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General Information about Journal of Agriculture and Agricultural Technology

Background:

The Journal of Agriculture and Agricultural Technology (JAAT), was established in the early 90s with Prof T. Z. Adama as the pioneer Editor-in-Chief. It is a publication of n the School of Agriculture and Agricultural Technology of the Federal University of Technology, Minna, Nigeria. The journal has been a prominent platform for disseminating research and knowledge in the field of agriculture and related technologies.

Philosophy:

The journal publishes original work and review articles to advance agricultural research and technology. It aims to foster innovation, promote sustainable agricultural practices, and contribute to the growth of the agricultural sector. By providing a scholarly space for researchers and experts, the journal plays a vital role in the academic and practical development of agriculture and related areas.

Management:

Under various visionary leadership and editorial teams, JAAT has remained dedicated to quality and excellent by upholding rigorous editorial standards, ensuring the publication of high-impact research, and facilitating a dynamic platform for collaboration and knowledge exchange within the agricultural community.

Future Prospects:

The journal has demonstrated remarkable growth evolving from an annual publication to a biannual one. Looking forward, there are ambitious plans to transition to a quarterly publication schedule. This strategic move reflects the journal's commitment to keeping pace with the rapid advancements in agricultural research and technology and providing a more frequent outlet disseminating groundbreaking findings.

The Journal of Agriculture and Agricultural Technology, Minna, aspires to expand its readership and impact, reaching an even larger community more repidly. By doing so, it aims to contribute significantly to the global discourse on innovative solutions to the challenges facing agriculture and related areas. The prospects include leveraging technology to enhance accessibility, collaborating with international researchers, and maintaining a steadfast commitment to excellence in agricultural research dissemination.

The journal has a rich history, a clear philosophical foundation, effective management, and ambitious plans for the future. Its evolution from an annual to a quarterly publication reflects its adaptability and commitment to advancing agricultural knowledge and technology.

EDITORIAL

Release of Volume 12 - Journal of Agriculture and Agricultural Technology (JAAT)

The Editorial Board is delighted to unveil Volume 12 of our esteemed Journal, marking another new milestone in our commitment to scholarly excellence. As we look ahead, we anticipate the release of two or more issues and a special edition in 2024, promising a year of enriched academic discourse and valuable insights.

We are thrilled to share that our online-first approach is now a permanent feature, ensuring that our esteemed readership has swift access to cutting-edge research. Furthermore, we are actively working towards digitizing all previous editions, aiming for a more extensive reach and impact in the academic community.

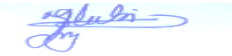
We extend our heartfelt gratitude is extended to every dedicated member of the Board for their unwavering commitment to bringing forth this edition despite the numerous challenges faced in 2023. The collective effort and perseverance have truly made this achievement possible. Our sincere appreciation goes out to our diligent reviewers who dedicated their time, effort and resources to ensure the timely and rigorous review of submitted articles. As we navigate a global audience, we encourage our reviewers to adopt a more critical stance, especially concerning citations and references. Rigorous referencing is essential in maintaining academic integrity, and we value your contribution to upholding scholarly standards.

We extend our profound thanks to the School of Agriculture and Agriculture Technology, as well as the entire University community, for the honour bestowed upon us. We recognize the significance of this trust and assure you that we do not take it lightly.

In closing, we appreciate everyone involved in making Volume 12 a reality. We are eager to continue our journey of academic exploration and look forward to the valuable contributions that will shape the future editions of the Journal.

Warm regards,

Editor-in-Chief



Prof. O.J. Alabi

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Original Research Paper

INFLUENCE OF FEEDING ROASTED LEBBECK (*ALBIZIA LEBBECK*) SEED MEAL DIETS ON THE GROWTH PERFORMANCE AND SENSORY EVALUATION OF BROILER CHICKENS

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ABSTRACT

This study was conducted to determine the dietary influence of graded levels of roasted lebbeck (Albizia lebbeck) seed meal on the growth performance and sensory evaluation of broiler chickens. One hundred and sixty Ross 308 birds were used for the experiment. The birds were randomly allotted to four treatments having forty birds per treatment with four replicates in a completely randomized design. Roasted lebbeck seed meal (RLS) was included in diets of broilers at 0, 1.5, 3.0, and 4.5 % levels for Treatments 1 (control), 2, 3, and 4, respectively. The diets formulated were isocaloric and isonitrogenous. The results showed that the dry matter and ash contents of the raw and RLS were similar. While the crude protein and nitrogen-free extract contents of the seed were increased upon roasting. The crude protein content increased from 28.03 in the raw to 31.93 (12.35 % change). However, crude fibre dropped from 18.50 in the raw seed to 7.50 % in the RLS, producing a drastic change of 59.9 %. There was a decrease in ether extract content from 11.06 in raw to 10.04 % in RLS, which is a 9.22 % decrease. Results revealed that as the inclusion levels of RLS increased in the diets, the daily feed intake, daily weight gain, and final live weight decreased significantly ($p<0.05$). This result may be because the growth-retarding factors in the RLS were partly eliminated during the processing of the seeds. However, the feed efficiency for all

treatments was similar (p>0.05), which may imply that the amount of feed required to produce a unit of weight gain was not significantly different for broilers fed different levels of Albizia lebbeck. The sensory attributes like; colour, juiciness, appearance, aroma, and overall acceptability were not significantly (p>0.05) influenced by the dietary treatments. However, flavour and tenderness were significantly (p<0.05) affected. It is, therefore, recommended that RLS be included up to 1.5 % in the diet of broilers for optimum growth performance.

Keywords: Performance, Roasted lebbeck, Ross 308 broilers, Antinutritional factors, Sensory attributes

INTRODUCTION

The high cost of conventional feedstuff has compelled animal nutritionists to focus research on unconventional feed sources, especially protein sources. Therefore, research efforts have been directed at producing quality feed at affordable prices to increase the net profit of farmers and provide animal protein to meet the daily protein requirement of the average Nigerian. The use of non-conventional feedstuff will go a long way to reduce the competition for conventional feedstuff like soybean and groundnut cake (Ukpah *et al*., 2021). One way of tackling this challenge is the use of unconventional feedstuff such as *Albizia lebbeck* which is widely distributed in Nigeria and can be exploited for feeding monogastrics because of its nutritive composition.

Albizia lebbeck is a species of lebbeck, native to tropical Asia, widely cultivated and naturalized in other tropical and subtropical regions (Sivakrishnan and Kavitha, 2018). English names for it include Lebbeck, Flea tree, Frywood, Koko**,** and Woman's tongues tree. The latter name is a play of sounds the seed makes as they rattle inside the pods (Chakrabarti, 2014). *Albizia lebbeck* often called the siris tree or the lebbeck tree, is indigenous to Southeast Asia and the Indian subcontinent. It is thought to have originated from the areas that include modern-day Thailand, Myanmar (Burma), India and Sri Lanka (Balkrishna *et al.,* 2022). In many other parts of the world, such as Africa, the Americas, and numerous tropical and subtropical climates, the tree has been extensively farmed and allowed to naturally occur (Petermann and Buzhdygan, 2021).

Albizia lebbeck has been used for many purposes; Arya and Pandey (2009) found that the tree of *Albizia lebbeck* has a wide range of medicinal properties, including anti-inflammatory, antipyretic,

and antidiarrheal effects. Mohan and Singh (2006) evaluated the nutritive value of *Albizia lebbeck* leaves for feeding to ruminants. They found that the leaves are a good source of protein and fibre, and they can be used as a substitute for conventional fodders. The leaves, pods, and seeds of *Albizia lebbeck* can all be fed to animals. The leaves are particularly high in protein and fibre. Singh and Singh (2009) reported that the lambs that were fed *Albizia lebbeck* leaf meal had similar growth rates and feed intake as the lambs that were fed a conventional diet.

Conventional feedstuffs are expensive, this has brought about the need to search for alternative feedstuffs that can replace the exorbitant ones to reduce the cost of livestock production, as well as the cost of meat and other animal products (FAO, 2014). Nutritional information and feeding trial using roasted *Albizia* is scanty. There is little or no information on feeding trials and nutritional information on roasted lebbeck seeds. Therefore, this study was conducted to evaluate the influence of feeding graded levels of roasted lebbeck (*Albizia lebbeck*) seed meal diets on the performance of broiler chickens.

METHODOLOGY

Location of the Study and Source of Experimental Test Ingredient

The research work was carried out at the Poultry Unit of the Department of Animal Production Teaching and Research Farm, Gidan Kwano Campus, Federal University of Technology Minna, Niger State. Mature and dry pods were harvested from lebbeck trees in Minna town. Raw seeds of lebbeck (*Albizia lebbeck*) were removed from the pods by threshing in a mortar using a pestle.

Processing Method (roasting)

Seeds of *Albizia lebbeck* were collected and sorted to remove undesirable particles (foreign materials). Raw seeds of lebbeck were ground to powder with the use of a hammer mill. A pot was heated to 120 ^{0}C before pouring 100 g of grounded lebbeck seed meal and stirring for 4-5 minutes until it turned light brown and gave an aroma similar to roasted beans. It was poured on a clean tray to cool and stored in an airtight container and labelled as roasted lebbeck seed meal (RLS) until ready for use.

Proximate Analyses

The proximate analyses of lebbeck seeds (both raw and roasted seeds) were carried out at the Animal Production Laboratory, Federal University of Technology, Minna, Niger State, Nigeria, using the methods outlined by the Association of Official Analytical Chemists (AOAC, 2000).

Experimental Design

A total of one hundred and sixty Ross 308 mixed-sex day-old broiler chicks were purchased. These experiments were carried out using a completely randomized design (CRD). Roasted lebbeck seed meal was included in diets of broiler chicken at 0, 1.5, 3.0, and 4.5 % levels for Treatments 1, 2**,** 3, and 4, respectively, in a single-phase feeding. The birds were randomly assigned to four dietary treatments with four replicates (40 birds per treatment). The diets were formulated as isocaloric and isonitrogenous.

Table 1: Experimental Composition of Varying Levels of Roasted *Albizia lebbeck* Seed Meal Diets

Ingredients	**0 % (T1)**	**1.5 % (T2)**	**3.0 % (T3)**	**4.5 % (T4)**
Maize	45.85	45.85	45.85	45.85
Soybeans (full fat)	40.00	38.50	37.00	35.50
Maize offal	6.00	6.00	6.00	6.00
Roasted lebbeck seed meal	0.00	1.50	3.00	4.50
Fish meal	4.00	4.00	4.00	4.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25
Toxin binder	0.15	0.15	0.15	0.15
Total	100	100	100	100
Calculated				
Crude protein %	22.42	22.33	22.24	22.15
ME (kcal /kg)	3044.22	3041.69	3039.15	3036.62

ME= Metabolizable energy

Management of Experimental Birds

Birds were raised on deep litter. The pen was washed and disinfected with Izal. Drinkers and feeders were thoroughly washed and made ready for use. Before the arrival of the birds, wood shavings were spread on the floor, a heat source was made available for brooding the chicks and a foot dip was provided at the entrance of the poultry house. On arrival of the chicks, they were weighed to obtain their initial weights after which they were randomly distributed to the various treatment groups. The birds were vaccinated against the prevailing diseases; the first dose of the Gumboro vaccine was administered at week one against Gumboro disease, and at week two the first dose of the Lasota vaccine was administered to the birds against Newcastle disease. When the birds were three weeks old the second dose of the Gumboro vaccine was given. The last dose of the Lasota vaccine was administered in the fourth week. The feeding trial was conducted for seven weeks. Feed intake was measured daily while the weighing of birds was done weekly.

Sensory Evaluation

Meat samples of broiler breast portions that had been frozen were thawed at room temperature for sensory evaluation. The meat samples were cut into smaller pieces of about 3-5 grammes of about 1-2 cm according to their treatments and replicates. The meat samples were then boiled in a pot containing 150ml of water for ten minutes, and one gramme of salt was added.

Thirty semi-trained taste panellists from the Federal University of Technology, Minna Gidan Kwano Campus community were used for the meat sensory evaluation. This evaluation was performed according to the method described by Grunert *et al*. (2004) using a 9-point hedonic scale rated as follows: 9= like extremely, 8= like very much, 7= like moderately, 6= like slightly, 5= neither like nor dislike, 4= dislike slightly, 3= dislike moderately, 2= dislike very much, 1= dislike extremely. The meat samples given to the panellists were evaluated for sensory attributes such as meat colour, appearance, juiciness, tenderness, taste, aroma, texture**,** and overall acceptability. Each panellist was given cracker biscuits and water to rinse their mouth with after tasting each sample to eliminate flavour carryover from previous samples.

Data Analysis

All data collected during the experiment from the measured parameters were subjected to one-way analysis of variance (ANOVA) using IBM SPSS version 23.0. The significant means were separated using Duncan's multiple range test.

RESULTS AND DISCUSSION

The proximate composition of raw roasted *Albizia lebbeck* seed meal on the growth performance of broiler chickens is presented in Table 2. The result showed that the dry matter and ash contents of the raw and roasted seeds were similar. While the protein and nitrogen-free extract content of the seed was increased upon roasting. The crude protein content increased from 28.03 % in the raw to 31.93 % (12.35 % change). However, crude fibre dropped from 18.50 % in the raw seed to 7.50 % in the roasted seed, producing a drastic change of 59.9 %. There was a decrease in ether extract content from 11.06 % in raw to 10.04 % in roasted seed, which is a 9.22 % decrease.

Table 2: Proximate Composition of Raw and Roasted Lebbeck (*Albizia Lebbeck*) Seeds

Nutrients	Raw lebbeck seeds	Roasted lebbeck seeds	Percentage change
Dry matter	91.81	91.28	0.58
Crude protein	28.03	31.98	12.35
Crude fibre	18.50	7.50	59.46
Ash	4 .52	4.50	0.44
Ether extract	11.06	10.04	9.22
Nitrogen free extract	29.70	37.26	20.29

Growth performance of Broiler Chickens Fed Varying Levels of Roasted *Albizia lebbeck* Seed Meal

The results of the effect of varying levels of roasted *Albizia lebbeck* seed meal on the growth performance of broiler chickens are presented in Table 3. The results showed that as the level of inclusion of roasted *Albizia lebbeck* seed meal diet increases, there was a significant ($p<0.05$) decrease in the final live weight, daily weight gain**,** and daily feed intake except the feed efficiency which was not significantly different ($p>0.05$) across dietary treatments. However, the result

revealed that Treatment 2 with 1.5 % roasted *Albizia lebbeck* was statistically the same ($p>0.05$) as the control in terms of final live weight, daily weight gain, and daily feed intake.

The final weight of broiler chickens fed 1.5 % roasted *Albizia lebbeck* seed meal diet was 1868.75g and the birds on the control had 1898.13 g was significantly ($p<0.05$) higher than broilers fed 3.0 and 4.5 % roasted *Albizia lebbeck* seed meal diet which recorded 1570.88 and 1357.50 g, respectively. Similarly, broiler chickens fed 1.5 % of roasted *Albizia lebbeck* seed meal diet (37.36 g) and the control (37.75 g) recorded statistically ($p<0.05$) higher daily weight gain compared to those fed 3.0 and 4.5 % of roasted *Albizia lebbeck* seed meal supplemented diet that had 37.75 and 26.93 g, respectively. The same trend was also observed in daily feed intake as the control (64.54 g) and broiler birds fed 1.5 % of roasted *Albizia lebbeck* seed meal supplemented diet (62.31 g) consumed significantly ($p<0.05$) higher than those fed 3.0 and 4.5 % of roasted *Albizia lebbeck* seed meal supplemented diet (52.27 and 44.63 g). The significant decrease in these growth parameters may be because *Albizia lebbeck* contained antinutrients, such as tannins and phytates that inhibited the absorption of nutrients and thus, led to the reduction in growth. The findings of this study are consistent with the findings of previous studies conducted by Olorunsanya *et al*. (2009) found that final live weight, average weight gain, and average feed intake of broiler chickens decreased significantly as the level of *Albizia lebbeck* inclusion increased from 0 % to 15 %.

The feed efficiency which was not significantly ($p>0.05$) different across dietary treatment, means that the amount of feed required to produce a unit of weight gain was not significantly different for broilers fed different levels of *Albizia lebbeck*. These findings agree with the reports of Olorunsanya *et al*. (2009); Chand *et al*. (2014) and Agboola *et al*. (2015) when they fed varying inclusion levels *of Albizia lebbeck* to birds. Therefore, the non-significant ($p>0.05$) effect recorded in the feed efficiency of birds in this research work showed that *Albizia lebbeck* is a potential feed ingredient in broiler chicken diets.

Table 3: Effect Of Roasted *Lebbeck* Seed Meal Diets on Growth Performance of Broiler Chickens

	Treatments						
	0 %	1.5 %	3.0 %	4.5 %			
Parameters	T1	T2	T3	T4	SEM	P-value	LS
Initial weight (g)	37.63	38.00	38.38	38.00	0.144	0.365	NS
Final weight (g)	1898.13^{a}	1868.75^{a}	1570.88^{b}	1357.50^{c}	59.877	0.001	*
Daily weight gain (g)	37.75^{a}	37.36^{a}	37.75^{b}	26.93^{c}	1.203	0.000	*
Daily feed intake (g)	64.54^{a}	62.3^{a}	52.27^{b}	44.63^{c}	2.335	0.000	*
Feed efficiency	59.06	60.16	60.14	60.58	0.948	0.961	NS

^{abc}; means with different superscripts along the row are significantly ($p \leq 0.05$) different, NS = Not significant, * =Significant, SEM = Standard error of mean, P-value = Probability value, LS = Level of significance

The treatment groups were tagged as follows:

T1 = Diet supplemented with 0 % *lebbeck* seed meal (RLS) control
T2 = Diet supplemented with 1.5 % *lebbeck* seed meal (RLS)
T3 = Diet supplemented with 3.5 % *lebbeck* seed meal (RLS)
T4 = Diet supplemented with 4.0 % *lebbeck* seed meal (RLS)

The result obtained from this study showed that flavour and tenderness were significantly affected by dietary treatments. The differences observed as pertains to the meat flavour and tenderness across groups could be attributed to the effect of the dietary inclusion of roasted *Albizia lebbeck* seed meal in the diets, although the mechanism or mode of this effect may be unknown. This result agrees with the findings of Tsado *et al.* (2018), who observed a significant ($p<0.05$) effect of boiled *Albizia lebbeck* on the flavour of the meat of rabbits.

Sensory Evaluation of Meat of Broiler Chickens Fed Graded Levels of Roasted *Albizia lebbeck* Seed Meal Diets

The organoleptic evaluation of meat of broiler chickens fed graded levels of roasted *Albizia lebbeck* seed meal diets is presented in Table 4. From the results, the sensory attributes like; colour, juiciness, appearance, aroma, and overall acceptability were not significantly ($p>0.05$) influenced by the different treatment groups. However, flavour and tenderness were significantly ($p<0.05$) affected.

Table 4: Sensory Evaluation of Meat of Broiler Chickens Fed Graded Levels of Roasted *Albizia Lebbeck* Seed Meal

Parameters	T1	T2	T3	T4	SEM	P-value	LS
Colour	5.80	6.18	6.13	5.97	0.27	0.67	NS
Juiciness	6.36	6.69	6.39	6.50	0.15	0.42	NS
Appearance	6.74	7.01	7.01	6.87	0.13	0.70	NS
Flavour	6.76^{ab}	7.15^{a}	6.50^{4b}	6.81^{ab}	0.06	0.04	*
Aroma	6.93	7.20	6.80	6.88	0.09	0.35	NS
Tenderness	7.13^{a}	6.97^{ab}	6.98^{ab}	6.84^{b}	0.08	0.05	*
Overall acceptability	7.25	7.39	7.11	7.26	0.09	0.47	NS

^{abc}; means with different superscripts along the row are significantly ($p \leq 0.05$) different, SEM = Standard error of mean, P-value = Probability value, LS = Level of significance, NS = Not significant, * =Significant

CONCLUSION AND RECOMMENDATIONS

Overall, the findings of this study suggest that *Albizia lebbeck* in poultry feed should be limited to low levels. It is, therefore, recommended that roasted *Albizia lebbeck*, an unconventional feedstuff, can be included up to 1.50 % in the diet of broiler chickens for optimum growth performance. Further research is needed to identify ways to mitigate the effects of higher inclusion levels of roasted lebbeck in broiler diets. In addition, there is a need to examine the effect of different roasting durations of *Albizia lebbeck* on the growth performance and sensory evaluation of broiler chickens and the combination of two processing methods for lebbeck.

