and 40mg/g of the algae mix denoted as T1(Control), T2, T3, T4 and T5 respectively. The feeding trial lasted 56 days. The best Feed conversion ratio (FCR) was recorded in T3 as 1.62 ± 0.05 . The haematological analyses and organosomatic index of the fish showed a significant increase ($P < 0.05$) in the value of red blood cells and haemoglobin up to the supplementation level of 20mg/g of algae mix and decreased slightly when the supplementation level was 30mg/g. This study showed that composite mixture of *S. platensis* and *P. tricornutum* improved zootechnical performance and health of African Catfish, *C. gariepinus*.

Keyword: zoo-technical, nutrition, microalgae, supplements, fish feed

INTRODUCTION

Fish are considered to be the primary source of nutrient in most developing and underdeveloped countries, thereby creating a huge demand for fish and fish products globally (FAO, 2019). The need to offset the shortfall in supply and stagnating global capture fisheries has led to an ever increasing focus on aquaculture to meet the shortage of fish products and cater for the growing demand of the ever increasing population (FAO, 2020). The aquaculture industry has flourished significantly in recent times to meet the requirements of the fish market. The industry has witnessed continual increase in production over the last couple of decades, and it has been suggested to be the fastest growing food production (FAO, 2020). The African catfish, *C. gariepinus*, which belongs to the family *Clariidae*, is a widely and most preferred cultured species in tropical and subtropical African countries, owing to its hardy nature, high cultivability, fast growth rate, reproductive ability in captivity, high survival rate, the capability to accept formulated feed, and somewhat cheaper in comparison with other fish species (Gbadamosi and Olanipekun, 2020).

Aquafeed production depends heavily on fishmeal because of high protein, essential amino acids, fatty acids, minerals and high digestibility (FAO, 2019). Thus, continuous demand for fishmeal and shortfall in its supply has made it imperative to source for alternative replacement. An extensive review on alternative sources of feedstuffs by Romano (2018) has highlighted the use of feather meals, insect meals, algae and seaweeds. Microalgae are important aquatic flora in the world, due to their importance as the primary source of nutrient for aquatic organisms, ease of farming, technology and vast applications (Romano, 2018). Several species of microalgae have been incorporated into fish diet to assess their nutritional value, and many have been shown to be beneficial: *Chlorella* or *Scenedesmus* fed to Tilapia; *Chlorella* fed to Korean rockfish (Promkunthong and Pipattanwattankhul, 2005). The two most well-known freshwater microalgae are *Chlorella vulgaris* and *Spirulina platensis*, and have been reported as a potential alternative source to fishmeal due to their economic cost and environmental safety, and they also contain all nutrients required for fish growth (Andrade *et al.*, 2018). *Spirulina* can be used as a partial supplementation or complete replacement for protein in aqua feeds and is a cheaper feed ingredient than other animal origin (Habib *et al.*, 2008). On the other hand, *Phaeodactylum tricornutum* is a diatom. It is the only species in the genus *Phaeodactylum* and has been reported to have high eicosapentanoic acid (EPA) content (Yongmanitchai and Ward, 1991).

The objective of this study is to determine the effects of graded composite *Spirulina platensis* and *Phaeodactylum tricornutum* algae mix on growth performance, nutrient utilization, haematological parameters and organosomatic index of the African Catfish raised in a recirculatory system.

MATERIALS AND METHODS

Experimental system and fish

African catfish, *Clarias gariepinus* juveniles with average weight of $44.75 \text{ g} \pm 0.25$ were obtained from the hatchery of Fisheries and Aquaculture Teaching and Research Farm, Federal University of Technology, Akure, Ondo State. The fish were distributed randomly into plastic tanks (40cm x 30cm x 35cm) at ten fish per tank in a water recirculatory system. Each treatment was in triplicate groups of fish. They were acclimated for fourteen days while being fed commercial diet of 40% crude protein. The juveniles were not fed for 24 hours to the introduction of experimental diet to maintain a uniform stomach condition of the fish and to induce their appetite for the commencement of the feeding trial. During the feeding trial, fish were fed to satiation with their respective diets twice daily between (8.00hours-9.00hours) and (16.00hours – 17.00hours) GMT for 56days (Gbadamosi *et al.*, 2022). Zootechnical performances such as growth and nutrient utilization efficiencies were monitored during the experiment.

Experimental diet

Five isonitrogenous diet containing 40% crude protein were formulated for African Catfish, *Clarias gariepinus* juveniles in an eight-week trial experiment (Table 1). *Spirulina platensis* and *Phyodactylum tricornutum* mix was used as a supplement at 0mg, 10mg, 20mg, 30mg, and 40mg each in diet 1,2,3,4 and 5 denoted as TI(Control), T2, T3, T4 and T5 respectively. Commercial *Spirulina platensis* powder were procured from Tee natural health store, Ota in Lagos State and *Phyodactylum tricornutum* from Algaebase store, Ota in Lagos State. All dietary ingredients were first milled to small particle size. The dry ingredients were thoroughly mixed by adding hot water until a consistent dough resulted from the mix. The dough was then pelleted using Hobart A-200 pelleting machine with 2.0mm die, starch was used as a binder. After pelleting, the diets were sun dried immediately for a week to avoid mold formation and later broken mechanically into small sizes and packed in dry, air tight containers and labelled prior to use.

Chemical analysis composition and water quality

The chemical analysis of the five diets and the fish used for the experiment were performed according to the procedure of AOAC (2010) for moisture content, crude protein, lipid content, crude fibre, ash content and carbohydrate composition. Water quality parameters were monitored and measured by using HANNA Multi-Parameters Checkers.

Growth performance and nutrient utilization

Zootechnical performance of experimental fish during the experiment was based on growth performance and nutrient utilization described by Gbadamosi and Salako (2014).

Weight gain = $W_2 - W_1$; where W_2 is the final weight of fish and W_1 is the initial weight of fish in each tank

$$\text{Specific Growth Rate (SGR)} (\%d^{-1}) = \frac{100 (\ln W_2 - \ln W_1)}{t}$$

Where; W_1 and W_2 are the initial and final fish weight, respectively, and t represents the duration of the feeding trial.

$$\text{Survival Rate (\%)} = N_1 / N_0 \times 100$$

Where: N_1 = Total number of fish survival in pond at end of experiments.

N_0 = Total number of fish in tank at the beginning of experiments.

$$\text{Feed Conversion Ratio (FCR)} = \frac{\text{dry weight of feed intake (g)}}{\text{Wet weight gain by fish (g)}}$$

$$\text{Protein Efficiency Ratio (PER)} = \frac{\text{Weight gain (g)}}{\text{Protein fed (g)}}$$

Fish blood analysis

Five fish specimen were taken from each tanks for blood analysis (Svobodova *et al.*, 2005). 1ml ml of blood from the fish was collected from the cardiac puncture using different 5ml disposable heparinized syringes, with ethylene diamine tetra acetic acid (10ml EDTA) as anticoagulant. The blood analysis were carried out according to the method described by Svobodova *et al.*, (2006).

Haematological analysis

Total erythrocyte and total leukocyte levels were determined using a haemocytometer following the methods described by Svobodova *et al.* (2006). Haematocrit was determined according to Brown (1988) using micro-haematocrit method and reported as percentage packed cell volume (% PCV). Sahli's (1896) method was used for the estimation of haemoglobin levels. Derived blood parameters were estimated as follows:

Mean corpuscular volume (MCV): This is average volume of red cells, and is expressed as;

$$\text{MCV (cu.}\mu\text{m}^3) = \frac{\text{Haematocrit (\%)} \times 10}{\text{RBC count in million}}$$

Mean corpuscular haemoglobin (MCH): This is the average haemoglobin content (by weight) of a red cell, and is expressed as;

$$\text{MCH (pg)} = \frac{\text{Haemoglobin} \times 10}{\text{RBC count in million}}$$

Mean corpuscular haemoglobin concentration (MCHC): This was obtained using the formula:

$$\text{MCHC (pg)} = \frac{\text{Haemoglobin}}{\text{PCV}} \times 100$$

Organosomatic index and Hepatosomatic index

At the end of feeding trials, fish were removed from each treatment for hepatosomatic, intestinosomatic index according to Gbadamosi and Salako (2014).

Statistical analysis of data

The data obtained were reported as mean ($\pm$ S.D) was analyzed statistically to test for significant differences in the mean treatments. All data collected from the experiment (including data from proximate composition of experimental diets, fish, water quality parameters, organosomatic index and hematological parameters) during the feeding trial were subjected to one way Analysis of Variance (ANOVA). Comparison of the mean treatments were considered Significant following Duncan's New Multiple Range Test ($P < 0.05$) using SPSS (Statistical Package for Social Science Version 22) and (Microsoft office Excel programme, 2013) to determine the best result.