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Original Research Paper

CENSORING THE HAEMATOLOGICAL AND SERUM BIOCHEMISTRY OF GROWING PIGLETS FED ALTERNATIVE ENERGY DIETS

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ABSTRACT

The study assessed the haematological traits/serum biochemistry of growing piglets, placed on alternative energy diets. Thirty-two growing piglets (Large White and Duroc) were used. Experimental animals were assigned to four treatments (1, 2, 3, and 4) in a completely randomized design (CRD). Each treatment group contained four replicates with two pigs per replicate. The control diet (1) had maize as the main energy source while other diets (2, 3, and 4) had palm kernel meal, brewer's dried grain, and wheat offal as alternatives to maize. Growing piglets were unrestricted to experimental diets and water for six weeks. Data obtained revealed that the haematological indices such as packed cell volume (PCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were significantly ($P<0.05$) influenced by the dietary energy treatments. The white blood cell (WBC), red blood cell (RBC), and mean corpuscular volume (MCV) were not significantly ($P>0.05$) affected. Serum protein, creatinine, urea, and glucose, showed no significant ($P>0.05$) effect while serum albumin, globulin, and cholesterol were significantly ($P<0.05$) influenced by the energy treatment diets under investigation. However, the values were within the tolerable ranges hence there were no noticeable health hazards arising from these experimental diets.

Keywords: Growing Pigs, Energy, Feed, Haematology and Serum.

INTRODUCTION

Pig production in Nigeria is massively gaining popularity as a means of augmenting protein sources from cattle, poultry, goats, sheep**,** etc. Livestock products contribute about 13% of the world's consumption of calories (FAO, 2009). The global contribution of pigs is still moderate and its production has tripled over the years only being surpassed by poultry (FAO, 2009). There is an ever-growing need to increase livestock (pig) production if the overwhelming shortage of animal protein must be addressed (Iwegbu *et al*., 2022). Akinmutimi and Onwukwe (2002) noted that in Nigeria, the need for animal protein sources is more than the production hence, an acute shortage of animal protein is evident in the diet of the citizenry. This problem is compounded by the prevailing high cost of meat and lack of food security. All these necessitated the need to expand the livestock industry of which pig production cannot be overlooked.

Pig is a fast-growing animal, high in protein, highly prolific, high in vitamins and minerals**.** and capable of bridging the gap of animal protein deficiencies. To achieve cost-effective pig production, there is a need for farmers to source locally for the feeding materials. De Lange *et al*. (2010) and Kim *et al*. (2011) observed that feeding of piglets with by-products of agriculture has been evaluated to indicate improved performance. These agro-based by-products are low cost (cheap), available and not directly consumed by man hence their suitability in feeding/pig production. Igene (2006) reported that pigs can effectively utilize by-products (agro) and kitchen remnants. However, in feeding pigs agro by-products, the farmer must be careful to ensure that feed does not deleteriously affect the haematology and serum counts of the animal. Omoikhoje (2011) stated that variation in the normal haematology of the cell will have a negative effect on the functionalities of the animal body. Corroborating the above, Ojebiyi *et al*. (2007) stated that the health status of the animal is very important and that one of the ways of assessing it is to evaluate the blood quality through haematological studies. An increase in packed cell volume (PCV) otherwise known as haematocrit indicates an increase in blood viscosity which results in distortion of blood flow. On the other hand, low concentration of erythrocytes indicates low blood viscosity which results in an increased blood flow and lowers blood pressure (Frandson, 1981). This scenario makes it very much imperative to ascertain the haematology and serum biochemical to determine their well-being. This experiment was carried out to assay the haematological traits and serum biochemistry of growing piglets fed alternative dietary energy treatments.

METHODOLOGY

Site of Experiment, Dietary Ingredients and Period

The feeding trial was carried out at the experimental farm of Ambrose Alli University, Ekpoma, Edo State, Nigeria. The university research farm is situated in the vegetative belt of the region having a Longitude of 6.44 ^{o}C North and 6.08 ^{o}C East. The Average temperature is 29 ^{o}C and a wavering humidity range of 68 % to 76 %. The dietary ingredients were sourced at different Animal Feed Shops in Benin City, Edo State. The animals were placed on an intensive feeding period of forty-two days.

Piglets and Design

The experimental animals numbering thirty-two crossbred Large white and Duroc growing piglets had an initial average weight of 20.8 kg and were ten weeks of age. The animals (piglets) were separated into four groups based on their average initial weights and were accordingly allocated to each of the four treatment diets (1, 2, 3, and 4) in a completely randomized design. Eight growing piglets were in each group with four replicates of two (one male and one female).

Before the experimental animals were brought in and subsequent allocation, the farm**.** and the hutches were thoroughly washed with disinfectants while the surroundings were cleared to ward off poisonous snakes and other predators. An acclimatization period of one week was allowed before actual experimentation using the dietary ingredients. While animals under investigation had their feed two times in day (8 am and 4 pm), water was administered *ad libitum* all through the period of the experiment. The animals were routinely vaccinated, dewormed**,** and followed by other medications and management practices.

Table 1: Proximate of Experimental Ingredients (%)

Nutrient	PKM	BDG	WO
DM	89.70	89.50	90.00
CP	20.53	22.49	18.74
EE	6.15	6.25	4.35
CF	16.25	21.00	17.00
CA	4.30	4.70	5.80

Amaefule *et al*. (2009)

KEY: DM=Dry matter, CP=Crude protein, EE=Ether extract, CF=Crude fibre, CA=Crude ash, PKM=Palm kernel cake, BDG=Brewer;s dried grains, WO=Wheat offal.

Diet Formulation

The diets consisted of the following energy sources: maize, palm kernel meal (PKM), brewer's dried grain (BDG)**,** and wheat offal (WO). Groundnut cake (GNC) served as the main protein source while other ingredients consisted of bone meal, vitamins/minerals premix, lysine, methionine**,** and salt. Dietary treatment 1 was used as the control. It (treatment 1) had maize while treatments 2, 3**,** and 4 had other alternative energy sources on weight for weight formulation pattern. Constant values were used in the inclusion of other ingredients in the respective diets before they were thoroughly mixed.

Data Collection and Analysis

On the last day of the sixth week, two growing piglets per treatment were used for blood collection. Blood samples were collected through the conspicuous ear veins using needles and syringes into ethylene diamine tetra-acetic (EDTA) dipotassium salt labeled bottles for haematological indices assessment. Another segment of blood samples was gathered from the same growing piglets into a heparinized bottle that did not contain ethylene diamine tetra acetic dipotassium salt for the determination of serum biochemicals. Both samples of the animal blood were analyzed as follows; packed cell volume (PCV), red blood cell (RBC), white blood cell (WBC), haemoglobin (Hb), protein, albumin, globulin, creatinine, urea**,** and cholesterol were determined using improved Neubauver haemacytometer and cynomethaemoglobin methods (Esonu *et al*., 2001).

Data Analysis

Data generated were analyzed using analysis of variance (ANOVA) while the means were separated by Duncan's Multiple Range Test method as explained by Steel and Torrie (1990).

Table 2: Diets Composition

Ingredients %	**TRT1**	**TRT 2**	**TRT 3**	**TRT4**
Maize	45.00	0.00	0.00	0.00
Palm Kernel Meal	0.00	45.00	0.00	0.00
Brewer' Dried Grain	0.00	0.00	45.00	0.00
Wheat Offal	0.00	0.00	0.00	45.00
Cassava	28.70	28.70	28.70	28.70
Groundnut Cake (GNC)	20.00	20.00	20.00	20.00
Blood Meal	3.30	3.30	3.30	3.30
Bone Meal	2.20	2.20	2.20	2.20
Vit/Min Premix	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15
Methionine	0.15	0.15	0.15	0.15
Salt	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**
Calculated	**21.40**	**22.97**	**22.79**	**21.12**
Crude Protein (%):	**3062.24**	**2652.25**	**2648.02**	**2644.59**
Energy (Kcal/kg)				

TRT 1=Treatment 1, TRT 2=Treatment 2, TRT 3= Treatment 3, TRT 4= Treatment 4.

corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH)**,** and mean corpuscular volume (MCV) were calculated (Jain, 1986).

RESULTS AND DISCUSSION

Table 3: Haematological Traits as Influenced by the Treatment Diets

Parameters	Dietary Treatments				
	1	2	3	4	
	Maize (Control)	PKM	BDG	WO	SEM
WBC (×10fl)	15.81	15.54	16.12	15.70	0.23
RBC ($\times 10^{12}$/l)	8.62	7.71	8.40	8.27	0.18
PCV (%)	40.31^{a}	39.42^{b}	38.94^{b}	38.88^{b}	0.52
Hb (g/dl)	10.22^{a}	9.51^{b}	9.34^{bc}	8.98^{c}	0.19
MCH (p/g)	19.82^{b}	20.31^{ab}	21.16^{a}	20.50^{ab}	0.46
MCV (g/dl)	62.26^{a}	61.44^{b}	62.11^{a}	62.11^{a}	0.42
MCHC (%)	29.30^{a}	28.80^{ab}	27.70^{b}	27.70^{b}	0.25

Means (abc) in the same row with different superscripts are significantly ($P<0.05$) different.

KEY: PKM=Palm kernel cake, BDG=Brewer's dried grains, WO=Wheat offal, SEM= Standard error of the mean WBC=White blood cell, RBC=Red blood cell, PCV=Packed cell volume, Hb=Haemoglobin, MCH=Mean corpuscular haemoglobin, MCV=Mean corpuscular volume, MCHC=Mean corpuscular haemoglobin concentration. SEMJ=Standard error mean.

Ikegwuonu and Basir (1976) and Olorede *et al.* (1996) reported that blood highlighted the relevance of blood to life and noted that for any meaningful work to be done on the biology of an animal, detailed blood analysis is of great essence. They further pointed out that any deviation from the normal haematological range will have an adverse effect on the performance and health status of the animal. An increase in white blood cells (WBC) and a significant decrease in red blood cells (RBC) and packed cell volume (PCV) could signal the presence of disease in the animal.

The haematological evaluation of the growing piglets fed the dietary treatments revealed significant ($P<0.05$) variations across the experimental diets for PCV, Hb, MCHC, MCV, and MCH as shown in Table 2 above while there were no variations ($P>0.05$) among all the experimental animals for WBC and RBC. Values obtained for the haematological traits were close though there existed

significant variations in some parameters. The haematological values obtained from the study fell within the normal physiological range published by Banerjee (2009). The mean corpuscular volume of treatment 3 which had brewer's dried grain (BDG) was comparatively the same as the maize-controlled treatment. In the same vein, the value obtained for mean corpuscular haemoglobin concentration for treatment 2 with palm kernel meal (PKM) is statistically the same as dietary treatment 1 (control). The control treatment (maize) proved to be statistically better on packed cell volume (PCV) and haemoglobin (Hb) than other treatment diets.

Table 4: Serum Biochemistry of Growing Pigs Fed Alternative Energy Sources.

Parameter	**Treatments**				
	1	**2**	**3**	**4**	
	Maize	**PKM**	**BDG**	**WO**	**SEM**
Total Protein (g/dl)	8.51	7.84	7.61	7.68	0.16
Albumin (g/dl)	3.51^{a}	2.92^{ab}	2.81^{b}	2.92^{ab}	0.12
Globulin (g/dl)	4.99^{a}	4.99^{a}	4.80^{ab}	4.66^{b}	0.06
Creatinine (mg/dl)	0.74	0.77	0.69	0.71	0.02
Urea (mg/dl)	22.24	21.48	23.06	22.04	0.28
Cholesterol (mg/dl)	118.16^{a}	117.24^{a}	114.11^{b}	109.02^{c}	1.23
Glucose (mg/dl)	93.41	92.82	92.64	93.08	0.24

Means (abc) in the same row with different superscripts are significantly ($P<0.05$) different.
PKM=Palm kernel cake, BDG=Brewer's dried grains, WO=Wheat offal, SEM= Standard error of the mean.

Table 3 indicates the effect of substituting maize with PKM, BDG**,** and WO on the serum biochemicals of growing piglets. Total protein, creatinine, urea**,** and glucose were not significantly ($P>0.05$) affected by the dietary treatments. These parameters are indicators of protein reserves and can be specifically influenced by dietary protein shortages (Adesehinwa and Ogunmodede, 2002).

The result from this study revealed that protein levels in the experimental diets supported normal protein reserves in the animals resulting in efficient protein utilization.

High serum creatinine and urea levels in animals are indicators of muscular wastage (Fashina, 1991). The values obtained in this study were fairly constant and comparable across the groups, such that the grower pigs could not have suffered muscular wastage but efficient utilization of diets. Maize and palm kernel meal diets had more significant ($P<0.05$) values in the cholesterol levels. This could probably be due to higher levels of fat in the maize and PKM diets as expected. This research finding corroborates the results of Adesehinwa and Ogunmodede (2002) and Igene (2006) who also reported comparable levels of glucose.

CONCLUSION

Since the values obtained in the experimental diets compared favorably with the control diet (normal ranges) as revealed in some literature, it could be concluded that the test experimental ingredients could partially or wholly alternate maize as an energy source as there were no adverse health implications in the animals arising from the experimental diets.

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Original Research Paper

ASSESSMENT OF SKILLS GAP OF EXTENSION PERSONNEL IN KANO STATE, NIGERIA

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ABSTRACT

The study assessed the skills gap of extension personnel in Kano State, Nigeria. Three Local Government Areas were purposively selected from each of the three administrative zones making a total of nine Local Government Areas. A total of 117 extension agents were selected for the study and data were collected using interviews and well-structured questionnaires. Frequency, percentages, mean, and Skills Gap Analysis were used to analyse the data. The study revealed that extension service in the study area was male-dominated (88.9%) and more than two-thirds were HND and diploma holders. Skill Gap Analysis revealed that areas of training required by the extension personnel include; linkage to credit formulation (3.56), use of ICT in agriculture (2.90), and demonstration of improved technology (2.83). The highest-ranking constraints of the extension personnel were interference of politicians in technical aspects (3.41) and having too many jobs with different specializations expected (3.12). Therefore, frequent professional and technical training, employment of more extension personnel especially women, disengagement of politicians from technical aspects, and collaboration with research institutes and universities would improve the capacity of the extension personnel and efficiency of extension service delivery in the study area. The study therefore concludes that extension personnel in Kano State required specialised training in addition to conventional training received.

***Keywords**:* Extension Personnel**,** Skills, Gap, Analysis.

INTRODUCTION

Agricultural extension is an indispensable way to reach farmers with the required knowledge and advice they need to upgrade their livelihoods. Agricultural extension services enable and lubricate the transfer of information, knowledge, and modern practices to farmers which they require to improve their yield and also the quality of their livelihoods. It is therefore necessary to provide farmers with adequate knowledge and information in the right ways and right time (Moon *et al.*, 2016; Sanga *et al*., 2013). In 1974, the Agricultural Development Authority (ADA) system was institutionalized in Nigeria with funding assistance from the World Bank, the Federal Government, and State Governments (Omoregbee and Ajayi, 2009). The Kano ADP termed Kano Agricultural and Rural Development Agency (KNARDA) has been in areas of improving agricultural services and human development. The agricultural extension agent is the one who examines the problems of the farmers and rural people and bring them back a suitable solution to such problem (Safdar, 2005).

For a successful and effective extension agent's job, there is a need for the extension agent to be well-trained and competent in their job, and this calls for continuous in-service training. An extension agent needs to be competent in their technical subject matter areas and also in areas like; teaching, communication administration and management, program planning and execution, and monitoring and evaluation (Okeowo, 2015). For relevant, efficient, and effective in-service training, identification of needs is necessary. A training program that is not based on actual needs is like a doctor prescribing medicine for a patient without diagnosis. The training will therefore not produce the intended outcome (Lego *et al.,* 2018). Therefore, this research intends to assess the level of professional competence and skill gap of extension agents of extension agents in Kano State.

There's been a great advancement in agricultural technology in recent years but the gap between the farmers and these technological advancements yet remains wide. Agricultural Development Authorities (ADAs) are the main organizations charged with the responsibilities of agricultural extension delivery, but it is clear that Agricultural extension in Nigeria has been drastically reducing in its effectiveness over the years. This has been a major factor that has been causing the decline in agricultural productivity (Igbokwe and Enwere, 2001). Therefore, the main objective of this study was to assess the task skill gap of the extension agents in the study area. Other objectives

were to; describe the socioeconomic characteristics of extension agents in the study area and describe the constraints affecting the extension agents in the study area.

Kano State is located in the north-western part of Nigeria. It has a total land area of 20,131 km^2 and lies between latitudes 11030' and 12037' North and longitudes 8030' and 9020' east. It is situated in the Sudan savannah agroecological zone of Nigeria. It shares boundaries with Bauchi State to the South, Kaduna State to the Southwest, Katsina State to the West and North West, and the East and Northeast Jigawa State (KNSG, 2008). The population of Kano State stood at 11,058,300 and the projected population as of 2021 stood at 14,707,539 using the anticipated annual growth rate of 3.3 % and also ranks first out of the 36 States of the Federation (NPC, 2011). Kano State is located on the "high plains of Hausa land" with the occurrence of rock outcrops predominantly in the Southern part of the State. The highest elevation is Riruwai in Doguwa Local Government Area, with a peak reaching up to 1,230 metres above sea level (Olofin, 1987; Rilwanu, 2011).

The Agricultural Development Authority (ADA) system in Nigeria was institutionalized in 1974 with funding assistance from the World Bank and federal and State Governments (Okeowo, 2015). The Kano State Agricultural Development Project (ADP) is named Kano Agricultural and Rural Development Authority (KNARDA).

Sampling Techniques: Multistage sampling was used for this study. The first stage was the purposive selection of three Local Government Areas from each of the three agricultural zones of Kano State based on the intensity of agricultural activities which gave a total of nine Local Government Areas. The second stage was the random selection of extension personnel from each Local Government Area. The lists of extension personnel in these Local Government Areas were used as a sampling frame for the selection of the extension personnel to be considered. Random sampling using random numbers was generated from Microsoft Excel and used for selecting required personnel.

The sample size was determined by a mathematical formula (Miller and Brewer, 2003);

$$n = \frac{N}{1+N(\alpha)^2} \text{ ---------- (1)}$$

Where;

n = required sample size

N = sample frame

α = margin of error (standard value of 0.07).

A simple proportion formula was then used to calculate the number of extension agents that will be interviewed in each local government using;

$y = \frac{x}{X} * N$ ---------- (2)

Where;

y = ward sample size, x = ward sample frame, X = total sample frame, and N = total sample size.

Table 1: Sampling Frame and Sample Size of the Extension Personnel

Agricultural Zones	Selected Local Government Areas	Sample Frame	Sample Size
Zone I	Gwarzo	25	13
	Kura	47	24
	Doguwa	24	12
Zone II	Dambatta	26	14
	Makoda	23	12
	Bagwai	21	11
Zone III	Gaya	20	10
	Warawa	27	14
	Takai	13	7
Total		226	117

Source: Kano State Agricultural and Rural Development Authority (KNARDA), 2019

Primary data were collected using a structured questionnaire which was designed in respect of the objectives of the study. The questionnaire was administered to extension agents in the study area. The questionnaire was structured to include; demographic characteristics, the skill gap of extension personnel, and also the constraints faced by the extension personnel in the study area. The data

collected were analysed using descriptive statistics and skills gap analysis. Descriptive statistics included the mean, frequency, percentages, and graphical representation. This tool was used to analyse the demographic characteristics and the constraints of the extension personnel in the study area.

This tool was used in assessing the task performance of extension personnel in the study area. Skill gap analysis is a tool used in determining the training requirements of an employee. The analysis helps in revealing the variances between the existing and the required skill levels, as well as identifying the best strategies to close the gap or reduce the variation. Twenty-six of such tasks were identified for this study and the extension personnel were asked to rate the required and actual level of such tasks.

To address the skill gap analysis, the Mean Weight Discrepancy Score (MWDS) instrument using the Borich needs assessment model was developed. The MWDS was then used to assess the skill gap of the extension personnel within 26 tasks of extension personnel identified from other research. The discrepancy score was first calculated by subtracting the actual level from the required level. The individual discrepancy score was then multiplied by the average required level to get the mean weight discrepancy score and the tasks were then ranked according to the MWDS.

As shown in Table 2, the majority (88.9 %) of the extension personnel were males while the females were the remaining 11.1 %. This shows that extension services in Kano State were male-dominated. Although there was a low number of female extension officers, the result further indicates that women were participating in extension delivery and this could be due to the continuous increase in women farmers. This is in line with the findings of Okeowo (2015) in "Analysis of Competency and Training Needs among Agricultural Extension Personnel in Lagos State" who reported that 74 % of the extension agents were male. There is a need for more female participation in the extension work.

Results from Table 2 show that 36.8 % and 35 % of the extension personnel had HND and National Diploma, respectively as their highest qualification. This contradicts the results of Omoregbee and Ajayi (2009) who reported that 55.3 % of the extension personnel had OND in a study carried out in Edo State. This indicates that there is an improvement in the level of education of the extension personnel. It is presumed that the higher the level of education of some extension personnel, the better ways to explore in dissemination of agricultural innovation to farmers.

Table 2: Socio-economic Characteristics of Agricultural Extension Personnel

Variables	Frequency	Percentage (%)	n = 117
Sex			
Male	104	88.9	
Female	13	11.1	
Educational level			
SSCE	7	6	
Diploma	41	35	
NCE	17	14.5	
HND	43	36.8	
Degree	9	7.7	
Interest in training			
Not interested	8	6.8	
Interested	109	93.2	

Source: Field Survey, 2022

As seen in Table 2, the majority (93.2%) of the extension personnel were interested in various trainings. This expresses the willingness of this personnel to be engaged in the training for capacity building and therefore improving their working abilities. It was also revealed that 6.8% of the extension personnel were not interested in any kind of training, this could be a result of extension personnel that were in managerial positions and had few more years to retire from service.

It can be deduced from Table 3 that more than one-third (35.9%) of the extension personnel were between the ages of 33 – 41 years with a mean age of 36 years. This shows that the extension personnel were at their productive age and the training acquired can be put to use for a long period in service. This is also in line with Omoregbee and Ajayi (2009) who reported that more than half of the extension officers in Edo State were in the age groups of between 40 - 49 years.

Table 3 illustrates that more than half (53%) of the extension personnel had 1-7 years of working experience. The study also revealed that the mean years of experience of extension personnel was 11 years, the low years of working experience can be a factor that makes the extension personnel

demand more training to improve their job performance. This is in line with the findings of Lalhmachhuana and Devarani (2017) and of Omoregbee and Ajayi (2009) who reported that 61.1% and 72.3% of the extension personnel had 3-6 and 6-7 years of working experience, respectively. The study also revealed that the mean years of experience of extension personnel was 11 years, which according to Ejembi *et al.* (2006) determines the length of service and level of commitment to work. Years of working experience will in turn demand more training to improve their job performance.

Table 3 showed that more than half of extension personnel (54.7 %) attended 1-5 training within their years of service. The mean number of trainings attended by the extension personnel was 7. This implies that the capacity of extension personnel was built through training and improved their level of competencies.

Table 4 revealed that the discrepancy values based on the mean perceptions were positive values for all 26 tasks ranging from 0.91 to 3.56. The table also shows the ranks of the tasks of the extension personnel based on the calculated MWDS. The average MWDS (2.13) was adopted for the establishment of the training needs of these personnel and out of the twenty-six tasks of the extension personnel subjected to the analysis, they required training in fourteen tasks. Although required training in more than half of the tasks, still indicated wide skill gaps.

The major tasks in which they required training as shown in Table 4 were; Linkage to credit formulation (MWDS = 3.56), campaign on HIV/AIDS (MWDS = 2.94), use of ICT in agriculture (MWDS = 2.90), demonstration of improved technologies (MWDS = 2.83), Irrigation farming (2.83), agrochemical skill training (MWDS = 2.71), nutrition and food utilization demonstration (MWDS = 2.61) and communication skills (MWDS = 2.50). Extension personnel's high training needs in credit formulation could be due to the lack of loans collected by the farmers to improve their agricultural production and livelihood in general which could be attributed to interest

Table 3: Socioeconomic Characteristics of Extension Personnel in Kano State (Continuation).

Variables	Frequency	Percentage	Min	Max	Mean	SD	n = 117
Age							
24 – 32	21	17.9	24	65	36	8.4	
33 – 41	42	35.9					
42 – 49	31	26.5					
50 – 57	14	12					
58 – 65	8	6.8					
Years of Professional Experience							
01 – 07	62	53	1	33	11	9.6	
08 – 14	22	18.8					
15 – 21	12	10.3					
22 – 28	6	5.1					
29 – 35	15	12.8					
Trainings Attended							
01 – 05	64	54.7	1	36	7	6.6	
06 – 10	26	22.2					
11 – 15	15	12.9					
16 – 20	6	5.1					
21 – 25	6	5.1					

Source: Field Survey, 2022

rates and much paperwork attached to loan collections. The use of ICTs in agricultural extension is becoming necessary in other to bridge the gaps in knowledge-sharing techniques. Moon *et al.* (2016) found that ICTs play an important role in every stage of the development process; social, economic, and political, creating opportunities for wide job markets -locally and globally- thereby rapidly changing living styles and livelihoods. It exalts the development process by increasing access to information to hardly reach individuals within the population. Training extension personnel in ICT could therefore help in improving the acceptance of technologies by the farmers

and improve their farming practices and livelihoods. Inadequate training in ICTs was also reported by Tafida (2017) as one of the highest areas of training needs by extension personnel.

Demonstration of technology is an easier way of teaching the farmers how to use new technology; inadequate training of extension personnel in that aspect could lead to poor adoption of technologies. Communication skill is the ability of the extension personnel to communicate verbally and in writing to farmers and also with their colleagues and superior agents to pass down knowledge and understand the problems of the farmers. A lack of such skills could lead to a communication gap between farmers and extension personnel and even between extension personnel and their superiors. It is a critical need yet expressed as a skill gap.

Table 4 above further reveals that farm visits (MWDS = 2.31), livestock production and disease control (MWDS = 2.24), and also formation of women's group (MWDS = 2.16) were areas of need for training. Other areas of training needs were rendering technical advice to farmers (MWDS = 2.16), record keeping (MWDS = 2.16), and crop production technology (MWDS = 2.13). Farm visits and record keeping are elements that could help the EAs in observing both the visible and recorded progress of the farmers (Ighoro *et al*., 2017).

The high need for training in livestock production and disease control was in line with the findings of Tafida (2017), most extension agents emphasize crop production-related aspects and thereby lacking in other aspects of the extension services like livestock production and delivery. The EAs need to be well trained and competent such as most farmers rear several animals within their localities. Lack of training in crop production technology, irrigation farming ICT in agriculture, recording and reporting, communication skills, and nutrition and food utilization were all reported by Okeowo (2015) among the high areas of need for training of extension agents.

Based on the means deduced in Table 5, the highest-ranked weaknesses and threats faced by extension agents in the study area were W4 (mean = 3.12), W2 (mean = 3.04), and W9 (mean = 3.02); T5 (3.41), T6 (mean = 3.32) and T4 (mean = 3.29) which ranked 1st, 2nd and 3rd respectively.

Table 4: Skills Gap Analysis of Extension Personnel

Tasks	Required level mean	Actual level mean	Discrepancy value	MWDS	Rank	n = 117
Linkage to credit formulation	3.55	2.58	0.97	3.56*	1	
Campaign on HIV/AIDS	3.42	2.62	0.80	2.94*	2	
ICT in Agriculture	3.6	2.81	0.79	2.9*	3	
Demonstration of technologies	3.98	3.21	0.77	2.83*	4	
Irrigation farming	3.79	3.02	0.77	2.83*	5	
Agro-chemical skill training	3.79	3.05	0.74	2.71*	6	
Nutrition and food utilization	3.62	2.91	0.71	2.61*	7	
Communication skills	3.78	3.10	0.68	2.5*	8	
Farm Visit	4.08	3.45	0.63	2.31*	9	
Livestock production and Disease control	3.63	3.02	0.61	2.24*	10	
Formation of women's groups	3.57	2.98	0.59	2.16*	11	
Rendering technical advice.	3.81	3.22	0.59	2.16*	12	
Record Keeping	3.65	3.06	0.59	2.16*	13	
Crop production technology	4.03	3.45	0.58	2.13*	14	
Storage and post-harvest	3.68	3.13	0.55	2.02	15	
Value addition on agricultural commodities	3.61	3.07	0.54	1.98	16	
Marketing of commodities	3.51	2.99	0.52	1.91	17	
Formation of cooperative groups	3.88	3.37	0.51	1.87	18	
Operation and maintenance of agricultural machines	3.44	2.96	0.48	1.76	19	
Recording and Reporting	3.57	3.09	0.48	1.76	20	
Planning demonstration	3.7	3.25	0.45	1.65	21	
Selection of contact farmers	3.73	3.31	0.42	1.54	22	
Evaluation trials	3.53	3.15	0.38	1.39	23	
Rodents and pest control	3.45	3.10	0.35	1.28	24	
Formation of farmers' groups	3.75	3.42	0.33	1.21	25	
Market Survey	3.28	3.03	0.25	0.91	26	
	Mean 3.67		Average MWDS	2.13		

Source: Field Survey, 2022

Table 5: Constraints of Extension Agents in Kano State

Weaknesses	Mean	n = 117
Ineffective management (W1)	2.62	
Poor implementation of policy formulation (W2)	3.04	
Top-down approach nature of organization (W3)	2.98	
Too many jobs with different specializations expected (W4)	3.12	
Scarce resources (W5)	2.86	
Lack of finance (W6)	2.83	
Poor farmer development (W7)	2.87	
Poor communication with farmers (W8)	2.87	
Poor communication within the service (W9)	3.02	
Threats		
Lack of technology and information for agents (T1)	2.65	
The development of unproductive farmers who cannot be commercial farmers (T2)	2.67	
Competition between other departments and Non-Government Organization in the same area (T3)	2.74	
Political will to effect change (T4)	3.29	
Interference of politicians into technical aspects (T5)	3.41	
Too many superior agents (T6)	3.32	

Source: Field Survey, 2022

It is important to note that the highest-ranking threat to extension personnel was the Interference of politicians in technical matters (T5). Almost every government comes up with different policies and plans on how to achieve those policies, which will last until another government comes into power which will certainly pay less or no attention to the previous government's policies, making new ones and forgetting how complex extension organisation could be, therefore is needs careful treatment and some things should not be tampered with.

"Too many jobs with different specializations expected" (W4) was the highest-ranking weakness of extension personnel in this study, this describes the diversity of agricultural extension services and extension personnel often complain about it.

The findings of this study are in line with the findings of Tafida (2017) who reported a lack of sponsorship for extension personnel training as one of their weaknesses and inadequate funding from the government which holds back the execution of projects.

The findings of the study revealed that the socio-economic factors of the extension personnel in the study area were mostly male and relatively young. The study expressed the weaknesses of the extension agents as the high expectations on them despite having too many jobs with different specializations and threats such as the interference of politicians in technical aspects.

This study concludes that there are wide gaps in the acquired skills of extension personnel in the study area and the need for the extension personnel to be trained in various skills to bridge the gaps.

1. The study found that extension service was male-dominated. It is therefore recommended that the government should employ more female extension personnel as the number of women farmers is increasing.
2. The study discovered that more than half of the extension personnel had diploma certificates. There is a need for more programmes like SAFE to collaborate with higher institutions to provide more opportunities for extension personnel to upgrade their educational qualifications.
3. Extension personnel in the study area were also found to have wide skill gaps within some of the most important tasks they were expected to perform. There is a need for government to collaborate with stakeholders to give training regarding areas with high skill gaps.
4. The study found that extension personnel were subjected to carry out several and diverse work simultaneously which affects their task performance. It is therefore recommended that each extension agent should be subjected to a few manageable tasks at a given period.
5. The study also revealed that politicians' involvement in technical subject matters is a big threat to the extension work. It is recommended that politicians should not be involved in such technical issues.
6. Finally, the study recommends that frequent skill gap analysis be put in place to have the main areas of need for training pointed out for the stakeholders to assist in giving training.

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Original Research Paper

RESOURCE PRODUCTIVITY OF RICE FARMERS UNDER THE AGRICULTURAL TRANSFORMATION AGENDA (ATA) PROGRAMME IN NIGER STATE, NIGERIA

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ABSTRACT

The study evaluated the resource productivity of rice farmers under the Agricultural Transformation Agenda (ATA) programme in Niger State, Nigeria. Primary data were used for the study and collected from three Local Governments Areas of the State from a total of 194 rice farmers consisting of both beneficiary and non-beneficiary farmers of the ATA programme. Data collected were analyzed using Total Factor Productivity (TFP) and Propensity Score Matching (PSM) methods. The results of the PSM technique to determine the impact of the programme on the productivity of the rice farmers shows that from all matching procedures, the programme had a positive and significant effect on total productivity, fertilizer productivity, seed productivity, land productivity, labour productivity, agrochemical productivity of the farmers and these variables were higher for the beneficiary farmers than that of the non-beneficiaries by at least 0.81 %, 3.9 %, 11.03 %, 4.96 %, 1.22 %, 4.79 % respectively. The study recommends that since the programme showed significant increases in the productivity of the beneficiaries when compared with the non-beneficiaries, government policies, investments, and efforts aimed at the sustainability of the programme should be encouraged and made to be able to stimulate further increases in the growth and productivity of farmers, particularly in rice subsector.

Keywords: Agricultural productivity, Total Factor Productivity, Propensity Score Matching, Agricultural Transformation Agenda.

INTRODUCTION

The agricultural sector has been one of the effervescent sectors driving Nigeria's economy and contributing to the overall growth of developing economies. According to Nepal Rastra Bank (2014), in many developing nations, about three-fourths of the population depends on the agricultural sector as their source of livelihood while also contributing significantly to their economies. In Nigeria, the sector accounted for about 30 % of the Gross Domestic Product of Nigeria in third quarter of 2021 and 34.66 % of total employment in 2020 (National Bureau of Statistics, NBS 2021 in Federal Ministry of Agriculture and Rural Development, FMARD 2022); over 70 % of non-oil exports and provides over 80 % of the food needs of the country (NBS, 2013; Muhammad-Lawal and Omotesho, 2008; Kolawole and Ojo, 2007). However, despite this importance, agricultural production and food supply in Nigeria is still lagging, as a result of low utilization of modern inputs by farmers, unavailability and inaccessibility of farmlands well as the non-mechanized nature of the prevailing agricultural production system (Olawuyi *et al.*, 2010). The potentials that abound in Nigeria's agriculture have remained largely untapped which has led to dwindling performance of the agricultural sector both domestically and in international trade over the years. These challenges thus necessitated the need to initiate a sustainable programme that will drive improved productivity in agriculture and return Nigeria's agriculture to its dominant status in food production and major commodity export. The FMARD (2011) noted that as part of the Federal Government of Nigeria's effort to revamp the agricultural sector, ensure food security, diversify the economy, and enhance foreign exchange earnings, the FMARD embarked on a Transformation Agenda with a focus on the development of agricultural value chains, including the provision of and availability of improved inputs (seeds and fertilizer), increased productivity, as well the establishment of staple crops processing zones. It was designed to achieve a hunger-free Nigeria, through an agricultural sector that drives income growth, accelerates the achievement of food and nutrition security, generates employment, and transform Nigeria into a leading player in the global food market to grow wealth for millions of farmers.

Rice (*Oryza sativa*) is targeted as one of the major or key crops of focus under the ATA programme. Nigeria spends about ₦356b on rice importation annually making it the second largest importer of rice in the world (AfDB, 2013). The rice transformation sub-component aims to transform Nigeria from a nation that depends greatly on imported parboiled rice to a nation more dependent on locally produced parboiled rice. Nigeria's growing demand for rice can be attributed to the effect of shifts in consumer preferences driven by urbanization and changes in employment patterns. Nigeria consumes nearly 6 million metric tons of rice annually and more than half of it is imported parboiled rice (FAOSTAT, 2013) while the local production according to Daramola (2005) is put at 2.0 million MT. Rice consumption in Nigeria is forecast to reach 36 million tons by 2050 (FMARD, 2012). Hence, rice is an economically important food security crop in Nigeria. This therefore means that if Nigeria is to be food-secure, adequate attention should be given to rice production and the rice subsector.

This study, therefore, investigated the extent to which the ATA has been able to increase rice production in Nigeria to ensure that local production can meet this huge demand of the population. Despite the prospects, hopes, and promises of the ATA, there has not been adequate research at evaluating its achievements in improving the productivity of the farmers and increasing local rice production, especially in Niger State, Nigeria. This therefore makes it imperative to evaluate the impact of the ATA programme on rice production in the State especially as it relates to the farm-level resource productivity of the rice farmers.

METHODOLOGY

Area of Study

This study was conducted in Niger State, Nigeria. The State is located in the North-Central zone and Southern Guinea Savannah agro-ecological zone of Nigeria. The state is bordered on the North-East by Kaduna State and on the South-East by the Federal Capital Territory (FCT), Abuja. It is also bordered on the North, West, South-West, and South by Zamfara, Kebbi, Kogi and Kwara States respectively. It also shares a foreign border with the Republic of Benin in the Northwest. The State covers an estimated land mass of about 76,363 square kilometres, constituting about 10% of Nigeria's total land mass, of which 85 % is arable land. The population of the State as of the 2006 census is put at 3,954,772 persons consisting of 2,032,998 males and 1,917,778 females (National Population Commission, 2009) and this population is projected to reach an estimated 5,853,062 persons by 2022 at a 3 % growth rate. An estimated 85 % of the population are farmers

which makes farming the major occupation of the people. The state has three principal ethnic groups – the Nupe, the Gwari, and the Hausa people with several other minority ethnic groups. Generally, the fertile soils and hydrology of the State permit the cultivation of most of Nigeria's staple crops and still allow sufficient opportunities for grazing, freshwater fishing, and forest development.

Data Collection and Sampling Procedure

Primary data was used for the study and were collected using a structured questionnaire with the aid of well-trained enumerators. The study involved data collection from both beneficiary and non-beneficiary rice farmers of the ATA programme. A multistage sampling technique was used to select respondents for the study. The first stage involved the random selection of one LGA from each of the three agricultural zones in the State. The LGAs randomly selected were Gbako in Zone A, Bosso in Zone B, and Wushishi in Zone C. The second stage involved the random selection of 10% of the rice-producing communities/villages in each of the local governments selected where the ATA programme was implemented. In the final stage, a proportionate-to-size sampling technique was used to select the sample size (respondents), who are registered rice farmers that participated in the ATA programme in each of the villages. Using the proportionate-to-size sampling technique, a total of 97 rice farmers that benefited from the ATA programme were randomly selected from the farming communities in the LGAs and interviewed.

Similarly, another 97 non-beneficiary rice farmers from these areas were randomly sampled proportionately from the neighbouring communities to serve as a control. This is to avoid location bias and the spillover effect of the programme if the control were to be selected from the same communities as the beneficiaries. This brought the total number of respondents to 194.

Analytical Techniques

Total Factor Productivity and Propensity Score Matching technique were used to determine the impact of the ATA programme on the productivity of the rice farmers.