RESULTS

Carcass composition of *Clarias gariepinus* juveniles fed with experimental diets

The carcass composition of the experimental fish is presented below in Table 2. The moisture content level varied from approximately 6.26% in T5 to 8.00% in T1, with T1 having the highest moisture content level. However, there was significant difference ($p < 0.05$) in the percentage moisture content recorded in T1, T2 and T5, but there was no significant between T3 and T4. The ash content level varied from approximately 11.72% in T4 to 20.24% in T1. However, there was significant difference ($p < 0.05$) in the percentage ash content recorded in T1 compare to T2, and T3, but there was no significance difference between T4 and T5. The crude protein level varied from 51.09% in T1 and 66.41% in T5. However, there was significant difference ($p < 0.05$) in the percentage crude protein recorded in T1, T2, and T3, but there was no significance difference

between T4 and T5. The nitrogen free extract level varied from approximately 3.09% in T1 and 4.31% in T3. However, there was no difference ($p>0.05$) recorded among the treatments. The lipid content level varied from approximately 11.12% in T5 to 17.38% in T1. However, there was significance difference ($p<0.05$) in the percentage lipid content level recorded in T1, T2, and T3, but there was no significance difference recorded between T4 and T5.

Proximate composition of experimental diets

The result of the proximate composition of the experimental diets are presented in Table 3. The moisture content level varied from approximately 8.11% in T1 to 8.90% in T3. However, there was significant difference ($P<0.05$) in the moisture content level in all the diets. The crude protein level varied from 39.73% in T1 and 40.05% in T3. However, there was significant difference ($p<0.05$) in the percentage crude protein recorded in T1, T3, and T4 but there was no significance difference between T2 and T5. The lipid content level varied from approximately 10.31% in T2 to 11.07% in T4. However, there was no significance difference ($p>0.05$) in the percentage lipid content level recorded in T1 and T3, but there was significance difference recorded between T2 and T5. The crude fibre varied from approximately 4.36% in T2 to 4.86% in T4. However, there was significant difference ($p<0.05$) in the percentage crude fibre level recorded in T2, T3, and T4, but there was no significance difference ($p>0.05$) between T1 and T5. The ash content level varied from approximately 6.89% in T2 to 7.06% in T4. However, there's no significant difference ($p>0.05$) in the percentage ash in all the diets.

Growth performance and nutrient utilization of *C. gariepinus* juveniles fed with experimental diets

The growth parameters of the experimental fish are presented below in Table 4. The mean initial weight varied from approximately 8.21g in T4 to 8.28g in T5. However, there was no significant difference ($p>0.05$) in the mean initial weight recorded in all the treatment. The mean final weight varied from approximately 16.79g in T1 to 19.86g in T2. However, there was significant difference ($p>0.05$) in the mean final weight recorded in all the treatments. The mean weight gain varied from 8.24g in T1 and 11.30g in T3. However, there was no significant difference ($p>0.05$) in the mean weight gain recorded in T2, and T3, but there was significance difference when T1 was compared with T4 and T5. The mean feed intake varied from approximately 16.98 in T5 and 19.42 in T2. However, there was significant difference ($p<0.05$) recorded among the treatments. The feed conversion ratio varied from approximately 1.62 in T3 to 2.22 in T1. However, there was significance difference ($p<0.05$) in the feed conversion ratio recorded in T1 when compared with T2, and T3, but there was no significance difference recorded between T4 and T5. The feed efficiency ratio varied from approximately 0.46 in T1 to 0.61 in T3. However, there was significance difference ($p<0.05$) in the feed efficiency ratio recorded in T1 and T3, but there was no significance difference recorded between T2, T4, and T5. The specific growth rate varied from 0.52 in T1 and 0.65 in T3. However, there was no significant difference ($p>0.05$) in the specific growth rate recorded in T4 and T5, but there was significance difference when T1 was compared with T2 and T3. The percentage survival varied from 86.67% in T4 and 96.67 in T3. However, there was no significant difference ($p>0.05$) in the mortality rate recorded in T1, T2, and T5, but there was significance difference between T3 and T4. The hepatosomatic index varied from 1.80% in T3 and 1.97% in T4. However, there was a significant difference ($p<0.05$) in hepatosomatic index in T1, T2 and T4, but there was no significant difference ($p>0.05$) recorded in T3 and T5. The intestinosomatic index varied from 3.91% in T1 and 4.67% in T5. However, there was a significant difference ($p<0.05$) in intestinosomatic index in T1, T2 and T4, but there was no significant difference ($p>0.05$) recorded in T3 and T5. There was increase in the weight of fish fed the experimental diets with increasing levels of composite algae supplementation.

Haematological parameters of the *Clarias gariepinus* fingerlings fed with experimental diets

The blood parameters of the experimental fish are presented in the Table 5 below. The pack cell volume level varied from approximately 24.00 in T1 to 27.00 in T3.

However, there was significant difference ($p>0.05$) in the packed cell volume recorded when T1 was compared with other treatments, but there was no significance difference recorded between T2 and T3. The red blood cell level varied from approximately 2.63 in T1 to 2.98 in T3. However, there was significant difference ($p>0.05$) in the red blood cell recorded when T1 was compared with other treatments, but there was no significance difference between T2 and T4. The haemoglobin concentration level varied from 8.00 in T1 and 9.00 in T3. However, there was significant difference ($p>0.05$) in the haemoglobin concentration recorded when T1 was compared with T2, T3 and T4, but there was no significance difference between T1 and T5. The white blood cell level varied from approximately 6320 in T2 and 7530 in T5. However, there was significant difference ($p>0.05$) recorded T1 was compared with other treatments, but there was no significance difference recorded between T3 and T4 when compared together. The mean corpuscular haemoglobin level varied from approximately 29.95 in T4 to 30.38 in T1. However, there was no significance difference ($p>0.05$) in the mean corpuscular haemoglobin level recorded among the treatments. The Mean Corpuscular Haemoglobin concentration varied from approximately 33.25 in T4 to 32.34 in T1. However, there was significance difference ($p<0.05$) recorded when T1 is compared to T5 but there was no significant difference ($p>0.05$) in the Mean Corpuscular Haemoglobin concentration level recorded among T1, T2, T3 and T4. The mean cell volume varied from approximately 90.08 in T4 to 91.14 in T1. However, there was no significance difference ($p>0.05$) in the mean cell volume level recorded among the treatments. There was increase in the packed cell volume of fish fed with increasing levels of composite algae supplementation. However, the increase in the packed cell volume followed a curvilinear trend. There was a gradual decrease in packed cell volume of the experimental fish after inclusion level of 20mg/g.

Water quality parameters of the culture water

The result of the water quality parameter during the experiment is presented in Table 6. Dissolved oxygen varied from approximately 4.94mg/l in T5 to 5.63 mg/l in T1. However, there was significance difference ($p>0.05$) in the dissolved oxygen level recorded when T1 was compared with other treatments, but there was no significant difference when among T2, T3, T4 and T5. There was no significance difference ($p>0.05$) in the temperature recorded among the treatments. Hydrogen ion concentration (pH) varied from approximately 6.62 in T3 to 6.68 in T1. However, there was significance difference ($p<0.05$) in the pH recorded when T1 was compared with other treatments, but there was no significant difference ($P>0.05$) between T3 and T5.

DISCUSSION

The results obtained in this study shows that *Clarias gariepinus* fingerlings fed with the experimental diets responded significantly in their growth performance to composite algal supplementation. The growth rate of fish fed experimental diets showed that fish fed with T3 with 20mg/g inclusion of *S. platensis* and *P. tricornutum* mix had the highest mean weight gain, lowest mean feed intake, highest SGR, best FCR, and highest FER. This indicated that the best growth rate and feed utilization recorded among the fish fingerlings was recorded in T3. The results of the current research are similar to those found by Ungsethaphand, (2010) in which *A. platensis* and *Phaeodactylum* inclusion up to 20% do not have adverse effect on the specific growth rate and feed conversion ratio of hybrid red tilapia. It was also reported that dietary *A. platensis* did not have negative impacts on the growth performance in rainbow trout and they found that a tendency toward better growth performance at 7.5% and 10%. *A. platensis* which suggested the inclusion of *A. platensis* as a feed additive improved feed efficiency by increasing gut bacterial colonization (Teimouri *et al.*, 2013). The results of this research are also similar to those found by Promkunthong and Pipattanwattankhul (2005) in which catfish fed with a diet of standard feed mixed with 20mg/g *Spirulina* and *Phaeodactylum* algae had the highest protein efficiency ratio and the most carotenoids in their meat. The crude protein content of the experimental fish increased with increasing level of the composite algae supplementation while the crude lipid decreases with increase in algae supplementation level. The result of this findings are similar in the experiment where the whole body crude protein content of Olive flounder increased with the increasing dietary

protein levels while the crude lipid decrease with increase in dietary protein (Kim *et al.*, 2002).