Total Factor Productivity

The Total and Partial Factor productivity was used to determine the productivity of the rice farmers in the study area. O'Donnell (2008), Sabasi and Kompaniyets (2015) showed that Total Factor Productivity (TFP) for a farmer *i* in period *t* can be expressed mathematically as in Eqn 1

:

$$TFP_{it} = \frac{Y_{it}}{X_{it}} \quad (1)$$

Where $Y_{it} \equiv Y$ ($\mathbf{y}_{it}$) is aggregate output, $\mathbf{y}_{it} \in i_{+}^{M}$ is a vector of output quantities, $X_{it} \equiv X$ ($\boldsymbol{x}_{it}$) is aggregate input, and $\boldsymbol{x}_{it} \in i_{+}^{N}$ is a vector of input quantities.

Ojo *et al.* (2018) and Emenyonu, *et al.* (2014) in the like manner expressed Total Factor Productivity as in Eqn 2:

$$\text{Total Factor Productivity (TFP)} = \frac{\text{VOP}}{\text{VIE}} \quad (2)$$

Where, TFP = Total Factor Productivity

VOP = Value of Output Produced (₦)

VIE = Value of Inputs Employed (₦).

The effect of ATA on the productivity of the farmers was determined using the following regression model as expressed in Eqn 3:

$$Y = f(X1, X2, X3, X4, X5, X6, X7, X8 + ei) \quad (3)$$

Where: Y = Total factor productivity index, X1 = Farm Size (Ha), X2 = Labour used (man-days), X3 = Fertilizer applied in (Kg), X4 = Seed used in (Kg), X5 = Agrochemical applied in (liters), X6 = NIRSAL Credit/Loan collected in (₦), X7 = Farmer registration in National farmer's Database (1 if registered, 0 if otherwise), X8 = ATA participation (1 if participated, 0 if otherwise).

Propensity Score Matching (PSM)

The Propensity Score Matching (PSM) technique was used to determine the impact of the ATA programme on the productivity of the rice farmers in the study area. In evaluating the impact of a project/programme, it is necessary to determine the difference between what occurred and what would have occurred if the agent had the opposite treatment participation. If a project's outcome indicator is household income, for instance, the average impact of the programme on the beneficiaries is referred to as the Average effect of the Treatment on the Treated (ATT) and is defined as the difference between the expected income earned by programme beneficiaries while participating in the programme and the expected income they would have received if they had not

participated in the programme/project (Nkonya *et. al*., 2007; Gebrehiwot and Van der Veen, 2015). The ATT is expressed in Eqn 4 as:

$$ATT = E(Y_1|p = 1) - E(Y_0|p = 1) \quad (4)$$

Where,

ATT = Average impact of Treatment on Treated;

p = participation in the programme (p = 1 if participated in the ATA project and p = 0 if did not participate in the programme);

Y_1 = outcome (household income) of the project beneficiary after participation in the programme;

Y_0 = outcome (household income) of the same beneficiary if he/she did not participate in the programme.

In implementing the PSM, an empirical model was specified to derive the propensity score. For the ATA programme, we estimated the propensity score for participation in the programme with a probit model using the observable variables that included both determinants of participation in the programme and factors that affected the outcome following Nkonya *et. al*. (2007); Wu *et. al.* (2010); and Gabrehiwot and Van der Veen (2015). The model is specified as in Eqns 5, 6 and 7:

$$y_i = \begin{cases} y_i^* \; if \; y_i^* > 0 \\ 0 \; if \; y_i^* \leq 0 \end{cases} \quad (5)$$

$$y_i^* = \beta_0 + X\beta_1 + \mu_i \;, \; \mu/x \sim N(0, \delta^2) \quad (6)$$

$$y_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots. + \beta_{13} X_{13} + \mu_i \quad (7)$$

where, yi* = dependent variable (Propensity scoring index), β = vector of unknown coefficients, X1 = Gender of the respondent (1 if male, 0 if otherwise), X2 = Age of respondent (in years), X3 = Farm size (in ha), X4 = Farming Experience (in years), X5 = Membership of cooperative society (1 if member, 0 if otherwise), X6 = Number of extension contact in a farming season (number), X7 = Number of labour force available for farming (number), X8 = Value of agricultural equipment owned (₦), X9 = Value of livestock owned (TLU), X10 = Distance to the all-weather road (Km),

X11 = Distance to the nearest town (Km), X12 = Access to potable water supply (Dummy, 1 if have access, 0 if otherwise), X13 = Means of transportation (Dummy, 1 if have access, 0 if otherwise).

The estimated propensity scores were used to construct the comparison groups. Several methods or matching algorithms were used for selecting the matching observations (Smith and Todd, 2005). These include nearest-neighbor matching, kernel matching, stratification matching, radius/caliper matching, etc. The algorithm will find for each agent in the treatment group a member or members of the control group who has (have) a similar-enough propensity score (PS), and these two are matched (Hudson *et al*., 2014). The average difference between the outcomes of the matches is an estimate of the ATT.

RESULTS AND DISCUSSION

Impact of Agricultural Transformation Agenda (ATA) on Productivity of Rice Farmers in Niger State, Nigeria

The Total Factor Productivity (TFP) Index and the Propensity Score Matching (PSM) were used to estimate the impact of the ATA programme on the productivity of the rice farmers in the study area. Table 1 shows the results of the impact of the ATA programme on the total productivity of the rice farmers in the study area using the TFP. The results show that the model has an F-ratio of 32.52 and that the whole model is statistically significant at 1% level of probability. The coefficient of determination (R^2) indicated that 34.2 % variations in the productivity of the rice farmers in the study area were explained by the explanatory variables included in the model.

Table 1 further revealed that farm size, labour used, the quantity of fertilizer applied, amount of improved seed used, the number of agrochemicals used, amount of NIRSAL loans collected, and ATA participation were all directly related to productivity and are all significant 1 % level of probability. This indicates that a unit increase in these variables holding other factors constant led to an increase in the productivity of the rice farmers by 0.190, 0.166, 0.975, 0.299, 0.866, 0.206, and 0.457, respectively. This finding is corroborated by the findings of Ojo *et al.* (2018), Obasi *et al.* (2013), and Fakayode *et al.* (2007) who reported that farm size, labour used, fertilizer use and planting material are among the main factors that determine farm productivity. Also, findings by Anyanwu (2014) confirm that agricultural credits/loans in the form of microcredits are one of the major determinants of farm productivity.

Table 1: Impact of the Agricultural Transformation Agenda Programme on the Productivity of Rice Farmers in Niger State, Nigeria (double-log as the lead equation)

Variables (n=194)	Coefficients	t-value
Farm Size, X_1 (Ha)	0.190	5.66***
Labour used, X_2 (Man-days)	0.166	3.04***
Fertilizer applied, X_3 (Kg)	0.975	5.83***
Amount of Seed used, X_4 (Kg)	0.299	4.49***
Agrochemicals Applied, X_5 (liters)	0.866	3.70***
Amount of NIRSAL Loan collected, X_6 (₦)	0.206	5.24***
Farmers Registration in National Farmer's Database, X_7 (Dummy, Yes=1, No=0)	-0.003	-0.22
ATA Participation, X_8 (Dummy, Yes=1, No=0)	0.457	3.97***
Constant	-2.088	-6.09
R^2 Square	0.342	
Adjusted R^2 Square	0.331	
F-Ratio	32.52***	

*** = Significant at 1% level of probability, ** = Significant at 5% level of probability, * = Significant at 10% level of probability.

Source: Field Survey, 2019.

Using the PSM, Table 2 shows the propensity score for participation on Total Productivity of the rice farmers in Niger State. The result shows that, among the various farmer characteristics, membership in a cooperative society has the strongest influence on farmers' likelihood of participating in the ATA programme in the State. This indicates that farmers who are members of cooperative societies or farmers' unions are more likely to participate in the ATA programme in the state. Similarly, other farmer characteristics such as gender, age, farm size, number of labour force available, farming experience, number of extension contact within a year, the value of agricultural equipment owned, and value of livestock owned also have positive influences on the likelihood of farmers' participation in the ATA programme in the State.

However, distance to all-weather roads, distance to the nearest town, means of transport, and access to public water supply all had negative influences on the likelihood of farmers' participation in the ATA programme in the State. This means that the farther the farmer to the all-weather road, the

less likely it will influence their decision to participate in the ATA programme in Niger State. Also, distance to the nearest town was not equally considered by the rice farmers as an influence on their participation in the programme as the farther the distance to the nearest town, the less likely farmers would participate in the programme. For access to portable water supply, this means that the farmer's participation in the ATA programme was not influenced by the access to the potable water supply to farmers in Niger State and therefore not considered as a factor to influence farmers' participation.

Table 3 shows the impact of ATA on the productivity of rice farmers in Niger State. The result from all matching procedures (nearest neighbour, radius, kernel, and stratification matching) shows that the programme had a positive and significant effect on total productivity, fertilizer productivity, seed productivity, land productivity, labour productivity, and agrochemical productivity.

The result, in specific terms, shows that total productivity for the beneficiary farmers in Niger State was higher than that of the non-beneficiary farmers by at least 0.81 %, fertilizer productivity for the beneficiary farmers was higher than that of the non-beneficiary farmers by at least 3.9 %, seed productivity for the beneficiary farmers was higher than that of the non-beneficiary farmers by at least 10.35 %, land productivity was higher for the beneficiary farmers by at least 1.17 % than that of the non-beneficiary farmers, labour productivity was higher for the beneficiary farmers by at least 1.22 % than that of the non-beneficiary farmers while agrochemical productivity for the beneficiary farmers was higher than that of the non-beneficiary farmers by at least 4.79 %.

Table 2: Propensity score for Participation in ATA on Total Productivity of Rice Farmers in Niger State

Variable Category	Variable Definition	Coefficient	p-value
Farmer-specific variables	Gender	0.42	0.32
	Age	0.05	0.01
	Farm size	0.01	0.78
Farm-specific variables	No of labour force available	0.05	0.20
	Distance to all-weather road	-0.01	0.67
	Distance to the nearest town	-0.02	0.13
Farmer-capital endowment variables	Farming experience	0.02	0.17
	Membership of a cooperative society	0.49	0.06
	No of extension contact	0.17	0.00
Asset endowment variables	Value of Agric equipment owned	0.01	0.07
	Value of livestock owned	0.01	0.18
	Means of transport	-0.14	0.50
	Access to portable water supply	-0.22	0.33
Constant	Constant	-2.27	0.02
Model Characteristics	No of Observations: 194	Log Likelihood: -115.5598	
	Pseudo R^2: 0.1362	p-value: 0.0005	

Source: Computations from data from field survey 2019.

Table 3: Impact of ATA on the Productivity of Rice Farmers in Niger State

Matching Algorithm	Outcome variables	Treated (N=97)	Control (N=97)	ATT	Standard Error	t-value (Significance)
Nearest Neighbour Matching (NNM)	Total productivity	3.58	2.71	0.87	0.18	4.89**
	Fertilizer Productivity	15.18	10.96	4.22	1.35	3.13**
	Seed Productivity	49.93	38.08	11.85	5.91	2.01**
	Land Productivity	4.61	3.43	1.18	0.87	2.68**
	Labour Productivity	6.22	5.00	1.22	0.40	3.03**
	Agrochem Productivity	9.79	5.00	4.79	7.29	2.75**
Radius Matching (RM)	Total productivity	3.56	2.71	0.85	0.13	5.14*
	Fertilizer Productivity	14.85	10.85	4.00	1.30	3.08**
	Seed Productivity	49.24	38.21	11.03	4.73	2.33**
	Land Productivity	4.69	3.46	1.23	0.92	2.92**
	Labour Productivity	6.20	4.94	1.26	0.35	3.57**
	Agrochem Productivity	9.91	4.94	4.97	7.47	2.60**
Kernel Based Matching (KBM)	Total productivity	3.52	2.71	0.81	0.13	4.71**
	Fertilizer Productivity	14.85	10.95	3.90	1.33	2.91**
	Seed Productivity	49.24	37.97	11.27	4.91	2.30**
	Land Productivity	4.69	3.37	1.32	0.93	2.71**
	Labour Productivity	6.20	4.93	1.28	0.37	3.48**
	Agrochem Productivity	9.91	4.93	4.97	7.47	2.60**
Stratification Matching (SM)	Total productivity	3.57	2.71	0.86	0.15	4.78**
	Fertilizer Productivity	15.18	10.41	4.77	1.47	3.25**
	Seed Productivity	49.93	39.58	10.35	7.17	1.44**
	Land Productivity	4.71	3.54	1.17	0.91	2.15**
	Labour Productivity	6.22	4.96	1.27	0.45	2.82**
	Agrochem Productivity	9.79	4.96	4.83	7.29	2.76**

Note: Significance level at ***1%, **5%, and *10%

Source: Data computations, 2019.

Balancing Test for Conditional Independence Assumption (Cia)

Propensity score estimation balances the distribution of independent variables in the groups of beneficiaries and non-beneficiaries of the ATA programme. Figure 1 shows the distribution and common support for the propensity estimation for the State. From the graph, the treated (matched) and the untreated (unmatched) individuals were within the region of common support indicating that all treated individuals have corresponding untreated individuals.

The results in Table 4 further indicate that there was a substantial reduction in bias as a result of matching. The estimates showed that reductions in the median absolute bias were all greater than 20 percent and hence considered 'large' (Rosenbaum and Rubin, 1983; Kirui *et al.,* 2012). Also, the results of the pseudo-R^2 after matching were all lower than before matching for each of the outcome variables. This implies that after matching, there were no systematic differences in the distribution of covariates between both the beneficiaries and non-beneficiaries of the ATA programme. The joint significance of the regressors was rejected after matching, whereas we failed to reject at any significance level before matching. This thus suggests that there was no systematic difference in the distribution of covariates between the beneficiaries and non-beneficiaries of the ATA programme

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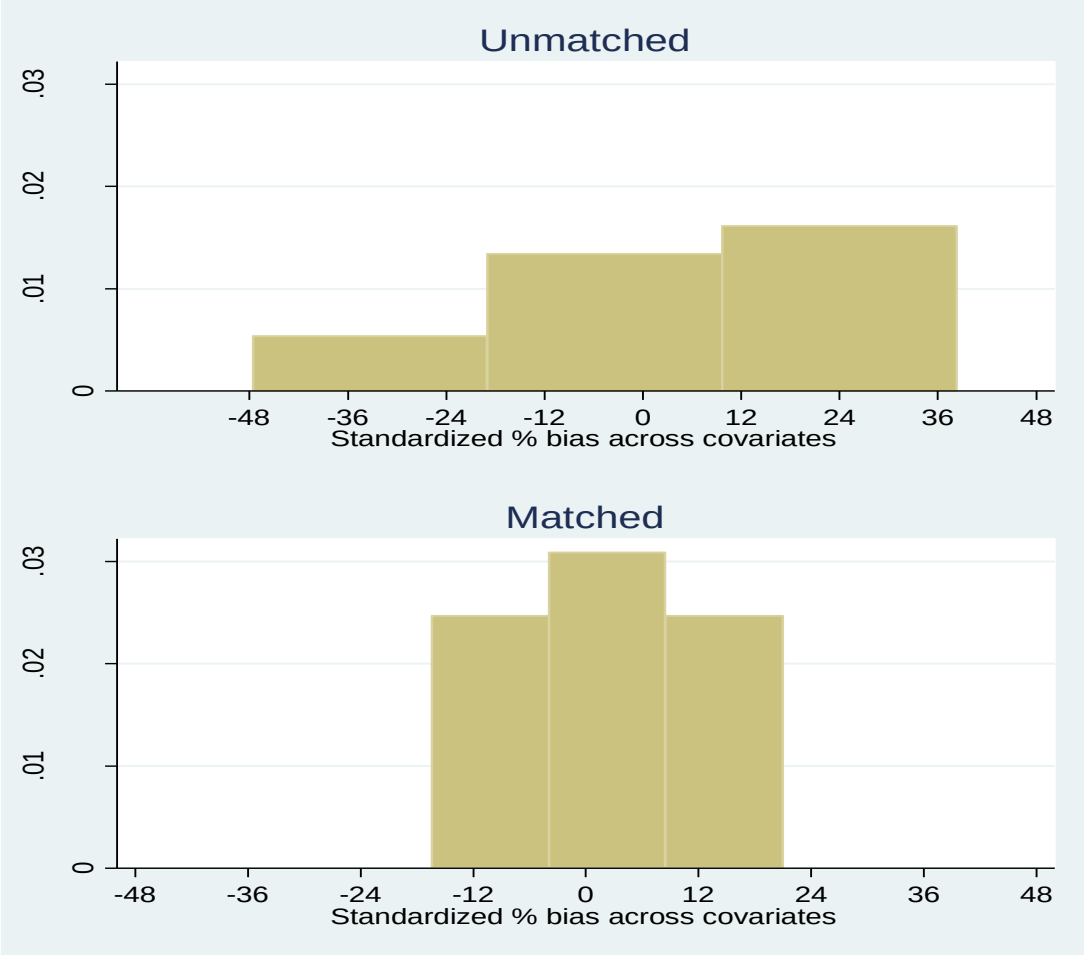

Figure 1: Propensity Score Distribution and Common Support for Propensity Score Estimation for Niger State

Table 4: Indicators of Covariate Balancing before and after Matching

Outcome variables	Mean bias before matching	Mean bias after matching	Median bias before matching	Median bias after matching	% bias reduction	Pseudo R^2 (Unmatched)	Pseudo R^2 (matched)	p-value of LR (Unmatched)	p-value of LR (matched)
Income	18.0	8.3	13.4	6.8	97.06	0.088	0.032	61.76	22.92
Total productivity	17.1	11.4	13.8	7.9	74.68	0.351	0.012	8.51	0.809
Fertilizer Productivity	32.3	11.9	23.3	12.4	87.90	0.351	0.066	78.81	14.91
Seed Productivity	23.1	12.2	14.1	7.6	85.53	0.187	0.146	39.92	31.16
Land Productivity	3.8	2.4	3.2	1.9	68.42	0.351	0.003	1.87	1.00
Labour Productivity	19.2	8.8	15.1	7.8	93.59	0.136	0.054	36.43	14.52
Agrochem Productivity	18.0	7.4	13.4	7.1	88.73	0.088	0.022	61.78	15.70

Source: Data computations, 2019

Test of Hypothesis

The null hypothesis states that there is no significant difference between the farm-level productivity of the beneficiary and non-beneficiary rice farmers under the Agricultural Transformation Agenda. A summary of the t-test computation is presented in Table 5. The results in Table 5 indicated that the computed t-statistic of 4.3027 is greater than the t-critical value of 2.326 at a 0.01 level of significance. This means that the null hypothesis is therefore rejected and we accept the alternative that there is a significant difference between the farm-level productivity of beneficiary and non-beneficiary rice farmers under the Agricultural Transformation Agenda. This result implies that the beneficiary farmers will be more productive and generate greater output per hectare than their non-beneficiary counterparts and would therefore be better off than them.

Table 5: Test of Difference between the Mean Total Productivity of Beneficiary and Non-Beneficiary Rice Farmers in Niger State, Nigeria

Paired Differences	Mean	Std. Deviation	t_{cal}	Significance t_{crit} @ 0.01 level of sig.	Decision
Beneficiaries	4.7028	2.6003	4.3027***	2.326	Reject
Non-beneficiaries	3.8274	1.9438			

*** Implies statistically significant at 0.01 probability level.

Source: Data computations (2019)

CONCLUSION AND RECOMMENDATIONS

The study established that the ATA programme had a significant impact on the productivity of rice farmers in North-central Nigeria. The programme was found to have afforded more farmers more access to farm inputs that enabled them to increase their productivity. Among the determinants of access to the ATA programme in the study area are farm size, membership of a cooperative society, level of education, age, and the number of extension contacts in a cropping season. The PSM results show that the programme had positive and significant effects on total productivity, fertilizer productivity, seed productivity, land productivity, labour productivity, and agrochemical

productivity of the farmers and these variables were higher for the beneficiary rice farmers than that of the non-beneficiaries indicating that the beneficiaries of the programme fared better than their non-beneficiary counterparts in terms of their outputs in the study area.

The study, therefore, recommends that since the programme shows significant increases in the productivity of the beneficiary rice farmers in the study area when compared with the non-beneficiaries, policies, and efforts aimed at the sustainability of the programme be able to stimulate further increases in the growth and productivity of farmers, particularly in rice subsector should be encouraged. Government policies such as the follow-up programmes, the Agricultural Promotion Policy (APP), and the National Agricultural Technology and Innovation Policy (NATIP) should be made such that future investments in the agricultural sector would build on the successes of the ATA programme while improving on the identified pitfalls or weaknesses to make it better to be able to drive further growth in the sector. Successive governments should build on the gains achieved in programmes like this to improve agricultural productivity and not discard it for other policies which would lead to policy summersaults that have been the bane of policy sustainability in the agricultural sector in Nigeria.

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Original Research Paper

EVALUATION OF THE NUTRITIVE QUALITIES OF RIPE AND UNRIPE PLANTAIN PEELS AS A POTENTIAL FEED INGREDIENT

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ABSTRACT

The study examined the nutritional properties of plantain peels subjected to different processing methods which were air-drying, sun-drying, and fermentation. Each method was replicated thrice. Experimental samples were subjected to proximate analysis, phytochemical evaluation, and functional properties determination. Data collected were compared using analysis of variance and significant differences between the means were determined using Duncan's Multiple Range Test. The results of the proximate analysis showed no significant difference between the treatments for moisture content. Ripe sun-dried plantain peels gave the highest crude protein value (9.62 %), Ripe air-dried plantain peels gave the highest lipid content (10.33 %), Unripe fermented plantain peels had a lower crude fibre (4.28 %), Ripe air-dried plantain peels gave the highest moisture content (10.00 %). Unripe air-dried plantain peels had the highest NFE (63.39 %). The result of the phytochemical evaluation disclosed the presence of saponin, alkaloids, and flavonoids. Unripe fermented plantain peels had the least saponin (0.70 %) and flavonoid content (0.08 %). The bulk density values of the ripe and unripe plantain peels reduced from air-dried to sundried, and fermented with the sun-dried sample, they were in the range of 0.34 -0.53 g/cm3. Unripe plantain peels subjected to air drying retained the highest water absorption capacity of 0.51 g/g while unripe plantain peels subjected to fermentation and sun drying had the least water absorption

capacity of 0.37 g/g. Fermentation with the sun-drying process had better results for phytochemical and functional evaluation. Hence, fermented sun-dried unripe plantain peels are recommended as a potential feed ingredient for animals.
Keywords: Alternative feed ingredient, functional properties, plantain peels, phytochemical evaluation, proximate analysis.

INTRODUCTION

Plantain peels, like many other fruit and vegetable peels, offer a series of nutrients and functional properties that can benefit animal alimentation (Oduje *et al.*, 2015). The utilization of fruit debris and agricultural waste provides alternative nutritious livestock dietary supplements. It has been shown that several important bioactive phytochemicals are present in them, required for long-term livestock development and healing growth (Achilonu *et al*., 2018). In developing countries, a significant challenge in livestock production is a clear cost rise, scarcity, and sparse availability of major feeding ingredients as well as the existing competition between humans and animals for these ingredients (Arogbodo *et al.*, 2021). Due to this fact, the profitability that goes to the farmer is significantly reduced since feed costs well over 70% of the entire cost of production (Abdulrahman *et al.*, 2022; Agama-Acevedo *et al.*, 2016). For these to be realized, some leftovers from farming may be utilized in feed composition. Plantain peels are a significant component of the list of agro-industrial by-products (Galani, 2019). The level of carbohydrates, protein, fibre, fat, ash, and moisture in the peel imply that they are capable of addressing those mentioned issues. This is because they are widely available and reasonably priced across the nation (Ighere, 2019; Ndarubu *et al*., 2021). Plantain peels are commonly found across most parts of Nigeria in large quantities but have been fully utilized as a source of feed ingredient, but rather regarded as a waste material (Kadirvel and Ramalakshmi, 2021). This gap is owing to limited information on its nutritive properties, hence the purpose for which this research was carried out (Etim *et al.*, 2018; Usman *et al.*, 2018). To investigate the proximate composition of raw, air-dried, sun-dried, and fermented ripe and unripe plantain peels. of plantain peels into valuable products as a good source of carotenoids, phenolics, and biogenic amines as examples of bioactive substances. (Mohd Zaini *et al.*, 2022; Zhang *et al.*, 2020). Hence, this research focused on determining the nutritive quality of plantain peels using different processing methods which will enable its usage as an alternative livestock feed ingredient.

MATERIALS AND METHODS

Experimental Location

The study was conducted accordingly at the Feed-Processing Unit of the Teaching and Research Farm of Landmark University, Kwara State, Nigeria. Kwara is located between latitude 8° 32 1 North and longitude 4°35 (Elemile *et al.,* 2019).

Plantain Peels Collection and Preparation

Healthy plantain fruits (unripe and ripe) exploited for this study were obtained from peels collected from several plantain vendors in Omu-Aran, Irepodun LGA of Kwara State. Collected plantain peels were subjected to different processing methods and each method was replicated thrice as shown in Table 1.

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Table 1: Processing method and allotment of treatment samples

Plantain Peels	Treatment Sample	Processing Method
Ripe	T1	Air-dried
	T2	Sun-dried
	T3	Fermented for 3 days + Sun-dried
Unripe	T4	Air-dried
	T5	Sun-dried
	T6	Fermented for 3 days + Sun-dried

Processing and Treatment of Samples

The Fresh peels of unripe and ripe *Musa paradisiaca* were properly washed with distilled water and subsequently processed by peeling with a keen sterile knife and the pulp was carefully removed; then collected, separated, and cut into smaller pieces. They were further cleaned using distilled water to rid them of any contaminants and then kept at room temperature after which they were separated for the air-drying, sun-drying, and fermentation. The plantain peels were sun-dried and air-dried in batches for 7 days to remove moisture. After sun and air drying separately, the

dried-out unripe and ripe plantain peels were pulverized utilizing a hand grinder, and the crushed plantain peels were stored at room temperature in sealed bags. Furthermore, the third set of peels was soaked in water under anaerobic conditions for three days after which they were oven-dried and then ground using a hand grinder. The powder form of the peels was stored in separate labelled air-tight plastic bags under dry conditions until use

Proximate Analysis of Plantain Peels

The moisture content, ash content, crude fibre content, ether extract, and crude protein of plantain peels were all determined using the proximate examination. The proximate composition of the peels was appraised using a standard procedure at Landmark University's Animal Science Laboratory, according to the protocols published by the Association of Official Analytical Chemists (AOAC, 2005).

Phytochemical Screening (Quantitative Analysis)

Quantitative determination of the air-dried, sun-dried, fermented oven-dried, ripe, and unripe crushed plantain peel specimens for flavonoid, saponin, alkaloids, and phenol showed positive results and, hence were determined quantitatively.

Determination of Total Phenol: The full phenol content was determined as designated by Oluba *et al.* (2021). In brief, the extracts were oxidized with 2.5 ml of 10 % Folin-Ciocalteau's reagent (v/v) and neutralized with 2.0 mL of 7.5 % sodium carbonate. The rejoinder mixture was incubated for 40 minutes at 45 °C, and the absorbance was measured in a spectrophotometer at 765 nm. Subsequently, the entire phenol content was assayed as gallic acid equivalent.

Determination of Alkaloid: The alkaloid content of plantain powdered material was determined using the method of Ojinnaka *et al.* (2017) with minor changes. In a 250 mL conical flask, 5 g of each sample was weighed and 200 mL ethanol in 10 % acetic acid was added. The resulting mixture was wrapped in foil and left at room temperature for 120 minutes. Following that, the mixture was placed in a 50 °C water bath and permitted to evaporate until the entire volume was abridged to one-quarter of its original level. A few droplets of concentrated ammonia solution were added, and the mixture was allowed to settle. The precipitate was removed using Whatman filter paper

(number 6) and oven-dried to a certain weight at 45°C. The alkaloid content was calculated in percentage as:

$\%\ Alkaloid = \frac{(\alpha)-(\beta)}{\infty} x\ 100$, *where;*

α=*weight of filter paper + residue*

β=*weight of filter paper*

∞=*weight of sample*

Flavonoid determination: The content of both extracts was determined using a tad-modified method described by Oleszek *et al.* (2023). In brief, 0.5 ml of properly diluted material was combined with 0.5 ml methanol, 50% AlCl3, 50% potassium acetate, and 1.4 ml water and incubated at room temperature for 30 minutes. The absorbance of the reaction mixture was then measured at 415nm, and the overall flavonoid content was computed.

Functional Properties of Plantain Peels

Bulk density: The method that was employed was described by Oluba *et al.* (2021). By weighing plantain peel samples (50g) into a 100ml graduated cylinder, beating the bottom ten times on the palm, and articulating the resulting volume in grams per milliliter, the bulk density of the samples was determined.

Swelling power: The procedure used by Alabi *et al.* (2023) was utilized for this analysis. After getting the specific gravity, each plantain peel sample was then given 30 ml of distilled water, and the cylinder was swirled and left to stand for 60 minutes even though the volume change (swelling) was noted every 15 minutes.

Water absorption capacity determination: The technique developed by Ojinnaka *et al*. (2017) was used to calculate water absorption capacity. Each treatment's one-gram sample of plantain peels was weighed separately (as well as with the spotless, dry centrifuge conduit it was placed in). Peels and up to 10ml of distilled water were combined to create the dispersion. It was at that moment centrifuged for 15 minutes at 3500 rpm. The tube's contents were reweighed as grams of

water absorbed per gram of material after the supernatant was removed. The rise in mass was due to the plantain peel sample's ability to absorb water.

Data Analysis

The data collected from all the analyses were subjected to analysis of variance (ANOVA), according to GenStat release Version 10, 2013. The means were separated using Duncan's Multiples Range Test.

RESULTS AND DISCUSSION

RESULTS

The proximate composition of variously processed plantain peels is shown in Table 2. The results of the plantain peel samples' proximal (%) composition are expressed as a means of triplicate. Parameters evaluated include - crude protein, crude fibre, ash, moisture, and nitrogen-free extracts as present in the proximate composition of plantain peels. There was a significant difference ($p<0.05$) between the ripe and unripe plantain peels. The proximate composition of RAP, RSP, RFP, UAP, USP, and UFP are shown in Table 1. From the results, moisture, crude fibre, and crude fat were not significantly ($p<0.05$) different while crude protein, ash, and nitrogen-free extract were significantly ($p<0.05$) different. The outcomes from the proximate analysis showed that there was not any significant difference ($p<0.05$) between the treatments for moisture content. RAP had a higher moisture (9.83 %), than RSP (8.33 %) and RFP 7.83 %. Similarly, UFP (8.17 %) had the lowest moisture compared to USP (9.50 %) and UAP (10.00 %).

Table 2: **Proximate Composition of Air-Dried, Sun-Dried and Fermented; Ripe and Unripe Peels**

Parameters (%)	RAP	RSP	RFP	UAP	USP	UFP	SEM	P. val.
CP	8.82^{ab}	9.62^{a}	8.63^{ab}	7.08^{c}	6.76^{c}	8.32^{b}	0.33	<.001
CF	4.00^{c}	7.36^{b}	4.91^{c}	8.86^{a}	4.58^{c}	4.28^{c}	0.43	<.001
Ash	9.00^{ab}	7.33^{bc}	7.00^{c}	9.67^{a}	9.00^{ab}	8.33^{b}	0.29	<.001
M	9.83^{a}	8.33^{b}	7.83^{c}	10.00^{a}	9.50^{ab}	8.17^{b}	0.27	<.001
EE	10.33^{a}	8.33^{b}	8.50^{b}	6.83^{c}	7.33^{bc}	7.50^{b}	0.25	<.001
NFE	58.01^{b}	59.02^{b}	63.13^{a}	57.56^{b}	62.83^{a}	63.39^{a}	0.73	<.001

CP: crude protein, CF: crude fibre, M: moisture, EE: Ether extract, NFE: nitrogen-free extract). RAP: ripe air-dried plantain peel samples, RSP: ripe sun-dried plantain peel samples, RFP: ripe fermented plantain peel samples, UAP: unripe air-dried plantain peel sample, USP: unripe sun-dried plantain peel samples, UFP: unripe fermented plantain peel sample.

The qualitative phytochemicals of plantain peels are shown in Table 3. The results showed that tannin and phlorotannin were absent in the air-dried, sundried, and fermented ripe and unripe plantain peel samples. Alkaloids, flavonoids, phenols, and saponin, were detected.

Table 4 shows the value of saponin, phenols, flavonoids, and alkaloids in RAP RSP RFP UAP USP. and the phenolic values in UFP. AP, RSP, RFP, UAP, USP, and UFP were significantly ($p<0.05$) but were not significantly ($p>0.05$) different in flavonoid and saponin. The UAP (0.855) showed the highest alkaloid level, while the USP (0.773) had the lowest value. The UAP and UFP showed significant alkaloid levels, while RAP, RSP, RFP, and URP were not significantly ($p>0.05$) different. The UAP 0.612 of flavonoid was the highest, while the lowest flavonoid was UFP (0.0779). The UAP had the highest saponin of 0.920, while UFP 0.704 had the least.

Table 3: Qualitative Phytochemical Screening of Plantain Peels

Parameters	RAP	RSP	RFP	UAP	USP	UFP
Phytochemical elements						
Alkaloid	+	+	+	+	+	+
Flavonoid	+	+	+	+	+	+
Phenols	+	+	+	+	+	+
Phlobatannin	-	-	-	-	-	-
Saponin	+	+	+	+	+	+
Tannin	-	-	-	-	-	-

RAP: ripe air-dried plantain peel samples, RSP: ripe sun-dried plantain peel samples, RFP: ripe fermented plantain peel samples, UAP: unripe air-dried plantain peel sample, USP: unripe sun-dried plantain peel samples, UFP: unripe fermented plantain peel sample.

Table 4: **Phytochemical Quantitative Screening of Plantain Peels**

Parameters (%)	RP			UP			SEM	P-value
	RAP	RSP	RFP	UAP	USP	UFP		
Alkaloid	0.74	0.77	0.80	1.15^{a}	1.11	1.14^{a}	0.66	<. 001
Flavonoid	0.33	0.23	0.29	0.61	0.11	0.08	0.00	<.001
Saponin	0.29	0.29	0.29	0.77	0.76	0.70	0.04	<. 001
Phenolics	0.23^{ab}	0.27^{a}	0.19^{b}	0.20^{b}	0.21^{b}	0.24^{ab}	0.01	0.024

RAP: ripe air-dried plantain peel samples, RSP: ripe sun-dried plantain peel samples, RFP: ripe fermented plantain peel samples, UAP: unripe air-dried plantain peel sample, USP: unripe sun-dried plantain peel samples, UFP: unripe fermented plantain peel sample. RP: ripe plantain peels, UP: unripe plantain peels.

The functional properties of plantain peels sample and unripe plantain peels exposed to different processing methods are shown in Table 5. The Table displays the data for bulk density, swelling power, and water absorption capacity of plantain peel samples. There was a significant ($p<0.05$) difference in the bulk density of the three differently processed plantain peels. The lowest value of UFP, 0.3467g/cm3, and the highest value of UAP 0.5133 g/cm3, occurred in the unripe plantain sample. The plantain peels were in the range of 0.34 -0.53 g/cm3. In unripe plantain peels, bulk density increased from UFP (0.3467) to USP (0.3867) to UAP (0.513). The same trend occurred in ripe plantain peels where bulk density increased from RFP (0.3733) to RSP (0.4167) to RAP (0.4167). However, unripe plantain peel samples (UFP-0.3467g/cm3; USP-0.3867) had lower bulk density than ripe plantain peel samples (RFP-0.3733, RSP-0.4167) in ripe plantain except in air-dried process.

Table 5: **Functional Properties of Plantain Peels**

TRT	RAP	RSP	RFP	UAP	USP	UFP	SEM	P value
BD	0.4167^{a}	0.4167^{a}	0.3733^{b}	0.5133	0.3867^{b}	0.3467	0.00577	<0.01
SP	50.0^{a}	50.8^{a}	50.0^{a}	29.2^{b}	29.2^{b}	54.2^{a}	2.97	<0.01
WAC	0.467^{ab}	0.460^{ab}	0.400^{bc}	0.407^{bc}	0.507^{a}	0.370^{c}	0.0269	0.032

BD: bulk density, SP: swelling power, WAC: water absorption capacity, RAP: ripe air-dried plantain peel samples, RSP: ripe sun-dried plantain peel samples, RFP: ripe fermented plantain peel samples, UAP: unripe air-dried plantain peel sample, USP: unripe sun-dried plantain peel samples, UFP: unripe fermented plantain peel sample.

DISCUSSION

The results from proximate analysis showed that there was no significant difference ($p<0.05$) between the treatments for moisture content. In feed analysis, the moisture content is affected by the method of processing. As a crucial parameter, it influences the shelf-life or how long a feed will last when stored (Oduje *et al.*, 2015). The moisture content of unripe plantain peels that were air-dried had the highest value (10.00 %), followed by ripe plantain peels which were air-dried (9.83 %); while the lowest percentage of moisture as reported in Table 2 was ripe plantain peels,

fermented for three days and sundried (7.83 %). The moisture contents of the air-dried, sun-dried, and fermented sun-dried ripe peels sample being higher than the unripe air-dried, sun-dried, and fermented sun-dried ripe peels sample coincides with the findings of Adamu *et al.* (2017). From the result obtained, fermented sundried ripe plantain peels will last longer when stored while air-dried unripe plantain peels have the shortest time of storage. The high level of moisture gained in the RAP and UAP may perhaps be caused by moistness absorbed from the atmosphere during the air-drying procedure, while the RSP and RFP moisture reduction was from the sun-drying process (Adamu *et al.,* 2017). However, RAP moisture is higher than UAP may be owed to the moisture gained from the ripening course and from general microbial activities as the fruit ripens (Shadrach *et al.,* 2020).

The ash content is a portion of the mineral content (Oduje *et al.,* 2015; Matthew *et al.,* 2020). The percentage of ash in this study is similar to results recorded by (Oduje *et al.,* 2015) with 17.24 % in ripe plantain peels and 13.33 % in unripe plantain peels; where unripe plantain peels had a higher value than ripe plantain peels. From the table, air-dried unripe plantain peels, UAP (9.67 %) had the highest ash content, similar to (Oduje *et al.,* 2015) findings. The plantain peel with the least ash was recorded in RFP (7.00 %) similar to Shadrach *et al.* (2020) findings where the plantain peels with the least ash were recorded in ripe plantain peels (10.35 %). The percentage ash in unripe plantain peel decreased to ripe plantain peel over the same processing method: UAP (9.67 %)>RAP (9.00); USP (9.00 %)>RSP (7.33); UFP (8.17 %)>RFP (7.00 %). Sun-drying reduces the inorganic content of the unripe plantain peels (UAP 9.7 %, USP 9.83 %, and UFP 8.83 %) which is similar in ripe plantain peels RAP (9.67 %), RSP (8.73 %), and RFP (7.83 %) as revealed in Table 2. The plantain peel treatment with the peak quantity of minerals is UAP (9.7 %). Oduje *et al.* (2015) observed that minerals are higher in air-dried, unripe plantain peels.

The result for ether extracts obtained from plantain peels in this study exhibited that there is a significant ($p<0.05$) difference between the treatments. RAP (10.33 %) showed the highest ether extract percent, while UAP (6.83 %) showed the least ether extract composition similar to Shadrach *et al.* (2020) who recorded 11.33 % in air-dried plantain peels. The ether extract composition increased significantly with an increase in ripeness as the value of RAP (10.33 %) is higher than the UAP value (9.33 %), RSP (8.50 %) than USP (8.50 %), and RFP (11.83 %) compared to UFP (10.5 %). Also, the EE values of the plantain peels decreased with the processing method: the highest was ripe plantain peels, (RP), then in unripe plantain peels (UP).