The weight gain of fish increase with increase in the supplementation level up to 20mg/g and subsequently decline after the inclusion level of 20mg/g. The regression coefficient was 0.81, showing the regression equation. There was a beneficial relationship between the supplementation of the composite algae mixture and weight gain of fish in the current study. This is in agreement with the work of Gbadamosi and Olanipekun, (2020) and Abdel-Tawab and Ahmed (2009), who observed that the inclusion of *A. conyzoides* was found to have a regression coefficient of 0.87. It was concluded that the beneficial effect was due to the beneficial phytoenes present in the plant. The result of this findings was also in line with the experiment which observed that the weight gain and specific growth rate of fish improved with increasing dietary protein levels up to 50% Crude protein (NRC, 1993).

The physiological status of the experimented catfish was investigated by using haematological parameters. These parameters are also used for assessment of nutritional status and feed composition relative to the environmental conditions that affect the fish (Svobodová *et al.*, 2005). White blood cell and red blood cell are employed in checking feed toxicity and fish health (Ozovehe, 2013). The increase in RBC and WBC without corresponding increase in HB the supplemented diet is capable of regulating the amount of protein in their blood cell, thereby maintaining the physiology of the fish. The insignificant change in the values of HB, MCH, and MCHC, observed throughout the levels of supplementation implies that supplement of fishmeal with either of the two algae did not penalize the health status of the fishes. The obtained values in all the experimental diets agree with hematological parameter of healthy catfish (Dienye and Olumuji, 2014; Taufek *et al.*, 2016). A considerable increase in weight gain was also observed at T3 (20) supplementation for both algae, leading to a higher value of SGR in the fishes fed with supplemented diets. The packed cell volume of fish increase with increase in the supplementation level up to 20mg/g and subsequently decline after the inclusion level of 20mg/g. The regression coefficient was 0.95, showing the regression equation. There was a beneficial relationship between the supplementation of the composite algae mixture and packed cell volume in the current study. This research is similar with the work of George *et al.*, 2007 where it was observed that when 50% fish meal was supplemented by soybean meal in the diet for *Clarias gariepinus*, there was increase in PVC, HB and RBC of the fish fed the diet. This is in agreement with the work of Gbadamosi and Olanipekun (2020) where the inclusion of *A. conyzoides* was found to have a regression coefficient of 0.95.

Furthermore, the observed increase in the value of HSI in fish fed with the supplemented diets could be because of high lipid and accumulation of glycogen in the liver (Cazenave *et al.*, 2006). This shows the availability of a large amount of food at a favorable aquatic environment for growth for the samples fed supplemented diet. Fishes with higher HSI values are more energetic because HSI value is related to the performance and size of the liver (Cazenave *et al.*, 2006). The fish fed with 20mg/g experimental feed exhibited higher haemoglobin, packed cell volume and a higher immunity stimulating capacity (George *et al.*, 2007). The red blood cell counts were especially significantly higher for the fish receiving T3 (20mg/g) experimental feed which was similar to the findings of Terry *et al.* (2000) that striped catfish fed with alga had a red blood cell count of 1.91-2.83 X 10⁶cell/μL. The increase in red and white blood cells and immunity stimulating capacity could be due to the presence of *C-phycoyanin* in the *Spirulina* algae, which can help build the immunity capacity (Vonshak, 1997). In this study, water parameters such as, temperature, pH, and dissolved oxygen were within the acceptable range for fish culture as recommended by Boyd (1979). This implies that the result obtained in this study were not influenced by physio-chemical parameters of the culture tanks.

CONCLUSION

The results of this study reveal that two microalgae, *S. platensis* and *P.tricornutum* dietary supplementation are capable of improving the growth performance and feed utilization of African catfish. When algae mix of 20mg/g is added to dry feed, it increases growth rate, nutrient utilization, and survival rate.

The red and white blood cells in *C. gariepinus* were higher when the fish were fed composite algal supplemented diets, thus, improve the immune capacity of the catfish. The best algae supplementation level was 20mg per 100g of feed.

Table 1: Composition of the experimental diets in g/100g containing various inclusion level of *Spirulina platensis* and *Phaeodactylum tricornutum* in the diets of *Clarias gariepinus*.

Ingredients	T1	T2	T3	T4	T5
Fishmeal (72%)	26.50	26.50	26.50	26.50	26.50
Soya bean meal (44%)	42.50	42.50	42.50	42.50	42.50
Maize (10%)	21.00	21.00	21.00	21.00	21.00
Vegetable oil	6.00	6.00	6.00	6.00	6.00
Vitamin	2.00	2.00	2.00	2.00	2.00
<i>S. platensis</i> (mg/g)	0.00	10.00	20.00	30.00	40.00
<i>Phaeodactylum</i> powder (mg/g)	0.00	10.00	20.00	30.00	40.00

Premix manufactured by Chemiconsult International Limited, Ikeja, Lagos, Nigeria (2023).

Vitamins supplied mg/100g diet: vitamin B1 (Thiamine) 1.2mg; vitamin B2 (Riboflavine) 2.4mg; vitamin B3 (Niacin) 10mg; vitamin B5 (Pantothenic acid) 4.0mg; vitamin B6 (Pyridoxine) 2.0mg; vitamin B7 (Biotin) 0.2mg; vitamin B9 (Folic acid) 0.4mg; vitamin K 2.0mg; vitamin B12 (Cyanocobalamin) 10.0mg; vitamin C (Ascorbic acid) 150mg, chlorine 160mg.

Table 2: Carcass analyses of African Catfish (% Dry Matter) fed with experimental Diets

Treatments	T1	T2	T3	T4	T5
Moisture Content	8.00±0.08 c	7.10±0.32 b	6.41±0.28 ab	6.68±0.23 ab	6.26±0.12a
Ash	20.24±0.71 c	17.56±0.37 b	15.44±0.86 b	11.72±0.90 a	13.12±0.28 a
Lipid Content	17.38±0.30 d	15.31±0.68 c	13.70±0.43 b	12.14±0.24 a	11.12±0.56 a
Crude protein	51.09±0.89 a	55.86±1.00 b	60.15±1.10 c	66.12±1.08 d	66.41±0.66 d
Nitrogen Free Extract	3.09±0.50 a	4.17±0.39 a	4.31±0.24 a	3.34±0.36 a	3.30±0.22 a

*Figures in each row having the same superscript are significantly different (P<0.05)

Table 3: Proximate composition of experimental diets

Treatments	T1	T2	T3	T4	T5
MC	8.11±0.00a	8.73±0.01 c	8.90±0.00 e	8.77±0.01 d	8.28±0.01 b
ASH	6.95±0.05 a	6.89±0.07 a	6.90±0.08 a	7.06±0.05 a	6.99±0.02 a
LC	10.62±0.02 b	10.31±0.09 a	10.63±0.01 b	11.07±0.04 c	10.97±0.02 c
CP	39.73±0.04 d	39.82±0.01 b	40.05±0.05 c	39.97±0.04 a	39.82±0.05 b
CF	4.62±0.00 b	4.36±0.07 a	4.58±0.01 b	4.86±0.09 c	4.74±0.04 b
NFE	29.97±0.07 a	30.88±0.20 b	29.94±0.14 a	30.26±0.23 a	30.19±0.09 a

Figures in each row having the same superscript are significantly different (P<0.05)

MC- Moisture content LC- Lipid content CP- Crude protein NFE- Nitrogen free extract

Table 4: Growth performance and nutrient utilization of *Clarias gariepinus* fed with experimental diets

Treatments	T1	T2	T3	T4	T5
Initial Weight (g)	8.24±0.02 a	8.26±0.14 a	8.23±0.11a	8.21±0.12a	8.28±0.03 a
Final Weight (g)	16.79±0.57a	19.86±0.55 c	19.44±0.93bc	18.50±0.16 abc	17.81±0.54 ab
Weight Gained (g)	8.24±0.56 a	11.00±0.62 b	11.30±1.03 b	9.98±0.12 ab	9.52±0.51 ab
Feed Intake (g)	18.06±0.98 bc	19.42±0.35 c	17.72±1.10 b	18.23±0.24 bc	16.98±0.53 a
Feed Conversion Ratio	2.22±0.28 b	1.72±0.08 a	1.62±0.05 a	1.82±0.02 ab	1.78±0.06ab
Feed Efficiency Ratio	0.46±0.05 a	0.58±0.02 b	0.61±0.02 c	0.54±0.02 b	0.56±0.02 b
Specific Growth Rate	0.52±0.02 a	0.64±0.00 b	0.65±0.02 b	0.60±0.02 ab	0.59±0.02 b
Protein Intake	718.38±39.30ab	753.84±13.64b	689.02±43.02ab	712.84±9.54ab	644.15±20.36a
Protein Efficiency Ratio	0.18±0.03 a	0.27±0.01 b	0.27±0.04 b	0.22±0.01 ab	0.23±0.02 ab
Survival (%)	93.33±6.67 b	93.33±3.33 b	96.67±3.33 c	86.67±3.33 a	93.33±3.33 b
Hepatosomatic Index	1.92±0.58 a	1.94±0.41 a	1.80±0.01 b	1.97±0.01 a	1.80±0.42 b
Intestinosomatic Index	3.91±0.89 a	3.97±1.07 a	4.60±0.09 b	4.10±0.13 a	4.67±0.87 b