According to Shadrach *et al.* (2020), the crude fibre in air-dried ripe plantain peels is less than in air-dried unripe plantain peels (RAP-8.78 UAP-12.58). Similarly, from Table 2, UAP (8.86 %) showed the highest crude fibre compared to RAP (4.00 %), the least fibre-containing plantain peel. UAP and RSP showed significantly high levels of crude fibre while RAP, RFP, USP, and UFP showed no significantly high level of crude. Although crude fibre is quickly digested by monogastric animals, the appropriate functioning of the intestinal tract of ruminant animals is dependent on the presence of sufficient fibre (Egbuna and Ifemeje, 2015; Oduje *et al.*, 2015). RSP (9.62 %) shows the highest level of CP as recorded in Table 2 while USP (6.76 %) showed the least crude protein. Generally, crude protein was higher in air-dried, sun-dried, and fermented sun-dried ripe plantain peels samples than in air-dried, sun-dried and fermented sun-dried unripe plantain peels. These levels of CP in ripe and unripe plantain peels agree with Oduje *et al.* (2015), with air-dried unripe plantain peels having 7.89 % and air-dried ripe plantain peels 5.72 %. The UFP (63.39 %**)** showed the highest nitrogen-free extract to UAP (57.56). NFE represents the soluble carbohydrate level in the peels UFP (63.39**)** was significantly ($p<0.05$) higher than both the RAP and RSP, (58.01 and 59.02, respectively). The difference in CP with Shadrach *et al.* (2020) (UAP-6.13) may be a result of environmental factors on the plantain peels as well as the differences in processing methods used for this study. This could also indicate an upsurge in the amount of carbohydrates in the pulp. It's also probable that a drop in protein in the plantain peels lead to an increase in carbohydrate.

Plant food, leaves, and other portions of plants contain natural bioactive compounds called phytochemicals. These compounds work in conjunction with nutrients and dietary fibre to protect other substances. (Egbuna and Ifemeje, 2015). Phytochemicals are unpalatable plant compounds with defense or disease-preventing capabilities. (Shadrach *et al.*, 2020). The plantain peels' phytochemical content raises the possibility of using them as nutritious animal feed (Egbuna and Ifemeje, 2015; Veer, 2021). The concentration of alkaloid content decreased from RP to UP. The occurrence of alkaloid in RP is in the order RSP>RFP>RAP (values in that order) while in UP is in the order UAP>UFP<USP (values in that order). In air-dried ripe plantain and unripe plantain, RAP had a lesser value of alkaloid, this may infer that ripeness is inversely proportional to alkaloid content in plantain peels. The same trend was also observed in RFP (0.800) and UFP (0.855) respectively. However, the USP (0.773) was higher than the RSP (0.8325). Alkaloids are naturally

occurring toxic amines produced by plants as a defense mechanism for protection (Taylor and Hefle, 2017). The result of the analysis showed that air drying is best for processing ripe plantain peels and sun-drying for unripe plantain peels.

Flavonoid content in UFP and USP is lower than in RFP and RSP respectively. This may be because the age of the plant part is directly proportional to its phytochemical content. Conversely, USP (0.6123) is higher than RAP (0.3307). The result of the flavonoid screening shows that RSP and UFP are the best-processed peels among ripe and unripe plantain peels for use in animal feed. Flavonoids are non-nutritive plant chemicals with disease-preventive properties, hence their presence in RSP and UFP suggests possible applications as animal feed (Egbuna *et al.,* 2019). According to Khan *et al.* (2018), saponins are phytochemicals that show anti-biotic properties in plantain peels. From the result obtained in this study, the inclusion of UFP (0.7040), being the least containing saponin UP, in feed ingredient is suitable (Dong *et al.,* 2020)
The presence of phenolic chemicals, including monomeric flavan-3-loss, polymerized prodelphinidins, glycosides, and B-type procyanidin dimers, as described by Rebello *et al*. (2014) in RP is in the order RSP>RFP>RAP while in UP is in the order UAP>UFP<USP. In air-dried ripe plantain and unripe plantain, RAP (0.2267) and UAP (0.2040) have lesser values of phenols. This may infer that ripeness is inversely proportional to total phenolic content in plantain peels. The same was also observed in RFP (0.800) and UFP (0.855) respectively. However, the USP (0.773) was lower than the RSP (0.8325). From the results obtained in this analysis, RFP (0.193) has the least phenolic value among all the samples, hence best for processed plantain peels when considering phenolic content.

Table 5 shows findings for bulk density, specific gravity, swelling power, and water absorption capacity of plantain peel samples**.** This implies that the processing method of both ripe and unripe plantain peels influences its bulkiness; which is a key factor for feed selection in animal nutrition. The bulk density values of the ripe and unripe plantain peels reduced from air-dried to sundried, and fermented with the sun-dried sample, they were in the range of 0.34 -0.53 g/cm3. In unripe plantain peels, bulk density increased from UFP (0.3467) to USP (0.3867) to UAP (0.513). The same trend occurred in ripe plantain peels where bulk density increased from RFP (0.3733) to RSP (0.4167) to RAP (0.4167). However, unripe plantain peel samples (UFP-0.3467; USP-0.3867) have lower bulk density than ripe plantain peel samples (RFP-0.3733 USP-0.4167) in ripe plantain

except in air-dried process. Bulk density makes known the relational volume of packaging material required. (Ojinnaka *et al.*, 2017). Therefore, UFP has the lowest volume required for storage, processing, or transport.

A higher WAC is relevant in certifying that feed ingredients hold good texture which influences palatability (Oluba *et al.*, 2021). The water absorption capacity (WAC) of the plantain peels decreased using increasing processing methods as shown in Table 4. Unripe plantain peels subjected to air drying retained the highest water absorption capacity of 0.507 while unripe plantain peels subjected to fermentation and sun drying had the least water absorption capacity of 0.37.

CONCLUSION

The study showed that nutrients that are essential for animal feed could be potentially derived from sun-dried, fermented, and air-dried unripe and ripe plantain peels. Despite the processing approach, all peel samples exhibited possibilities as animal feed. It is recommended that plantain peels be studied for further processing methods to enhance their use as a feed ingredient. Further studies should be carried out on the medicinal qualities of processed plantain peels to know their application in animal health. Processed plantain peels functional properties make it a good additive in animal feed formulation. Therefore, it is recommended that feeding trials should be carried out to evaluate its potential as an alternative animal feed ingredient source.

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Original Research Paper

INTERROGATING THE CHICKEN GROWTH HORMONE GENE OF SELECTED NIGERIAN CHICKEN BREEDS USING DNA-SEQUENCING DATA

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ABSTRACT

The growth hormone gene is one of the most significant genes in the body. It regulates hormones related to growth, development, and egg production in avian species among other important traits. The study is centred on understanding the cellular, molecular, and biological mechanisms underlying the activity of the gene by interrogating it using the National Centre for Biotechnology Information (NCBI) database. After extraction of genomic DNA in selected Nigerian indigenous chickens (FUNNAB Alpha, Noiler, Frizzled feathered, Fulani ecotype), and an exotic broiler chicken (Cobb 500), it was amplified at intron 3 of the cGH yielding a product of 715bp. These were sequenced and aligned against the chicken genome with the BLAST programme of the NCBI website to verify their identity. A dendrogram for the five studied chickens and five closely matched species after carrying out Basic Local Alignment Search (BLAST) was generated showing their relationship using the facility for generating phylogenetic relationships on the website. Dendrogram for the five studied chickens based on Nei's unbiased genetic distances was also obtained using MEGAX software. The cGH gene identified was subjected to functional enrichment analysis using the STRING database concentrating on ascertaining molecular, cellular, and

biological processes/pathways associated with the gene. Functional enrichment analysis revealed key associated genes of cGH, as well as the processes and pathways linked to the gene. Markedly, the gene's involvement in the regulation of growth, protein, endocrine, cell proliferation, cell signaling, enzyme activity, response to food, and regulation of appetite were highlighted amongst others. The study has contributed to a profound perception of how the gene impacts on growth and development of avian species. Conclusively, the study revealed that a combination of transcriptomic data and pathway analysis could serve as a powerful tool that will be helpful in the unraveling of the complex molecular activities linked to growth in the chickens.
Keywords: Broilers chicken; Growth hormone; DNA-seq; STRING; Functional enrichment analysis.

INTRODUCTION

The growth hormone is one of the hormones secreted by the somatotropic cells of the anterior lobe of the brain pituitary. It together with its associated genes, are documented to have positive influences on animal growth, metabolism, lactation, and reproduction (Breier, 1999). This gene, with its positional and functional capacity, has been widely used as a genetic marker in many farm animal species (Adigun *et al.,* 2021). The gene is located on the 27th chromosome and contains 5 exons and 4 introns with a total length of 4.35 kbp. These exons and introns have been reported to account for the greatest diversity and are correlated with the performance of animals (An *et al.,* 2010; Wickramaratne *et al.,* 2010). Being a polypeptide hormone, it is produced and discharged by the pituitary gland. It has been particularly reported to affect growth traits (growth rates, body weight, maturation, metabolism rates, egg production, reproduction, appetite control, and aging) in broiler chickens (Harvey, 2013). Growth performance and carcass traits are noteworthy traits of economic importance in broiler chickens' production.

The chicken growth hormone (*cGH*) is a 22 kDa protein, comprised of 191 amino acid residues (Hrabia *et al.,* 2008). The *cGH* consists of 4,101 bp (Kansaku *et al.,* 2008), and affects a variety of physiological functions in the chicken (Apa *et al.,* 1994). It is one of the key genes influencing chicken performance traits (Vasilatos-Younken *et al.,* 2000) including the promotion of muscle and bone growth and development, as well as the regulation of the fat content of meat (Zhang *et al.,* 2007; Mazurowski *et al.,* 2015). Studies revealed its involvement also in sexual differentiation and pubertal maturation processes as well as active participation in gonadal gametogenesis,

steroidogenesis, and ovulation (Hull and Harvey, 2001). A greater level of genetic diversity in the *cGH,* was reported by Nie *et al.* (2002) to exist in the less artificially selected indigenous or native chicken breeds compared to the commercial breeds.

Growth is a trait that is primarily, controlled by polygenic genes. Some of the genes like the Signal Transducer and Activator of Transcription (STAT) gene, which contains 5 conserved domains and occurs in two isoforms (*STAT5A* and *STAT5B*), are associated with growth (Hennighausen *et al.,* 2008; Zhao *et al.,* 2012); yet another like the Bone Morphogenetic Proteins (BMPs), belonging to a bigger subclass of the Transforming Growth Factor-β (TGF- β) performs an important part in ovarian physiology; its isoform (*BMPR-IB*) influences ovulation rate and hence, production of egg (Zhang *et al.,* 2008). Lots of research has been carried out on how genes, *cGH* inclusive, have significantly affected traits of importance (Okumu *et al.,* 2017; Adigun *et al.,* 2021). Okumu *et al.* (2017) for instance, analyzed different indigenous chicken populations based on genetic characterization using microsatellite markers and/or other modern techniques in Kenya. Adigun *et al.* (2021) evaluated the polymorphism and genetic diversity of *cGH* gene in selected chicken breeds in Nigeria and reported the existence of polymorphic variants in them. While these reports are not exhaustive, additions to the body of knowledge are highly welcome because the discovery of genetic diversity will provide opportunities for genetic improvement. However, there's a need for an initial assessment of candidate genes linked to these diversities (Pagala *et al.,* 2017). In Nigeria, such information is insufficient or at worst even nonexistent. Hence, the present study is aimed at interrogating the *cGH* gene of selected Nigerian indigenous chicken breeds using DNA-seq data.

MATERIALS AND METHODS

Study Area

The study was carried out at the poultry farm of the Department of Animal Production, Federal University of Technology, Minna, Niger state, Nigeria located in the Southern Guinea Savanna zone. Its latitude, longitude, annual rainfall and temperature regimes, and altitude are as described by Ojimaduka *et al.* (2020). The study was carried out using five chicken breeds commonly reared in Nigeria (Fulani ecotype, Frizzle feathered, Noiler, FUNNAB Alpha broilers, Cobb 500). The Noiler, FUNNAB Alpha broilers, and Cobb 500 chickens were managed intensively, while the Fulani ecotype and Frizzled feathered chickens were managed extensively.

Blood Sample Collection

Blood samples (5 ml) were collected from the brachial vein of the chickens using separate 5 ml syringes to prevent cross-contamination. The blood samples were collected into separate Ethylene Di-amine Tetra-acetic Acid (EDTA) bottles and stored in ice packs for onward transfer to the laboratory where genomic DNA was extracted. DNA extraction was done at African Biosciences Ltd., Ibadan, Oyo State, Nigeria, using a gSYNCTM DNA extraction kit (Geneaid) according to the manufacturer's protocol. The extracted DNA quantity and quality were checked by using a spectrophotometer and agarose gel electrophoresis, respectively. The primers used for the study were designed using the NCBI website (Table 1). The Polymerase Chain Reaction (PCR) products obtained after DNA extraction were sequenced and then aligned against the chicken genome with the BLAST programme of the National Centre for Biotechnology Information (NCBI) website (http://ncbi.nlm.nih.gov) to verify their identity. Before sequencing, the extracted DNA was cleaned to ensure that the genes were not contaminated with impurities; this was done using a DNA clean and concentrator kit using the manufacturer's protocol (ZYMO Research).

Sequencing of the Genomic DNA

The procedures used in genomic DNA extraction, polymerase chain reaction, and DNA sequencing had been explained previously by Adigun *et al.* (2021). The procedure includes the use of primers (Table 1) for PCR to amplify specific DNA regions from the extracted genomic DNA. The products obtained were subjected to Sanger sequencing and used to determine the nucleotide sequence of the PCR products. The sequencing was followed by sequence alignment whereby the sequenced DNA fragments were aligned against the chicken genome using the BLAST programme on the National Centre for Biotechnology Information (NCBI) website. This alignment was performed to verify the identity of the DNA fragments and to compare them with existing genomic data.

Table 1. Primer used for the Study

5'TCAGTACGCAGACCTACCCTC3'	Forward
5'TGCACATCATGTCCCACGTTT3'	Reverse

Data Analysis

The *cGH* gene obtained from the studied chickens, including DNA, was compared with what was obtainable in the NCBI information gene bank by using the BLAST, and similar sequences and nucleotides were investigated. A dendrogram for the five studied chicken breeds and the five closely matched species following blasting on the NCBI website was generated to show the genetic relationship using a facility for generating phylogenetic relationships on the website. A dendrogram for the five studied chicken breeds based on Nei's unbiased genetic distances, using the Unweighted Pair Group Method with Arithmetic mean (UPGMA), was generated to show the populations' genetic distances using MEGAX software. The *cGH* gene identified was subjected to functional enrichment analysis using the Search Tool for the Retrieval of Interacting Genes/Proteins (STRING) database focusing on identifying biological processes and pathways associated with the genes.

RESULTS

Extracted DNA, PCR Products

The agarose gel electrophoresis results of the isolated genomic DNA of selected chicken breeds in Nigeria and of the PCR amplified *cGH* are presented in Figures 1 and 2. The amplified products appeared as clear single bands, and occupied the position with approximately 700 bp of amplicon size, with no variation in sizes between the chicken breeds studied.

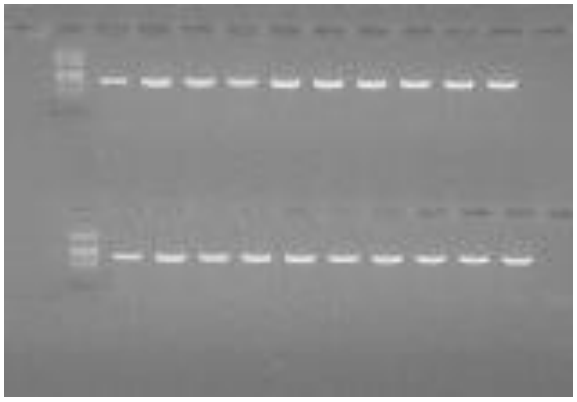

Figure 1. Isolated genomic DNA of the chickens

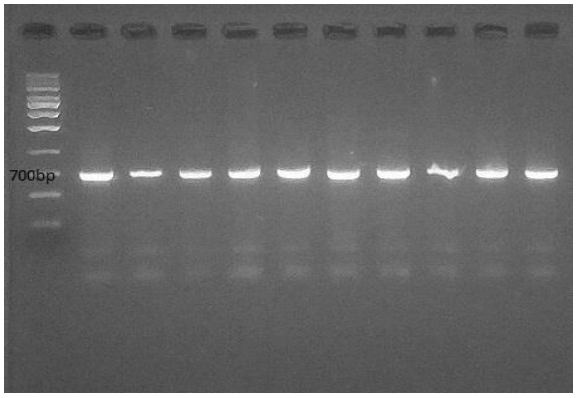

Figure 2. Amplified PCR products of the *cGH*

Scoring of Similarity and Matching Rate of Sequences of Different Chicken Genotypes

The scoring of similarity and matching rate of the different sequences of the different chicken genotypes with the reference genotype, and the next five closely related genotypes (*Meleagris*

gallopova, Rollulus rouloul, Tetrao urogalus, Lagopus leucura, Somateria mollisima) is given in Table 2. The maximum scores were all >1200 and the *cGH* fragments for all the chickens accessed were >99 % in homology with the reference chicken's genomic sequence (*Gallus gallus* accession no. AY461843.1). The similarity of each of the chicken breeds studied to the five closely related genotypes on the NCBI database was in the following order; *Rollulus rouloul* > *Meleagris gallopova* > *Lagopus leucura* > *Tetrao urogalus* > *Somateria mollissima.*

Phylogenetic Relationship between the Selected Chicken Breeds, the Reference Gallus gallus Gene, and the Five Most Closely Related Genotypes

Figure 3 shows the phylogenetic relationship among the selected chicken breeds, the reference *Gallus gallus* gene, and the five most closely related genotypes. The phylogenetic relationships among each of the studied breeds, the reference breed, and the five most closely related genotypes were similar. Each of the selected breeds is represented by the unknown in the figure. Six different clades were observed, with the farthest being that between the genotypes and *Somateria mollissima.* Figure 4 shows the phylogenetic relationship between the selected chicken breeds only (Adigun *et al.,* 2021). Two clades were observed in the studied birds.

Functional Enrichment of the cGH Gene

The functional enrichment of the *cGH* gene showed its association with certain genes and biological processes (Figure 5). The associated genes of the *cGH* are: Growth Hormone Releasing Hormone gene (*GHRH*), Neuropeptide Y Receptor gene (*NPY2R*), Pancreatic Polypeptide gene (*PPY*), Proopiomelanocortin gene (*POMC*), Glycoprotein hormones, alpha polypeptide gene (*CGA*), Insulin-like Growth Factor 1 gene (*IGF1*), Growth Hormone (*GH*), Gherelin and obstatin prepropeptide gene (*GHRL*), Growth Hormone Receptor gene (*GHR*), Prolactin gene (*PRL*) and Prolactin Receptor gene (*PRLR*). The genes are associated with many biological processes at a False Discovery Rate (FDR) of between 0.000075 to 0.024.

DISCUSSION

The amplified gene products obtained in the study were consistent with the expected target fragments and all had a good specificity, which was directly analyzed through the PCR-RFLP technique. The present findings on the *cGH* gene in terms of product size, are in agreement with earlier reports; Muin and Lumatauw (2013) in Indonesia native chickens' population, and

Bingxue *et al*. (2003) in F2 chickens (from broilers x Silky crossing in China), respectively. However, others (Khoa *et al.*, 2013; Makhsous *et al*., 2013; Rahmadani *et al.*, 2014; Saikhom *et al.*, 2017) reported product sizes of 563 bp, 1164 bp, 367 bp, and 713 bp, respectively. While some of these reported lower product sizes, others observed higher product sizes. The differences in the base pairs of the PCR fragments in the current study when compared to those reported by the authors cited above, suggest the possibility of insertion/duplication of the sequences.