*Figures in each row having the same superscript are significantly different (P<0.05)

Table 5: Hematological parameter of *Clarias gariepinus* fed with the experimental diets

Treatments	T1	T2	T3	T4	T5
Packed Cell Volume (%)	24.00±0.58a	26.00±1.15 b	27.00±1.15 b	25.68±0.88 ab	24.33±0.88 a
Red Blood Cell (x103/mm3)	2.63±0.06 a	2.87±0.15 b	2.98±0.13 c	2.85±0.10 b	2.70±0.10 ab
Haemoglobin count (g/100ml)	8.00±0.17 a	8.67±0.38 b	9.00±0.38 bc	8.53±0.29 b	8.13±0.29 a
White Blood Cell (x103/mm3)	7.00±0.99 bc	6.32±0.82a	6.60±0.47 b	6.87±1.07 b	7.53±0.48c
Mean Corpuscular Haemoglobin	30.38±0.19 a	30.26±0.26 a	30.17±0.10 a	29.95±0.16 a	30.12±0.23a
Mean Corpuscular Haemoglobin Concentration	33.34±0.08 ab	33.33±0.07 ab	33.33±0.19 ab	33.25±0.08 ab	32.42±1.19 ab
Mean Corpuscular Volume	91.14±0.62 a	90.76±0.80 a	90.51±0.27 a	90.08±0.27 a	90.14±0.26 a

*Figures in each row having the same superscript are significantly different (P<0.05)

Table 6: Water quality parameters of the culture water

Treatments	T1	T2	T3	T4	T5
Temp(°C)	25.59±0.00a	25.59±0.00 a	25.59±0.00 a	25.59±0.00 a	25.59±0.00 a
Dissolved Oxygen (mg/l)	5.63±0.02 b	5.14±0.03 a	5.18±0.03 a	5.06±0.17 a	4.94±0.05 a
pH	6.68±0.01 c	6.67±0.01 bc	6.62±0.01 a	6.64±0.01 ab	6.63±0.02 a

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BIOCONTROL OF *Curvularia lunata* and *Coniella diplodiella* CAUSING LEAF SPOT AND LEAF BLIGHT DISEASES OF KENAF (*Hibiscus cannabinus*)

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ABSTRACT

The efficacies of varying concentrations of sawdust extracts of *Cola nitida*, *Anogeissus leiocarpus*, *Chlorophora excelsa*, *Funtumia elastica*, *Albizia zygia*, *Gmelina arborea* and *Triplochiton scleroxylon* in controlling *Curvularia lunata* and *Coniella diplodiella* causing leaf spot and leaf blight diseases of kenaf respectively, were assessed *in vitro*. The experiment was laid out in a completely randomised design with three replicates. Sawdust extract of evaluated tree species were more effective at 10% w/v concentration in limiting the mycelial growth of pathogenic fungi. *C. excelsa* extracts (10% w/v) induced 100% mycelial growth inhibition of *C. diplodiella* while *A. zygia* extract (10% w/v) induced 93% inhibition on *C. lunata*. These two extracts were comparable significantly ($p \leq 0.05$) to the synthetic fungicide (Z-force) in reducing the incidence of the fungal diseases on the field. In conclusion, extracts from sawdust of *C. nitida* and *A. zygia* have potentials for the management of foliar disease of kenaf, hence, they are recommended for use in managements of foliar diseases in kenaf.

Keywords: Kenaf, sawdust, extracts, disease, control

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) belongs to the Malvaceae family and the *Hibiscus* genus [16], a family notable for both its economic and horticultural importance [6]. Kenaf is useful for industrial, pharmacology and domestic applications [7, 14, 20, 22].

Plant diseases have been reported as the most significant constraints in different growing areas [21, 22] with fungal diseases being the most prevalent [11, 10, 17, 13]. The occurrence of stem rot, vascular wilt, web blight and leaf spot had been reported in savanna and semi-arid zones of Nigeria [13], incidence of leaf spot disease was reported in northern Guinea savanna region [4] and *Coniella* leaf blight, *Curvularia* leaf spot and anthracnose in South West Nigeria [19].

The continuous and indiscriminate use of fungicides causes adverse effects to human health and the environment [12], and therefore the need for new active molecules that can be used as control agents against phytopathogenic fungi [12, 15]. Plant extracts with fungistatic properties, particularly those that come from abundant forest residues and without apparent use, could be used directly and at low cost for disease control in crops.

Sawdust is a waste with little economic value, available in saw-milling industries, pulp plant and paper industries as well as wood processing industries particularly, in the southern part of Nigeria in large volume as heaps with attendant environmental pollution [21]. There is therefore the need to explore the usefulness of these available material, such as in the control of fungal diseases. It is therefore necessary to evaluate the effect of sawdust from some tropical tree species for their potential as antifungal control agents.

This study was aimed at determining the effect of sawdust extract on the mycelial growth of *Curvularia lunata* and *Coniella diplodiella* causing leaf spot and leaf blight diseases of kenaf respectively.

MATERIALS AND METHOD S

Isolation of associated fungi from kenaf

Symptomized leaf samples were collected from kenaf plants at the teaching and research farm of I. A. R & T, Ibadan and cut into small pieces of about 2 mm-diameter from the advancing margins of lesions and healthy portions, surface sterilized with 1% sodium hypochlorite (NaOCl) for one minute followed by three serials washing with sterile distilled water. Sterilized leaf bits were aseptically plated on solidified streptomycin amended PDA (Potato Dextrose Agar) medium in 90 mm diameter Petri dishes incubated at $27 \pm 1^\circ\text{C}$ for seven days.

Developing fungal colonies were purified by hyphal tip cut method to obtain pure culture of the isolates, these were kept for further use.

Evaluation of the in vitro effect of sawdust extracts on pathogenic fungi

Sawdust of seven (7) tropical plants were collected from sawmill at Kotopo, Abeokuta, Ogun State. The tropical trees from which sawdust were obtained are; *Anogeissus leicarpus* (DC) Guill & Perr, *Gmelina arborea* (Roxb), *Albizia zygia* (DC) J. F. Macbride, *Cola nitida* (Vent.) Schott & Emdl., *Triplochiton scleroxylon* (K.) Schum, *Funtumia elastic* (Preuss) Stapf and *Chlorophora excelsa* (Welw) Benth & Hook. The tree species were selected based on their reported antimicrobial properties.

The extracts were added at concentrations of 0.5 g/ml, 0.75 g/ml and 1.0 g/ml each in Petri dishes with a PDA culture medium before solidification. An absolute control without plant extract was also included. When the culture medium solidified, 2mm diameter disk of the corresponding pathogens were placed at the centre and left to incubate at 27 ± 1 °C. Mycelial growth was measured after 5 days. Percentage inhibition of mycelial growth was calculated using Equation:

$$\text{Growth inhibition (\%)} = \frac{dc-dt}{dc} \times 100 \quad [16]$$

where: *dc* is diameter of fungal colony in control treatment and *dt* is diameter of fungal colony with treatment.

Assessment of the saw dust extracts for the control of the foliar diseases

Saw-dust extract of *C. nitida*, *F. elastica* and *A. zygia* were chosen based on highest mycelia growth inhibition observed during the *in vitro* experiment and highest concentration of 1.0 g/ml. These were prepared by weighing ten grams of each plant sawdust with a sensitive weighing balance (Camry Sensitive Scale Model EKS350). Weighed samples were each mixed in 1 L of water, soaked for 24 hrs and sieved through 1 mm cheese cloth for each extract. Three fungicides with different active ingredients viz; hexacal (Hexaconazole), Z-force (Maconzeb 80% WP) and Red-force (Metalaxyl M 6% + Copper (I) oxide) were used at the rate of 50 g in 15 L of water.

Field experiment was carried out at the experimental field of IAR&T. Three varieties of kenaf; Ifeken DI 400 (indigenous), Cuba 108 (exotic) and Tianug 2 (exotic) were planted. The experiment was laid out in a Randomized Complete Block Design with three replicates. Natural infestation of kenaf plants was allowed, spraying with sawdust extracts commenced at 4 WAP and repeated at 2 weeks interval till 10 WAP. Control plots were sprayed with sterile distilled water. Disease incidence was assessed at weekly interval from 6 WAP to 10 WAP within each plot. Percent disease incidence was determined.

Data analysis

Data collected were subjected to analysis of variance to determine significant effects of the treatments imposed and means of significant treatments were separated using Duncan's Multiple Range test at 5% probability.

RESULTS

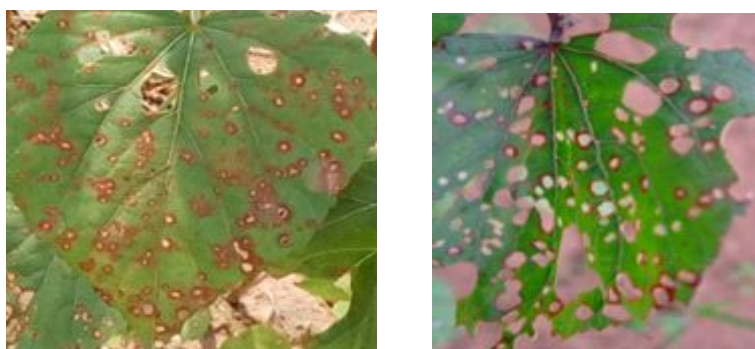


Plate 1. Curvularia leaf spot disease early stage (a), later stage (b),

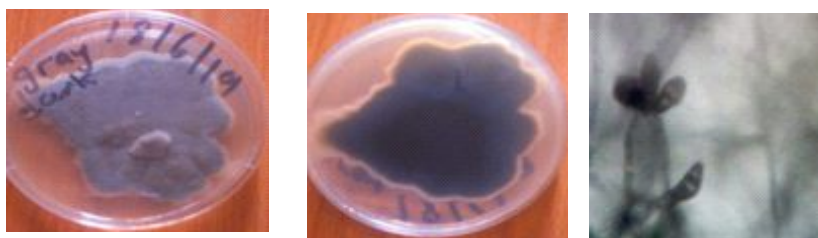


Plate 2. Colony of causal pathogen



Plate 3: Coniella leaf blight disease of kenaf



Plate 4: Culture of the causal pathogen

The effect of sawdust extract on the mycelial growth of *Coniella diplodiella* are presented in Figure 1. Sawdust extracts of *C. excelsa* at 10 w/v induced total (100%) inhibition on the mycelial growth of *C. diplodiella*. The pooled effect of the extract revealed an inhibition range of the sawdust extract from 75% (*C. nitida*) to 93% (*A. zygia*) with the highest inhibitory effect from *A. zygia*, *C. excelsa* and *G. arborea* then *A. leiocarpus*.

The mycelial growth of *Curvularia lunata* was significantly ($p \leq 0.05$) reduced by the sawdust extract (range of 37% to 100%) relative to the control (Figure 2). The pooled effect of the sawdust extracts over the three concentrations emphasized the effectiveness of sawdust extracts from *F. elastica* and *A. zygia*, then *G. arborea*, *A. leiocarpus* and *T. scleroxylon* in inhibiting the mycelial growth of *C. lunata*.

Assessment of sawdust extracts for fungitoxicity on diseased kenaf plants on the field

Effects of the foliar spray of sawdust extracts from *Albizia zygia*, *Cola nitida* and *Funtumia elastica* at 10 w/v on the incidence of *Curvularia* leaf spot, *Zonate* leaf spot, *Coniella* leaf blight, *Anthraxnose* and *Fusarium* leaf blight diseases on the field are presented in Table 1. Foliar spray of *A. zygia* and *C. nitida* significantly ($p \leq 0.05$) reduced the incidence of *Curvularia* leaf spot on kenaf compared to the control on the field. The incidence of the disease in plots sprayed with sawdust extract from *F. elastica* was also similar to the control plots. None of the sawdust extracts used and the synthetic fungicides were effective in reducing the incidence of *Coniella* leaf blight, incidence of *Coniella* leaf blight with Hexical (5.17), is comparable to the control 2.75%, 7.33% and 0.50% respectively.

DISCUSSION

The ability of these sawdust extracts to cause significant reduction in the mycelia growth of each fungus showed their fungicidal ability enhanced by possession of bioactive compounds. These plants had been reported to possess alkaloids, flavanoids, tannins, phenolics and many more phytochemicals [3, 21] which may also have conferred the antimicrobial and fungicidal properties on them [15, 9]. *C. nitida* had been confirmed to contain alkaloids, tannins, flavonoids and saponins [3, 5]. the efficacy of sawdust extract of *C. nitida*, *G. arborea* and *M. excelsa* in reducing the mycelial growth of cassava rot fungi had been reported [1]. The antifungal property of *Anogeissus leiocarpus* conforms to the report of [26] that the extract effectively inhibited the mycelial growth of *Curvularia* sp isolated from leaf blight of *Jatropha curcas*. Furthermore, the antifungal potential of *Funtumia elastica* had been reported [2] *in-vitro* against *Aspergillus flavus*, *Candida albicans*, *Microsporium audouinii*, *Penicillium* sp, *Trichophyton mentagrophytes*, *Trichoderma* sp. and *Trichosporon cutaneum*.

The activities of these sawdust extracts against *Curvularia lunata*, and *Coniella diplodiella* increased with increasing concentration in the study. This may be an indication that the quantity of secondary metabolites in a plant extract positively correlates with its concentration [8, 25].

CONCLUSION

Aqueous extract of *Cola nitida* and *Albizia zygia* sawdust at 10% w/v were most effective in the control of fungal pathogens of kenaf and reduces the incidence of the diseases on the field.

RECOMMENDATIONS

Aqueous extract of *Cola nitida* or *Albizia zygia* should be used to control the incidence of *Curvularia* leaf spot at the rate of 2.5 kg/ha. The aqueous extract of *Cola nitida* and *Albizia zygia* sawdust should be further investigated for the control of other diseases of kenaf in Southwest Nigeria.

Table 1: Effect of sawdust extracts of *Albizia zygia*, *Cola nitida* and *Funtumia elastica* on incidence of curvularia leaf spot and coniella leaf blight on the field in Ibadan

Sawdust extract	Disease incidence (%)	
	<i>Curvularia</i> leaf spot	<i>Coniella</i> leaf blight
<i>Albizia zygia</i>	0.00d	5.58bc
<i>Cola nitida</i>	0.33d	8.17abc
<i>Funtumia elastica</i>	1.00cd	6.67abc
Hexical (Hexaconazole)	4.00b	5.17c
Red-force (Metalaxyl M 6%+ copper (I) oxide	15.00a	9.50a
Z-force (Mancozeb 80% WP)	0.33d	8.83ab
Control	2.00c	7.33abc

Means with the same letter along the column are not significantly different at 5% probability according to Duncan's Multiple Range Test

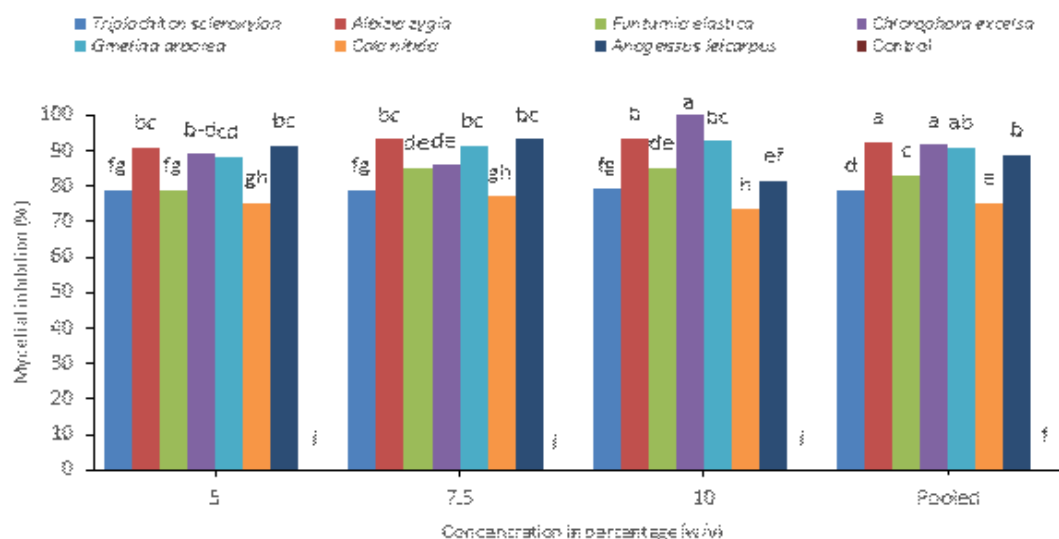


Figure 1. Inhibitory effect of sawdust extracts of *T. scleroxylon*, *G. arborea*, *A. leiocarpus*, *C. excelsa*, *A. zygia*, *F. elastica* and *C. nitida* on mycelial growth of *Coniella diplodiella* culture at 5 days after inoculation

Means with the same letters between the concentrations, and within the pooled means are not significantly different at 5% probability according to Duncan's multiple range test