The *cGH* fragments for all the chickens studied obtained more than 99 % homology with the reference chicken's genomic sequence (accession no. AY461843.1) of *Gallus*. This means that the percentage of genetic bases similar to the reference sequence is very high. The lower values obtained with *Somateria mollissima* however, is a reflection of the genetic distance between the breeds studied and this species. This shows that *Somateria mollissima* became detached from the others quite a long time ago along the evolutionary journey. The higher the similarity percentage, the closer the relationship; meaning the co-ancestry is high either because of a speciation occurrence, a duplication consequence, or a lateral (horizontal) gene transfer (Koonin, 2005). This is evidence that the genotypes are closely related by evolutionary changes emerging from a common ancestor. This is further affirmed by the phylogenetic map, where the closest relationship was between the individual genotypes (unknown; Figure 4) and the reference sequence. The farthest distance between the studied genotypes and *Somateria mollissima* therefore, is a clear indication of how distant their homologs are. This is a reflection of the number of genetic bases that have become different over time in the evolutionary journey.

The phylogenetic relationship between the studied genotypes divided them into two groups. While the Fulani ecotype chicken was found in the same group with the FUNNAB Alpha and Cobb 500 (both chickens with a high percentage of exotic blood), the Noiler and Frizzled feathered were in the same group. Tiamiyu (1999) opined that the Fulani chicken was developed from exotic cockerels (Rhodes Island Red) bloodlines used in previous improvement programmes when they were used to mate with indigenous hens. The Noiler and Frizzled feathered chickens are both dual-purpose birds and this might have accounted for their closeness and possible co-ancestry.

Functional enrichment analysis is a powerful tool used in the discovery of the molecular, biological, and cellular processes or functions associated with a particular gene. This is because it helps in

bringing out the protein–protein interaction networks that are important ingredients for the understanding of cellular processes in organisms. Such interaction networks are useful in sifting through and evaluating functional genomics data; this helps in providing an intuitive platform for explaining and interpreting of structural, functional, and evolutionary properties of proteins. This kind of exploration is capable of suggesting novel guidelines for future experimental research and providing cross-species predictions for efficient gene interaction mapping (Schwartz *et al.*, 2008). The gene under study (*cGH*) has been linked to function in the extracellular space and molecularly, it aids neuropeptide receptor binding hormone activity, protein-coupled receptor binding, and in signaling receptor binding. Its biological functions are multifaceted including regulation of glucocorticoid secretion, positive regulation of growth hormone secretion, response to food/regulation of appetite, insulin-like growth factor receptor signaling pathway,

Table 2: Scoring of Similarity and Matching Rate of Sequences of Different Chicken Genotypes in the Case of *cGH* Gene

Genotype	FUNNAB Alpha		Cobb 500		Noiler		Fulani ecotype chicken		Frizzled Feathered chicken	
Related genotypes	Max Score	Identity (%)	Max Score	Identity (%)	Max Score	Identity (%)	Max Score	Identity (%)	*Max Score	Identity (%)
Gallus gallus AY461843.1	1277	99.58	1272	99.44	1257	99.02	1268	99.30	1272	99.58
Meleagris gallopova (Turkey) OW982277.1	1006	90.50	1011	90.63	1000	90.37	1006	90.50	997	90.22
Rollulus rouloul (Creasted Partridge) EF521549.1	928	91.64	932	91.80	921	91.50	932	91.80	919	91.33
Tetrao urogalus (Western Capercaillie) (OX596320.1	850	85.95	864	86.37	857	86.25	864	86.37	859	86.23
Lagopus leucura (White-tailed Ptarmigan) XR_006181562.1	680	86.40	680	86.40	689	86.75	689	86.75	680	86.40
Somateria mollissima (Common Eider) OX598326.1	545	75.39	549	75.65	541	75.79	549	75.52	545	75.39

*Max = maximum

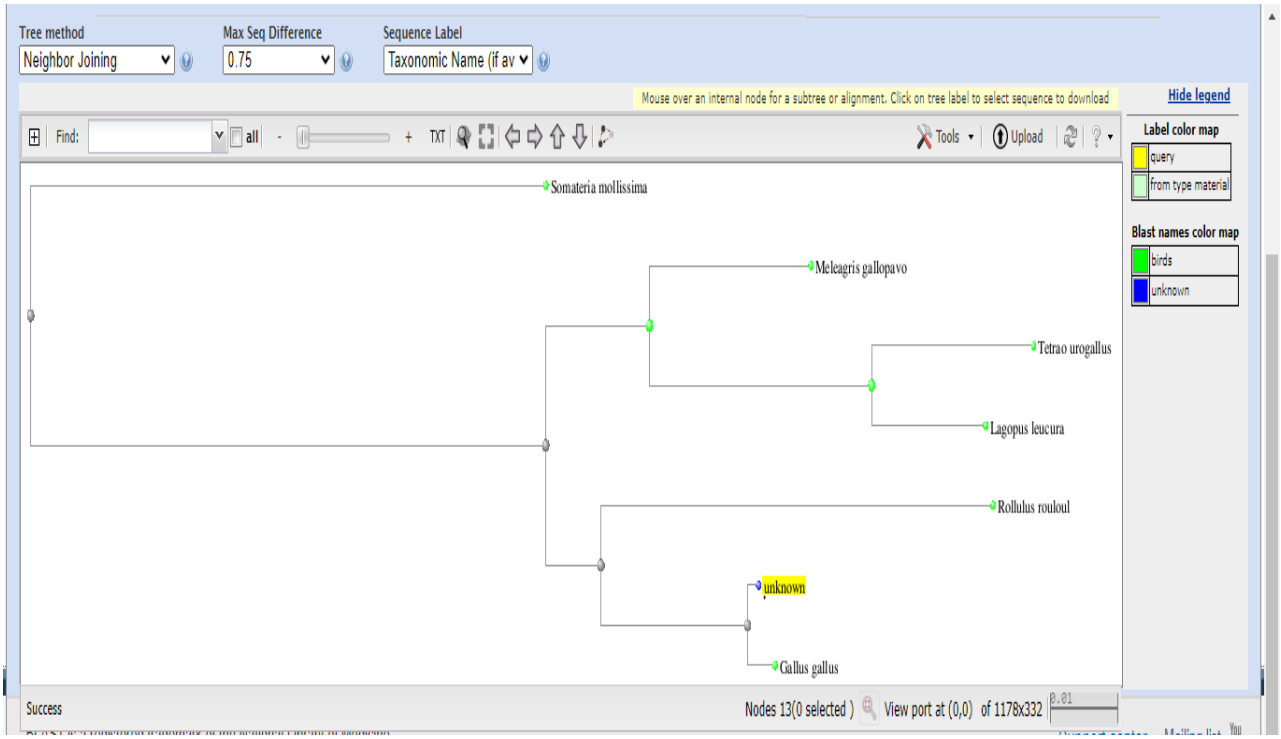

Figure 3: Phylogenetic Relationship Between the Selected Chicken Breeds (unknown) and the Closest Neighbours

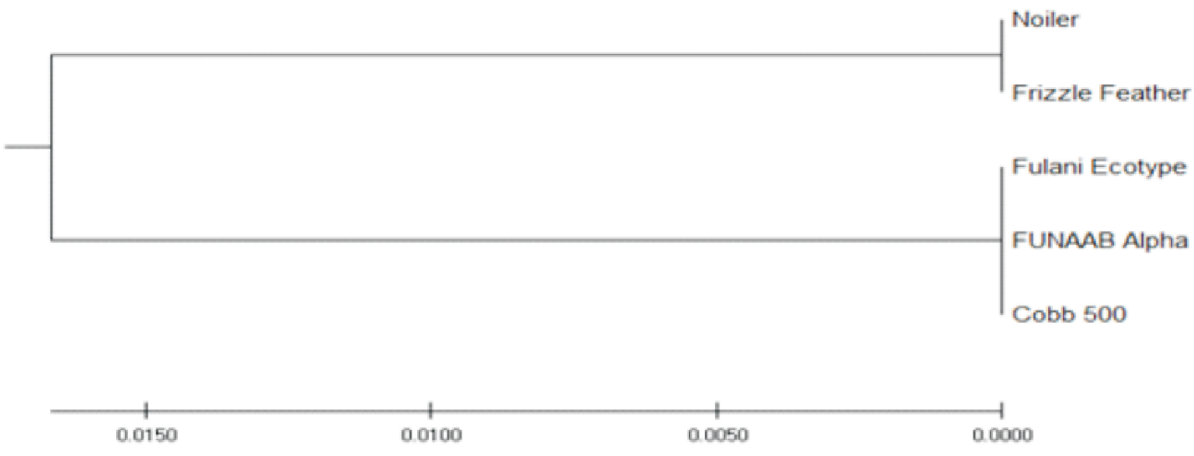

Figure 4: Phylogenetic Relationship Between the Chicken Breeds at the *cGH* Gene Locus

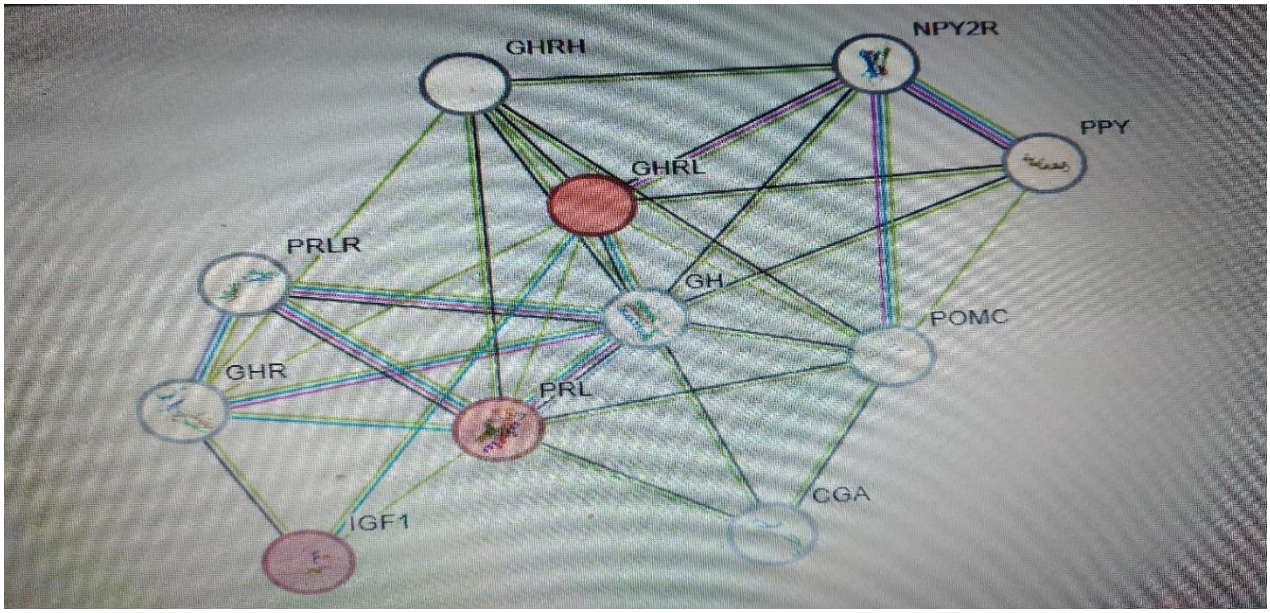

Figure 5: Genes Related to the *cGH* Following Functional Enrichment Analysis

Key: *GH* = growth hormone gene, *GHRH* = growth hormone releasing hormone gene, *NPY2R* = neuropeptide Y receptor gene, *PPY* = pancreatic polypeptide gene, *POMC* = proopiomelanocortin gene, *CGA* = glycoprotein hormones, alpha polypeptide gene, *IGF1* = insulin-like growth factor1 gene, *GHRL*= ghrelin and obstatin prepropeptide gene, *PRLR* = prolactin receptor gene, *GHR* = growth hormone receptor gene, *PRL* = prolactin gene.

positive regulation of receptor signaling pathway via JAK-STAT, growth hormone receptor signaling pathway, regulation of endocrine process, negative regulation of insulin secretion, regulation of multicellular organism growth, negative regulation of hormone secretion, tumor necrosis factor production, and endothelial cell proliferation, positive regulation of peptide hormone secretion, and control of the neuropeptide signaling pathway. Other biological functions are positive regulation of peptidyl-tyrosine phosphorylation, response to nutrient levels, response to hormones, enzyme-linked receptor protein signaling pathway, positive regulation of cell population proliferation, metabolic processes, cell communication, signal transduction, and G protein-coupled receptor signaling pathway. With all these important biological, cellular, and molecular functions, it means any mutation in the gene (positive or negative) will likely have an impact on the functions that the gene and its associated genes control. This has been alluded to by several authors (Kastrup *et al.*, 1978; Schmidt *et al.*, 1996; Ariyasu *et al.*, 2005; Liu *et al.*, 2016;

Aguiar-Oliveira *et al.*, 2017, 2018; Aguiar-Oliveira and Bartke, 2019). The application of functional analysis in the understanding of modern biology and medicine (Barabasi and Oltvai, 2004; Hu *et al.*, 2016; Conte *et al.*, 2020) can therefore, not be discountenanced. Their usage will enable not only the interpretation of molecular functions via the 'guilt-by-association' principle as postulated by Tian *et al.* (2008) and Cowen *et al.* (2017), but also, allow for the classification of modularity in biological processes (Choobdar *et al.*, 2019; Serban, 2020) and may serve as a benchmark for deeper learning (Camacho *et al.*, 2018; Gligorijevic *et al.*, 2018). Other applications are in the area of drug target detection or drug repurposing (Lotfi Shahreza *et al.*, 2018; Pushpakom *et al.*, 2019). It will also come in handy in interpreting genomic variation in various species (Wu *et al.*, 2018).

CONCLUSION

Investigation of the *cGH* gene has shed some light on its complex cellular, biological, and molecular functions. Identification of some of the genes connected with growth and development in the chicken could accelerate exploring into the dynamics and functional pathways associated with the gene. Integrating transcriptomic data and pathway analysis as was done in the study will help in deciphering the complex activities of *cGH* and its associated genes.

Competing Interests

The authors declare that they have no competing interests associated with this article.

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Original Research Paper

EFFECT OF SOCIO-ECONOMIC FACTORS ON VEGETABLE PRODUCTION OF SMALLHOLDER FARMERS IN SELECTED LOCAL GOVERNMENT AREAS OF KADUNA STATE, NIGERIA

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ABSTRACT

The study examined the socio-economic factors influencing vegetable production of smallholder farmers in selected Local Government Areas of Kaduna State, Nigeria. A combination of purposive and random sampling techniques was used in selecting respondents in the study area. The first stage involved a purposive selection of two Local Government Areas, considering the preponderance of vegetable production. The second stage involved a random selection of two villages from each Local Government Area viz; Unguwar-Fatika, Samaru, Tudun Wada, and Bomo. Finally, one hundred vegetable farmers were randomly selected using balloting. Data were elicited through a structured questionnaire and personal interview schedule. Descriptive statistics were employed to describe the socioeconomic characteristics of smallholder vegetable farmers. Results revealed that the mean age of the farmers was 36 years inferring an active working age bracket. These farmers also have one form of education or the other while the mean for household size stood at 5 persons contributing to family labour. The majority (57 %) of farmers sourced their capital through personal savings indicating the need for alternative funding. Logit regression model analysis was used to estimate the socioeconomic variables influencing vegetable production of smallholder farmers. Results revealed that age, marital status, and credit were positive and

statistically significant at 1 % while year of experience was significant at 5 % level of probability infers that these variables are the major determinants of vegetable production in the studied area. The high cost of fertilizer was the foremost constraint in the production of vegetables. It was concluded that despite the exigencies in the studied area vegetable production was profitable though operated on a small scale. It was, therefore, recommended that key stakeholders in the vegetable industry comprising the government and non-governmental organizations should assist farmers in subsidizing inputs to increase their production capacity.
Keywords: vegetable production, social-economic factors, small holder farmers, food security

INTRODUCTION

Vegetable production is of great economic importance in the agricultural sector. Its value chain can provide income and reduce poverty and unemployment. Vegetables have been part of the human diet right from time; some are perennials but mostly annuals and biennials, usually harvested within a year of sowing or planting (Schreinemacher *et al.,* 2018). Vegetables are of great nutritional value in Nigeria and other sub-Saharan Africa and are majorly comprised of minerals, vitamins, proteins, carbohydrates, and dietary fibres. They form an important component in the human diet (Aju and Popoola, 2010). Vegetables, in no small measure, offer people with limited access to meat and fish sources of protein and some vital micro-nutrients needed for healthy living. They are crop plants with immature succulent roots, bulbs, stems, blossoms, leaves seeds, or fruit that are eaten (Musa and Ogbadoyi, 2012). Vegetables such as tomato, potato, beetroot, carrot, cabbage, onion, sweet potato, and hot pepper are mostly grown in Nigeria, particularly in Kaduna State. Tomatoes, peppers, and onions are important vegetables in the global economy due to their high consumption (Schreinemachers *et al*., 2018).

Tomato is one of the foremost, essential vegetables in Nigeria, virtually consumed by every tribe, and grown all over Nigeria (Abur, 2014). Tomato is a highly nutritious food ingredient used in the preparation of many foods. (Shehu and Mohammed, 2017). Vegetable crops mostly tomato crops, for example, not only contribute to the share of agriculture in the national economy but possess a great potential and comparative advantage to compete in a liberalized economy. According to Katanga (2018), Nigeria's annual tomato imports are valued at US$170 million. Despite this importance, vegetables are still mainly produced in Kaduna State by resource-poor small farmers with small farm holdings and they are responsible for the vegetables consumed in the nation.

One of the problems of the production of vegetables in Nigeria is stagnant production technology among the Nigerian farming community, the majority of whom are small-scale producers. Therefore, the extent to which inputs supply and productivity relate to a shortfall in food demand and supply in Nigeria and a source of concern. Furthermore, the impact of factors such as the policy environment, and the availability of markets for the disposal of farm outputs is not often considered even though such factors make farmers work harder and thus, produce higher outputs.

It is pertinent to note that the productivity of smallholder farmers and their contribution to the economy, food security, and poverty reduction depend on the services provided by well-functioning ecosystems, including soil fertility, freshwater delivery, pollination, and pest control. Smallholder farming practices, in turn, affect the condition of ecosystems. These impacts are not always negative, but poverty and immediate needs can drive smallholders to put pressure on ecosystems and this is worrisome. Therefore, this study became imperative since an effective ecosystem can increase vegetable output.

Therefore, the study examined the socio-economic characteristics influencing vegetable production of smallholder farmers in selected Local Government Areas of Kaduna State, Nigeria.

Finally, the results of the study will be useful to policymakers as a guide in designing appropriate policies needed to improve the efficiency of vegetable production.

MATERIALS AND METHODS

Study area

Kaduna State is located between Latitude 9˚ 03¹ and 11˚ 32¹ North of the Equator and Longitudes 6˚ 05¹ and 8˚ 38¹ East of the Greenwich Meridian (Kaduna State Agricultural Development Agency KADA, 2007; Kaduna State Government, KSG, 2015). It shares common boundaries with Kano and Katsina to the north, Bauchi and Plateau State to the North East, Federal Capital Territory Abuja, and Nasarawa State to the South, Niger and Zamfara State to the South West (Alabi and Abdulazeez, 2018; Yakubu, 2015).

It has a total land mass of 46,053 square kilometers (KSG, 2015) with a population of 6,113,503 people as of 2006. The projected population of the State is put at 9,476,053 people in 2020 at a growth rate of 3.18 % per annum. The wet season lasts from April through mid-October with a peak in August, while the dry season extends from mid-October of one calendar year to April of the next (Abaje and Giwa, 2010). The annual average rainfall in the state is about 1323 mm. The

spatial and temporal distribution of the rain varies, decreasing from an average of about 1733 mm in Kafanchan-Kagoro areas in the South of the study area to about 1203 mm in the central part (Kaduna) and about 1032 mm in Zaria, lkara, and Makarfi LGAs in the north.

The highest average air temperature normally occurs in April (28.9 ^{0C}) and the lowest in December (22.9 ^{0}C) through January (23.1 ^{0}C). The mean atmospheric relative humidity ranges between 70-90 % and 25-30 % for the rainy and dry seasons respectively. Kaduna State consists of four Agricultural zones viz; Birnin-Gwari, Lere, Maigana, and Samaru-Kataf. The state consists of 23 local government areas; Birni-Gwari, Chikun, Igabi, Ikara, Jaba, Jema'a, Kachia, Kudan, Kajuru, Kaura, Kauru, Kubua, Kaduna North, Kaduna South, Lere, Markafi, Giwa, Kagarko, Sabon-Gari, Sanga, Soba, Zangon-kataf, and Zaria.