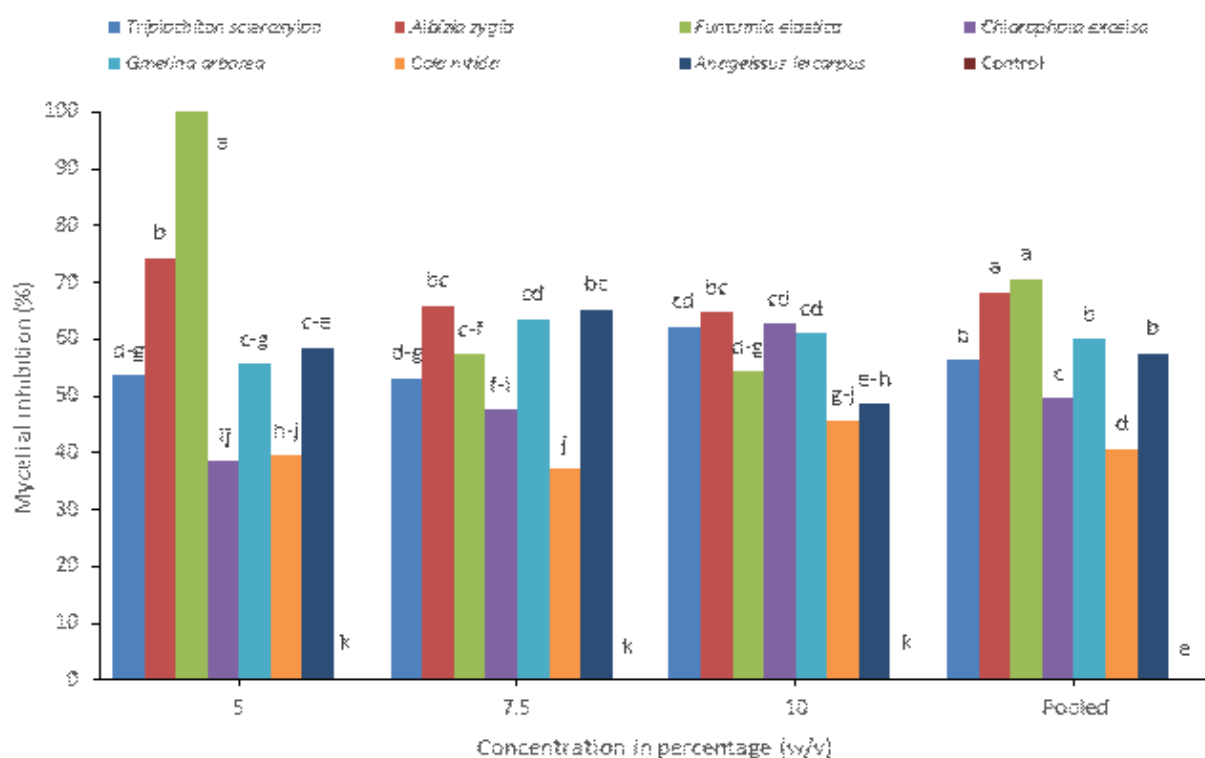


Figure 2. Inhibitory effect of sawdust extracts of *T. scleroxylon*, *G. arborea*, *A. leiocarpus*, *C. excelsa*, *A. zygia*, *F. elastica* and *C. nitida* on mycelial growth of *Curvularia lunata* at 5 days after inoculation

Means with the same letters between the concentrations, and within the pooled means are not significantly different at 5% probability according to Duncan's multiple range test

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ASSESSMENT OF THE NUTRITIONAL COMPOSITION OF THE FRUITS OF JUTE MALLOW (*Corchorus olitorius*)

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ABSTRACT

Corchorus olitorius is a multipurpose leafy green vegetable with enormous nutritional and nutraceutical advantages. Nutritional quality of the edible portions of crops is largely influenced by genotypes and crop management practices. The study investigated the variation in the nutrient quality of fresh fruits of organically produced *Corchorus olitorius* accessions. Poultry manure was applied at the rate of 10 tonnes per hectare. Proximate and selected minerals of the fresh fruits were assayed. The proximate and mineral contents of the fresh *Corchorus* fruits were significantly ($p < 0.05$) influenced by accession (genotype). The crude protein was in the range of 2.4-2.9%, crude fibre 1.6-1.94%, ash 1.46-2.30%, crude fat 0.13-0.18%, carbohydrate 5.14-7.16%, moisture 85.20-89.22%. Co-Ekiti had the highest concentrations of the crude protein, crude fat, ash, carbohydrate, crude fibre and the least moisture content. Manganese (Mn) was in the range of 1.5-5.64 (mg/100 g), Phosphorus (P) 43.25-85.50 mg/100 g, copper (Cu) 0.13-0.23 (mg/100 g), sodium (Na) 10.92-11.88 (mg/100 g). Co-Ekiti recorded the highest Mn content, Co-Lagos had the highest Na content, while Cu and P concentrations were highest in Co-Osun. Co-Ekiti demonstrated superior nutrient quality and its production and consumption are recommended.

Keywords: *Corchorus olitorius*, minerals, proximate, fruits, vegetable

INTRODUCTION

Global hunger, which is the measure of the prevalence of undernourishment remained unchanged, affecting about 9.2 percent of world's population in 2022. Around 900 million (11 percent) people in the world were severely food insecure, while 2.4 billion were reported to be moderately or severely food insecure in 2022 (1). The report further noted that while progress was made towards reducing hunger in Asia and Latin America, hunger is still on the increase in Western Asia, The Caribbean and the sub-regions of Africa. Baiyeri et al. (2) noted that malnutrition was considered the problem of the resource-poor people in time past, however, research in recent times revealed that “hidden hunger” (micronutrient malnutrition) is a more complex nutritional challenge and could be less obvious. Hidden hunger affects the elites as well as the resource-poor people. There are however promising opportunities in the underutilized and neglected crops and especially the indigenous fruits and vegetables for global food and nutrition security that have not been exploited, especially by low income and resource-poor people.

Corchorus olitorius is one of these important and multipurpose green leafy vegetables with enormous opportunities for food, medicine and raw materials that are yet to be exploited. *Corchorus olitorius* is considered to be a native to the African and Asian continents, but grown in South America, Africa, Australia and some parts of Europe for dietary preparations and industrial use (3, 4). It is valued for its high mineral, vitamin and phenolic contents (5). It is an excellent source of bioactive compounds, protein, certain hormones, and carbohydrates (6, 7). Earlier reports have shown that this green leafy vegetable has enormous nutraceutical and medicinal values (8, 9). The nutritional and the antinutritional values of its fruits have been reported by various authors (10, 11, 12).

Antinutritional and nutritional compositions of crops are usually affected by a number of genetic and environmental factors. Soil nutrition (soil fertility) is one of the environmental factors that largely influence nutritional quality of the edible portions of crops. Numerous advantages have been associated with organic fertilizers like poultry manure that make them invaluable for high yield in crop production and enhanced nutritional quality. Organic fertilizers increase the soil organic matter content of the soil, thereby enhancing the fertility of the soil. They improve soil cation exchange capacity and promote soil aggregates. They enhance soil structure, improve air spaces and water retention capacity of the soil, thereby improving root growth and development as well as nutrient uptake (13).

Organic fertilizers play major roles in sustainable intensification of crop production since they are released slowly in the soil in a sustained manner.

Baiyeri and Samuel-Baiyeri (11) reported the nutritional and anti-nutritional contents of fresh fruits of *Corchorus* grown using inorganic fertilizer (NPK). Baiyeri et al. (12) reported the nutritional and anti-nutritional composition of the fruits of *Corchorus olitorius* organically grown using poultry manure at five tonnes (5 tonnes) per hectare. Increasing organic fertilizer usage has been reported to influence nutritional quality in a green leafy vegetable production (14). It was deemed necessary to investigate the differences in the nutritional composition of the fruits of *Corchorus olitorius* accessions as a response to higher poultry manure application, than the rate that had been earlier reported. This study was therefore initiated to investigate the effect of organic fertilizer (poultry manure at 10 tonnes/ha) on the nutritional quality of the fresh fruits of five Nigerian accessions of *Corchorus olitorius*.

MATERIALS AND METHODS

Sample collection: The fresh fruits of *Corchorus olitorius* used for this study were collected from an agronomic evaluation of *Corchorus* accessions (cultivars) collected from Ekiti, Lagos, Ondo, Osun and Oyo States, Nigeria. Each accession was named after the state where it was collected from; having the prefix Co (*Corchorus olitorius*) attached to it. The *Corchorus* accessions were evaluated on the field using poultry manure applied at 10 tonnes per hectare. No agrochemicals were used in growing the vegetable. The collected fresh fruit samples were put in new and well labeled envelopes and immediately taken to the laboratory for biochemical analysis.

Proximate analysis: Proximate composition was carried out using AOAC (15) method. Crude protein was analysed using the AOAC 2005 (955.04), crude fat (954.02), moisture (930.15), ash (920.117) and crude fibre (978.10). Carbohydrate was obtained by taking the difference: $100\% - (\% \text{ moisture} + \text{crude protein} + \text{crude ash} + \text{crude fibre})$.

Mineral analysis: The minerals were analyzed using AOAC 2005 method (968.08). Mineral concentrations in the digested fresh fruit samples of *Corchorus* were determined using a Buck Scientific Atomic Absorption Spectrophotometer (Model: 210VGP).

Statistical analysis: All nutritional data collected were analyzed using the R statistical analysis package version 4.1.1. The analysis of variance was done using the library *Agricolae*.

RESULTS AND DISCUSSION

The accessions significantly ($P < 0.05$) influenced the proximate composition of the *Corchorus* fruits. Co-Ekiti had the highest concentrations of crude protein, crude fat, ash, carbohydrate and crude fibre. Co-Ekiti recorded the least moisture content. Co-Ondo accession recorded significantly lowest crude protein, ash and carbohydrate. Co-Lagos recorded the least fibre content, while Osun had the least crude fibre content. The crude protein was in the range of 2.4-2.9%, crude fibre 1.6-1.94%, ash 1.46-2.30%, crude fat 0.13-0.18%, carbohydrates 5.14-7.16%, moisture 85.20-89.22%. The proximate composition of the fresh *Corchorus* fruits analysed in this study was comparable with what has been reported for fresh okra pods (fruits) per 100 g (protein 2.10 g, carbohydrate 8.20 g, fat 0.2 g, fibre 1.70 g, moisture 88.6 g) (16). The proximate quality result was within the range of what had been reported by (11, 12) for fresh *Corchorus* fruits. The crude protein in the fruits of these accessions in the present study was however higher than the crude protein that Samuel et al. (10) had reported in *Corchorus olitorius* fresh fruits. Fruits of the *Corchorus* accessions that were grown with 10 tonnes of poultry manure in this study did not significantly differ in their proximate quality when compared with proximate composition of the *Corchorus* fruits grown with 5 tonnes of poultry manure (12). This suggests that the application of more than 5 tonnes per hectare of poultry manure for enhanced proximate quality in the production of fruits may not necessarily result in significantly higher proximate parameters. Hence the application of poultry manure rates above 5 tonnes/ha, solely for enhanced proximate composition may not be recommended and could be of huge economic losses considering the costs of its purchase, transportation, and its application.

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The mineral content of the fresh *Corchorus* fruits was significantly ($p < 0.05$) influenced by accession. Manganese (Mn) was in the range of 1.5-5.64 (mg/100 g), Phosphorus (P) 43.25-85.50 mg/100 g, copper (Cu) 0.13-0.23 (mg/100 g), sodium (Na) 10.92-11.88 (mg/ 100 g). Co-Ekiti recorded the highest Mn and the least Na and Cu concentration, Cu and P was highest in Co-Osun, while Co-Lagos recorded the least P content. The Na and P contents of the fresh *Corchorus* fruits were slightly higher than the levels reported for dry okra pods by Habtamu et al. (17). The Mn and P in the present study was higher than what have been reported for fresh *Corchorus* fruits by Samuel et al. (10) but Na was higher in the fruit of the accession they analyzed. The four minerals in this study were similar in their concentrations to the Mn, P, Cu and Na contents of fresh *Corchorus* fruits grown with the application of 5 tonnes/ha of poultry manure (12). This suggests that 5 tonnes/ ha of poultry manure could be optimum for the levels of the minerals obtained in this study. Manganese and copper are very important micronutrients in human nutrition; Mn functions as an activator in many enzymatic reactions, while Cu is involved in energy metabolism and crucial in the release of iron from the cells into plasma (18). Phosphorus as phosphate is involved in energy metabolism, a component of bones and cells while Na is a systemic electrolyte and an important mineral involved in the co-regulation of ATP with potassium (19).

CONCLUSION

The study revealed the nutritional density (proximate and mineral) of the fresh fruits of the *Corchorus* accessions. Producing *Corchorus* fruits with the application of 5 tonnes/ ha of poultry manure could be optimum for the levels of the minerals and proximate quality obtained in this study. Co-Ekiti demonstrated superior nutrient quality and its production and consumption are recommended.

Table 1. Proximate composition (%) of the fresh fruits of *Corchorus olitorius* accessions

Accession	Crude protein	Crude fat	Crude ash	Moisture	Dry matter	Carbohydrate	Crude fibre
Co-Ekiti	2.90 ^a	0.18 ^a	2.24 ^a	85.20 ^b	14.80	7.16 ^b	1.94
Co-Lagos	2.45 ^c	0.17 ^a	1.46 ^b	88.51 ^{ab}	11.49	5.94 ^c	1.49
Co-Ondo	2.24 ^d	0.16 ^a	1.46 ^b	89.22 ^a	10.78	5.14 ^d	1.80
Co-Osun	2.75 ^b	0.13 ^b	2.30 ^a	87.23 ^{ab}	12.77	8.16 ^a	1.61
Co-Oyo	2.32 ^d	0.14 ^b	1.84 ^{ab}	86.89 ^{ab}	13.11	6.90 ^b	1.92
Mean	2.53	0.16	1.86	87.41	12.59	6.66	1.75

Means followed by different letters are significantly different by a Tukey's HSD test at $\alpha = 0.05$

Table 2. Mineral composition (mg/100 g) of fresh fruits of *Corchorus olitorius* accessions

Accession	Phosphorus	Manganese	Sodium	Copper
Co-Ekiti	64.60 ^d	5.64 ^a	10.92 ^d	0.13 ^c
Co-Lagos	43.25 ^e	2.64 ^d	11.88 ^a	0.23 ^b
Co-Ondo	66.35 ^c	1.52 ^e	11.16 ^c	0.14 ^c
Co-Osun	85.50 ^a	4.65 ^b	11.66 ^b	0.27 ^a
Co-Oyo	70.53 ^b	3.18 ^c	11.24 ^c	0.15 ^c
Mean	66.05	3.53	11.37	0.18

Means followed by different letters are significantly different by a Tukey's HSD test at $\alpha = 0.05$

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PERFORMANCE OF HOT PEPPER ON SOIL AMENDED WITH RENDERED ABATTOIR EFFLUENT ON AN ALFISOL

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ABSTRACT

Abattoir waste management is of great concern in both urban and rural areas of Nigeria. Despite the potential benefits of abattoir effluent to improve the soil fertility and yield of crops, its integration into agricultural soil management strategies depend on soil type and environment which vary widely. This study was established to evaluate the effect of rendered abattoir effluent on performance of hot pepper 'sombo'. The experiment was a 4x4 factorial laid out in split plot arrangement. The treatments were: time of application of effluent - 6 weeks before transplanting (6WBT); 4WBT, 2WBT and at transplanting and rate of application of effluent-control (0); 15,000; 20,000; and 25,000 L/ha. Data was collected on the yield and yield parameters such as plant height, number of leaves, stem girth, fruit weight, number of fruits and fruit length. Data was subjected to Analysis of Variance and significant means separated using New Duncan Multiple Range Test at 5% probability. Results showed that time of application had no significant effect on all the parameters observed, while rate of application was significant. At vegetative stage, control treatment gave the highest means for plant height, number of leaves and stem girth. Though yield was not significantly affected, application of effluent at rate of 15000L/ha gave the highest mean fruit weight and fruit length.

Key words: waste water, pollution, soil amendment, slaughter house.

INTRODUCTION

Capsicum (chilies and other peppers) belong to family Solanaceae, which also includes other economically important crops such as tomato, potato and tobacco [6]. Pepper is an important agricultural crop because of its' economic importance, nutritional and medicinal content and most importantly it is an excellent source of natural colors and antioxidant compounds. Pepper is the world second most important vegetable, ranking after tomatoes and the most produced type of spice flavoring and coloring for food, while providing essential vitamins and minerals. The crop can also be distinguished by its strong, sharp smell or flavor. Both hot and sweet peppers contain more vitamin C to prevent flu colds than any other vegetable crop [5]. World production of pepper was estimated at 21.3 million tons. from a harvested area of 1.6 million ha in 2001 [7]. Comparatively, yield in the developing countries is about 10 – 30% of that in developed countries [8]. However, Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of the African production and the major area of production lie within the derived savannah zone of Northern Nigeria [7].

Although, pepper is widely cultivated throughout Nigeria, yields obtained by peasant farmers are often very low [3]. Organic agriculture has the potential to meet the global food demand and to lessen the damaging environmental effects of conventional agriculture. Investigations on the application of abattoir waste as an organic fertilizer is therefore an appropriate proposition. Application of the abattoir waste on agricultural land would circumvent the necessity of conventional treatment of the abattoir waste, which as observed previously is cost intensive. Abattoir effluent, is the by-product from slaughtered animals not used for human consumption. Considerable quantities of abattoir effluent is often disposed of, via community sewers with little or no primary treatment thus contributing to organic and nutrients load of streams leading to eutrophication [1]. These contributed greatly to possible food-borne diseases and potential health hazards associated with food, especially in developing countries like Nigeria [4]. Application of abattoir waste to improve soil is a good option due to its rich mineral content for nourishing plants. Nitrogen and phosphorus are the major nutrients released from the waste for plant uptake after decomposition by heterotrophic microorganisms [9]. Studies have shown that improved soil fertility, plant growth and improved yield could be achieved. However, it has been reported that application of abattoir effluent without proper treatment may pose reflective impact on the soil

characteristics, which are related to the soil fertility [2]. Rendering of the abattoir effluent before use has been prescribed [4]. It is a process of cooking that converts the semi-solid waste into a protein-rich substance that appears like soil. Products derived from rendering permits storage for a long period of time. This study thus evaluated the performance of pepper on soil amended with rendered abattoir wastewater.

MATERIALS AND METHODS

The experiment was carried out at the nursery section of the Faculty of Agriculture, University of Ilorin Teaching and Research Farm, University of Ilorin, Kwara State. The University of Ilorin is located in the southern Guinea Savanna zone of Nigeria which lies on latitude 8° 29'20.9N and longitude 4°33' 11.1E. It is categorized under the bimodal rainfall pattern with high rainfall in June and September, and a break between mid-July and August. In Ilorin, the average annual temperature is 26.5 °C with average annual rainfall of 1217 mm. The potted experiment was a 4 x 4 factorial laid out using split plot arrangement. The topsoil used for the study was collected around the nursery behind the Faculty of Agriculture. The seedlings were raised in the nursery by broadcasting method and then covered with top soil lightly for easy emergence. The seedlings were transplanted ten weeks after to pots filled with 10kg of topsoil. The treatments were; Time of application of effluent which served as the main plot which include; T1: 6weeks before transplanting, T2: 4weeks before transplanting, T3: 2weeks before transplanting and T4: at time of transplanting. The rates of application were the sub plots; R1: control, R2: 15000L/ha, R3: 20000L/ha and R4: 25000L/ha. All treatments were replicated thrice. Abattoir effluent was collected from Akerebiataa, Ilorin, Kwara State while the pepper variety used was obtained at the Ministry of Agriculture, Ilorin, Kwara State. After collection of abattoir effluent from the slaughter house, bovine blood and rumen (digesta) in ratio 3:1 was weighed in a metallic container. The contents was boiled for 90 minutes by placing the container on a coal-fired earthen stove. The digesta was stirred continually until the content was almost free of water. Finally the mass was dried under the sun for 3 days to obtain the dried organic fertilizer. The product was a dry, solid, deep brown-colored powder and easily spread. It was then applied to the top soil based on the treatment specifications on time and rate of application. The seedlings were transplanted at the rate of two seedlings per bucket at a spacing of 50cm. The plants were irrigated throughout the period of the study. Topsoil samples between 0-15 cm depths were taken randomly from the experimental site to form a composite, air dried, sieved and taken to the laboratory for the determination of some physical and chemical properties using standard laboratory procedures (AOAC, 1990): Data were collected on the following parameters: plant height, number of leaves, stem girth, number of fruit /plant and fruit weight / plant. All data were subjected to Analysis of Variance (ANOVA) using Genstat. Significant means were separated where appropriate by the New Duncan Multiple Range Test at 5% probability level.

RESULTS AND DISCUSSION

The physical and chemical properties of the soil and abattoir effluent prior to planting were presented on table 1. The values showed that the soil was sandy-loam, low in total Nitrogen (0.48%) and available phosphorus (3.55mg/kg) indicating need for amendment. The soil is slightly alkaline. The abattoir effluent is high in Nitrogen, Calcium, and Magnesium but low in Potassium and Sodium.

Table 2 showed the effect of time and rate of application of abattoir effluent on the mean plant height, number of leaves and stem girth of chili pepper. Time of application of abattoir effluent had no significant effect on the vegetative parameters observed at ($P < 0.05$) throughout the period of study. However, there was a significant effect of the rate of application of abattoir effluent on plant height at $p < 0.05$ throughout the period of observation. This can be as a result of the abattoir effluent having high nitrogen content [10]. The effect of time and rate and rate of application of abattoir effluent on the yield parameters were presented on table 3. There was no significant effect of time of application on fruit weight, numbers of fruit and fruit length.

However, application of abattoir effluent at transplanting time gave the highest yield in terms of fruit weight followed by 4WBT, while 2 WBT had the lowest fruit weight. Application of abattoir effluent at transplanting had the highest yield in terms of number of fruits and fruit length. Also there was no significant effect of rate of application on the yield parameters. But application of abattoir effluent at the rate of 15000L/ha gave the highest mean in fruit weight and fruit length while control had the least. 20000L/ha gave the highest mean number of fruits. Interaction effects of time and rate of application were not significant for all parameters assessed in the study.

CONCLUSION

Application of abattoir effluent at time of planting and application rate of 15,000L/ha gave the highest fruit yield and fruit length and was hereby recommended.

Table 1: Physical and chemical properties of the soil of the experimental plot before planting and abattoir effluent used as organic fertilizer

Physical Properties				Chemical Properties						Exchangeable bases(Cmol/Kg)				
Clay (%)	Silt (%)	Sand (%)	USDA	p ^H (H ₂ O)	p ^H KCl	P mg/g	N mg/g	C %	OM %	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	H ⁺
2.6	13.4	84.0	Sandy loam	7.72	7.21	3.55	4.8	0.62	1.08	0.58	1.02	8.51	0.18	10.66
				6.77		0.29	61.32			0.95	1.89	0.98	0.40	1.7

Table 2: Effect of time and rate of application of abattoir effluent on plant height, numbers of leaves and stem girth of chili pepper

Time of transplanting	PH (cm) 3 WAT	PH(cm) 4 WAT	NOL 3 WAT	NOL 4 WAT	SG(cm) 3 WAT	SG(cm) 4 WAT
6weeks before	32.21	33.38	81.50	104.83	1.71	1.82
4weeks Before	32.67	33.88	55.92	89.92	1.63	1.72
2weeks Before	29.96	31.71	65.83	95.50	1.61	1.68
At transplant	31.93	33.43	103.08	133.33	1.69	1.82
SEM	1.39 ^{ns}	1.62 ^{ns}	13.67 ^{ns}	16.55 ^{ns}	0.03	0.04
P value	0.66	0.79	0.1001	0.2727	0.0792	0.0914
Rate(g)						
Control	38.41 ^a	39.34 ^a	93.67	123.33	1.71	1.81
15000L/ha	32.62 ^{ab}	34.21 ^{ab}	82.33	115.33	1.66	1.79
20000L/ha	31.43 ^b	32.71 ^b	71.00	102.17	1.66	1.78
25000L/ha	24.30 ^c	26.15 ^c	59.33	82.75	1.60	1.66
SEM	1.39 [*]	1.62 [*]	13.67 ^{ns}	16.55 ^{ns}	0.03 ^{ns}	0.04 ^{ns}
P value	<.0001	<.0001	0.3383	0.3450	0.1269 ^{ns}	0.0962 ^{ns}
Time*Rate p value	0.5640 ^{ns}	0.5463 ^{ns}	0.7095 ^{ns}	0.8456 ^{ns}	0.9859 ^{ns}	0.9988 ^{ns}

*=significant difference @0.05, ns= not significant, WAT= weeks after transplanting , PH = plant height, NOL = numbers of leaves, SG = stem girth. Means followed by the same letter are not significantly different.

Table 3: Effect of time of application and rate of application of abattoir effluent on yield parameters of chili pepper

Time of transplanting	Fruit Weight/ plant(g)	Numbers of fruit/ Plant	Mean Fruit length (cm)
6weeks Before	23.29	9.33	3.95
4weeks Before	34.96	11.25	4.42
2weeks Before	23.22	11.08	4.31
At transplant	38.49	15.25	4.50
SEM	8.69 ^{ns}	3.34 ^{ns}	0.68 ^{ns}
P value	0.49	0.65	0.93
Rate(g)			
Control	17.25	7.67	4.76
15000L/ha	43.37	15.08	4.87
20000L/ha	36.59	15.67	4.54
25000L/ha	22.74	8.50	2.96
SEM	8.69	3.34	0.68
P value	0.14ns	0.21ns	0.18ns
Time*Rate p value	0.92ns	0.82ns	0.66ns

*=significant difference @0.05, ns= not significant, WAT= weeks after transplanting , PH = plant height, NOL = numbers of leaves, SG = stem girth. Means followed by the same letter are not significantly different.

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