Kaduna State has different ethnic groups including Hausa, Fulani, Gbagyi, Karama, Bajju, Kataf, Kadara Jaba, and so on including other ethnic groups from various parts of the country. The major religions are Islam and Christianity, followed by Traditional African Religion as a minority. In addition to vegetables, maize, cowpea, sorghum, soybeans, potato, ginger, groundnut, and other crops are grown, while other farmer rear animals including goats, sheep, cows, pigs, vegetable, duck, and their likes. The predominant occupations in the area are farming, complimented by other livelihood (off-farm) activities such as trade, collection, and gathering of firewood, fruit, and vegetables. The majority of the farmers are small-scale farmers who cultivate vegetables alongside other crops alongside other crops for household consumption, while part of their produce including cash crop harvested is sold for income generation.

A multistage sampling technique was used to select farmers for this study. In the first stage, a purposive selection of two Local Government Areas, due to the preponderance of vegetable production. In the second stage, a random selection of two villages from each Local Government Area which are Unguwar-Fatika, Samaru, Tudun Wada, and Bomo. Finally, one hundred vegetable farmers were randomly selected using balloting.

Descriptive statistics was used to describe the socio-economic characteristics involved in the production of vegetables in the study area. Arithmetic means, frequency distribution, and percentages were used in cross-tabulation. Multiple Regression analysis was used to examine the

socio-economic variables that affect vegetable production. The Linear function was selected based on the magnitude of the coefficient of determination (R^2), a prior expectation, and the statistical significance of the estimated regression coefficients. The multiple regression analysis is estimated in linear functional form as;

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + e \ldots\ldots (1)$$

Y= Output

X_1= Access to credit (Access=1, no access=2)

X_2= Age (number of years)

X_3= Years of Experience (number of years)

X_4= Marital Status (Married 1, Single 0)

X_5= Educational Level (number of years in school)

X_6= Household Size (number of persons)

X_7= Farm Size (ha)

a= constant

$b_1 – b_7$= Régression coefficients

e= error term.

RESULTS AND DISCUSSION

Socioeconomic characteristics of vegetable farmers

The socioeconomic characteristics of the vegetable farmers greatly influenced their behaviour. Some of these characteristics are age, marital status, household size, educational background, access to credit, farm size, and years of experience.

The distribution of the farmers according to age showed that about 41 % of the farmers were within the active age of 20-30 years while 32 % of them were 31-40 years of age with a mean age of 36.07 years. This implies that these farmers were within the active working age bracket. These farmers were particularly young people who could afford to venture into the vegetable business which is

known to be characterized by risks such as disease, drought, and theft and they are mature enough to take credit decisions that can sustain their vegetable production. This finding agrees with the findings of Sekumade and Toluwase (2014).

Findings of the marital status of the farmers showed that the majority (62.0 %) of the farmers were married while only 29.9 % were single. indicating that married households were more involved in vegetable farming than unmarried households. This study supports the findings of (Amos, 2007; Maikasuwa and Jabo, 2011) that married farmers were more involved in vegetable production than unmarried farmers.

The result of the analysis on household size showed that about 60 % of the farmers had household size of 1-5 persons, while the least was 6-10 persons per household (35 %) with a mean household size of 5 persons. A higher number of members of the household contributed to family labour. This supports most of the studies that confirmed large house size among the farming households where they see family size as a workforce that supplies the most needed labour requirement for production activities in the study area (Emaikwu *et al.,* 2011).

It can be deduced that the majority (37 %) of the farmers had primary education, while those who had only secondary and tertiary education were 10 % and 5 % respectively and 29 % had adult education, and 19 % of no formal education. This indicates that about 52 % of vegetable farmers were literate. The educational level of farm owners is very important in the management of vegetable birds and it is known to affect their farming activities, since the majority of the farmers are educated, it will improve the productivity and efficiency of tomato production in the study area. This agrees with the finding of (Ezeh *et al,* 2012) which states that the level of education attained by a farmer increases his farm, productivity and enhances his capacity to understand and evaluate new production technologies.

The findings in Table 1 revealed that 54 % of the farmers had 1-5 years of experience, 30 % had 6- 10 years, 8 % had 11- 15 years, and 8 % of the farmers had more than 20 years of experience. The mean years of experience was found to be 7 years. This suggests that the majority of the vegetable farmers in the study were new entrants into the business. It is generally expected that productivity increases with years of experience (IFPRI, 2008). Farmers master the techniques of production and avoid previous mistakes. Experienced vegetable farmers are likely to make better

decisions to enhance productivity and income because it is expected that experience in vegetable production usually determines the effectiveness of farmers' decisions concerning input combinations or resource allocation. Years of farming experience affect the productivity and technical efficiency of vegetable production. The longer the years of farming experience, the more knowledge acquired the more efficient the farmer becomes.

The result of the distribution of farmers showed that 63 % were non-members of cooperative societies, while only about 37 % of the farmers were members of cooperative societies. This implies that the benefit of cooperative membership was not fully accessed by the farmers. Cooperative membership avails co-operators the benefit of pooling resources together. Members also benefit from enhanced delivery of agricultural extension services, especially to farm financial institutions, and government and private institutions.

The distribution of farmers according to their source of credit is presented in Table 1, it shows that 57.0 % sourced for credits through personal savings that possibly might have been accumulated over time and from the sale of their products, and this is closely followed by friend and family as asserted 31.0 %, while 12.0 % sourced from commercial banks. Access to credit is one of the major determinants of outputs and effective productivity of farmers.

The regression model shows that the R^2 was found to be 0.469 which implies that socio-economic factors affecting the vegetable production in the study area were explained by variation in the independent variables and also implies the survey has a positive impact on vegetable production having about 47 % significance in the study area. The result of the socio-economic factors influencing vegetable production in the study area showed that the positive values of the coefficient imply that increasing the independent variables by one unit will increase the vegetable

Table 1: Socio-economic characteristics of the respondents (n= 100)

Variables	Frequency	Percentage	Mean	Std. Dev	Min	Max
Age			36.07	11.03	23	65
0 < 30	41	41				
31 - 40	32	32				
41 - 50	16	16				
51 - 60	7	7				
> 60	4	4				
Marital status						
Single	29	29				
Married	62	62				
Divorced	3	3				
Widow	4	4				
Separated	2	2				
Education level						
Adult education	29	29				
Primary education	37	37				
Secondary education	10	10				
Tertiary education	5	5				
Quranic education	19	19				
Household size			4.95	3.31	1	15
1 - 5	60	60				
6 - 10	35	35				
11 – 15	5	5				
Years of Experience						
1 - 5	54	54				
6 - 10	30	30				
11 - 15	8	8				
16 - 20	6	6				
21 – 25	2	2				
Membership of cooperative						
Member	37	37				
Non-member	63	63				
Source of Capital						
Personal saving	57	57				
Friends and family	31	31				
Commercial banks	12	12				

Source: Computed from field survey data, 2021

production level by the value of the coefficient while negative values of the coefficient imply that increasing the independent variable by one unit will reduce the vegetable production level by the value of the coefficient. It revealed that of the three variables included in the regression model farm size and labour were significant at a 1 % level of probability. Marital status and source of land were significant at a 5 % level of probability. Only cooperative was significant at a 10 % level of probability. Labour and farm size had negative coefficients, and marital status and source of land had positive coefficients.

The coefficient of marital status was positive and statistically significant at the 5 % level of probability. The positive coefficient indicates a direct linkage between marital status and vegetable production. It is expected to be positive given that marriage offers the vegetable farmers labour constraints to be minimized so that they will have the opportunity to produce more with less labour and this affects their standard of living. The coefficient for labour was negative and statistically significant at the 1 % level of probability. This implies that labour has an indirect linkage with vegetable production by the farmers; this implies that the cost of labour reduces the production level of the vegetable farmers.

The coefficient of the year of membership of the cooperative was positive and statistically significant at the 10 % level of probability. The positive coefficient implies that there is a direct linkage between the year of membership of the cooperative and vegetable production. It is expected to be positive given that cooperatives offer vegetable farmers financial constraints to be minimized so that they will have the opportunity to improve their standard of living. Social capital and entrepreneurial skills will be increased as they become a member of the cooperatives. The coefficient for the source of land was found to be positive and statistically significant at the 5 % level of probability. The positive coefficient depicts a direct linkage between the source of land and vegetable production. The possible reason could be as an individual owns land; it reduces the cost of production which possibly could increase their productivity.

The coefficient for Farm size was negative and statistically significant at the 1 % level of probability. The negative coefficient depicts an indirect linkage between farm size and vegetable production. This implies that farmers' output could only be increased if the farmland is fertile and all the management practices put in place and not necessarily large farm size. Farmers sometimes count more on their farm size than educational attainment to increase their productivity which consequently leads to higher return on investment. (Tables 1 and 2)

Note: ***, **, and * imply significance at 0.01, 0.05, and 0.1 levels, and Ns implies no significance. Values in parentheses are the respective t – t-ratios

Constraints in vegetable production in the study

About 76 % of the farmers ranked the incidence of pests and disease attacks as the major constraint in vegetable production. Vegetable requires prompt application of agrochemicals such as insecticides and herbicides to check the menace of pests and disease infestation that may occur as a result of overgrowth of weeds. About 33 % ranked poor seed quality as the last constraint. Poor seed quality lowered domestic vegetable output, distribution, and marketing by various stakeholders and government agencies. About 45 % of the farmers ranked shortage and high cost of farming, fertilizer, and other inputs asconstraints (Table 3).

Table 2: Socio-economic factors influencing vegetable production in the study area

Variable	Coefficient	Std. Error	T-value
Constant	-4.59E-06	0.00	-3.034
Age	0.006067	0.00156	1.112
Marital status	0.0045717**	0.00583	0.225
Labour	-0.0347087***	0.00584	0.234
Household size	7.84E-09	0.00	-0.478
Education	-0.2088	0.0977	-1.22
Source of capital	0.000141	0.0001	-1.123
member of cooperative	2.83E-07*	0.00	-2.324
Farm size	-0.0402925***	0.0098	5.465
Source of land	0.1233935**	0.05254	0.244
Cropping pattern	-0.01951	0.01894	-1.306
Number of observation	100		
R^2	.469		
Adjusted R square	.403		
Prob> f	7.064		

Source: computed from field survey data, 2021

This is one of the problems confronting vegetable production in the study area. Farmers in the study area are poor and cannot afford to buy some of the farming inputs. This implies the fact that inputs are too expensive for an ordinary farmer in the study area considering the farmer's financial status.

Table 3: Constraints of vegetable production (n=100)

Constraint	Frequency	Percentage	Rank
Incidence of pests and diseases	76	76	1st
Shortage and high cost of fertilizer	76	76	1st
Unpredictable sales and perishability	57	57	4th
Lack of storage facilities	54	54	5th
Environmental problem	45	45	6th
Shortage and high cost of labour	45	45	6th
Poor seed quality	33	33	8th
Difficulty in accessing	27	27	9th
Difficulty in acquiring farmland	27	27	9th

Source: field survey, 2021

CONCLUSION

The study establishes that vegetable farmers in the study area though on a small scale has the potential to increase food security while factors such as age, marital status, farming experience, and credit respectively are determinant of vegetable production of the farmers in the face of constraints such as pest and disease attack, high cost of farming inputs, unpredictable sales/marketing, lack of storage facilities.

RECOMMENDATIONS

The study recommends the provision of competent extension agents to visit and enlighten vegetable farmers on the technicality of production processes and how they can improve using advanced technology. This will not only enhance the skills of the farmers but also ensure food security. Key stakeholders in the vegetable industry comprising the government and non-governmental organizations could assist farmers in increasing their use of improved seeds by supporting them with production capital with which they can purchase the inputs and also provide machinery to reduce the cost of labour by subsidizing the vegetables of the working hour for those farmers that cannot purchase the machines. This is because the use of these inputs in vegetable production enhances the outputs which translate to higher returns. Farmers should be encouraged to form an association to enable them to benefit from such associations' training, information on innovations, and access to credits.

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Original Research Paper

PERFORMANCE, NUTRIENT RETENTION, AND CARCASS ATTRIBUTES OF BROILER CHICKENS ON DIETARY SOYBEAN WASTE REPLACEMENT

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ABSTRACT

A feeding trial was conducted to evaluate the effect of dietary soybean replacement with soybean waste on growth performance, nutrient retention, and carcass characteristics of broiler chickens. Three hundred Arbor acre day-old broiler chicks were assigned into five treatments and 3 replicates each in a completely randomised design. The feeding trial was for 8 weeks. The birds were fed starter diets (23 % crude protein and 2800 Kcal/kg ME) for the first 4 weeks and finisher diets (20 % crude protein and 3000 kcal/kg ME) for the remaining 4 weeks. Final Body Weight (FBW) and Weight Gain (WG) of birds on diets of Soybean (SBW) at 0 and 40 % were significantly higher ($p<0.05$) compared with those birds on diets SBW 20, 60, and 80 %. This was reflected in their better feed conversion efficiency. There were no significant differences in the crude fibre retention of birds at the finisher stage of the experiment regardless of the experimental birds as compared with the crude fibre retention at the starter stage of the feeding trial, which showed variations in the crude fibre retention. Carcass attributes of birds on the SBW 0 % diet were significantly higher ($p<0.05$) than those birds on SBW 20, 40, 60 and 80 %, respectively. Birds on SBW 40 % had a better growth performance and enhanced carcass attributes than other

replacement levels of 20, 60, and 80 % diets. The performance of birds on SBW 40 % could also be compared relatively to birds on SBW 0 %, the control treatment.

Keywords: Soybean waste, Replacement, Performance, Carcass attributes

INTRODUCTION

Research indicates that substituting soybean waste for a portion of the soybean meal in broiler diets can improve performance, carcass attributes, and meat quality (Amirul *et al.,* 2023). It can boost meat quality characteristics like tenderness and juiciness as well as growth performance and carcass weight. To achieve performance, it is essential to strike the optimum balance and guarantee proper nutrient content in the feed. The replacement of soybean waste in broiler chicken diets has been the subject of numerous articles. In a study by Zelalem *et al*. (2022) which examined the results of substituting brewery-dried grains for soybean meal in broiler diets, results showed that adding fermented soybean waste enhanced growth, increasing body weight and feed conversion efficiency. The effects of substituting defatted soybean waste for soybean meal in broiler diets were assessed by Makinta *et al*. (2021). The study found that adding defatted soybean waste improved carcass characteristics (breast muscle yield and decreased abdominal fat deposition). In addition, a study by Vierira *et al*. (1992) examined the impact of switching from soybean meal to high-fibre sunflower meal as the main source of protein in laying hens, their findings showed no negative effects on body weight. They claimed that adding soybean hulls improved the qualities of meat, such as increased softness and reduced cooking loss. All of the studies mentioned above point to the possibility of improving broiler chicken performance, carcass features, and meat quality by replacing dietary soybean waste. It is crucial to keep in mind that the precise outcomes can change based on the type and processing of soybean waste, as well as the total diet composition. This study intends to ascertain the amount of soybean waste that, when used in place of soybean meal, will produce the same growth performance and good carcass qualities.

MATERIALS AND METHODS

Study Area

The experiment was carried out at the poultry unit of the Teaching and Research Farm of the Department of Animal Production, Kwara State University, Malete, Moro Local Government Area,

Kwara State, Nigeria. The study area is located between latitude 08^{o} 71′ N to 08^{o} 96′ N and longitude 04^{o} 44′ E to 04^{o} 76′ E at 365 m above sea level. The climatic condition of Malete is characterised by distinct wet and dry seasons with an annual mean rainfall of about 1,150 mm and an annual temperature that ranges from 25 to 28.9 ^{0}C (Hakeem *et al.*, 2020).

Experimental Animals and Diets

A total of 300-day-old Arbor acre broiler chickens were purchased from an Agro-allied farm in Ilorin, Kwara State. The chickens were grouped into five (5) experimental treatments; Treatment 1 (control diet) contained 0 % soybean waste (SBW), Treatment 2 (20 % SBW replacement), Treatment 3 (40 % SBW replacement), Treatment 4 (60 % SBW replacement) and Treatment 5 (80 % SBW replacement). The treatments were replicated thrice and had 20 birds per replicate. The birds were placed on a formulated broiler starter diet which contained 23 % crude protein and 2800 kcal/kg for the first four weeks, while the finisher diet contained 20 % crude protein and 3000 kcal/kg which was given to the birds for the last four weeks (Tables 1 and 2).

Data Collection

Data were collected on initial body weight, final body weight, feed intake, and feed conversion ratio. The initial body weight of the birds was the weight of the birds measured at the beginning of the experiment. The final body weight was the weight of the birds taken at the end of the eighth week of the experiment. Feed intake was evaluated as the difference between the feed given, and the leftover after 24 hours. Weight gain was calculated as the difference between the final body weight and the initial body weight of the birds. While the feed conversion ratio was determined by dividing the feed intake by the body weight gain.

Nutrient digestibility was determined at the 4th and 8th weeks of the feeding trial. A quantity of 3 kg of feed daily was fed to 10 birds selected in each treatment and faecal samples were collected over 72 hours. The excreta samples were weighed and dried in the oven at 60 o C for 72 hours, re-weighed, and ground and proximate content analysed using the A.O.A.C. (2005) procedure. The same was done for the feed.

Table 1: Nutritional Composition of the Starter Diets 23 % CP, 2800 kcal/kg of Broiler Chickens Fed with Soybean Waste.

Ingredients	Treatments				
	(control) 0 %	(20 %)	(40 %)	(60 %)	(80 %)
Maize	65.00	66.00	66.52	67.52	65.52
Wheat offal	2.52	0.00	0.00	0.00	0.00
Soybean meal	20.00	16.00	12.00	8.00	4.00
SBW	0.00	4.00	8.00	12.00	16.00
GNC	7.52	8.00	8.00	4.00	4.52
Fish meal	1.00	2.04	1.52	4.52	6.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.00	1.00	1.00	1.00	1.00
Premix	0.24	0.24	0.24	0.24	0.24
Methionine	0.24	0.24	0.24	0.24	0.24
Lysine	0.24	0.24	0.24	0.24	0.24
Salt	0.24	0.24	0.24	0.24	0.24
Total	100.00	100.00	100.00	100.00	100.00

SBW: Soybean waste. GNC: groundnut cake

Table 2: Nutritional Composition of the Finisher Diets 20 %CP, 3000 kcal/kg of Broiler Chickens Fed with Soybean Waste.

	Treatments				
Ingredient	(control) 0 %	(20 %)	(40 %)	(60 %)	(80 %)
Maize	50.00	50.00	48.00	45.00	45.00
Wheat offal	5.04	0.04	0.04	0.04	0.04
SBM	25.00	20.00	15.00	10.00	5.00
SBW	0.00	5.00	10.00	15.00	20.00
Fish meal	2.00	2.00	2.00	2.00	2.00
GNC	13.50	18.50	20.50	23.50	23.50
Bone meal	2.50	2.50	2.50	2.50	2.50
Oyster shell	1.00	1.00	1.00	1.00	1.00
Premix	0.24	0.24	0.24	0.24	0.24
Methionine	0.24	0.24	0.24	0.24	0.24
Lysine	0.24	0.24	0.24	0.24	0.24
Salt	0.24	0.24	0.24	0.24	0.24
Total	100.00	100.00	100.00	100.00	100.00

SBW: Soybean waste, SBM: Soybean meal, GNC: groundnut cake

Carcass Attributes

Two birds from each replicate were slaughtered, deplumed, and eviscerated after fasting them overnight (so that they did not have much waste content in their gut). Data were collected on carcass yield, and parameters like the primal cuts (breast, back, wing, thigh, and drumstick) were weighed and recorded. The carcass weights of each chicken were taken after the removal of the intestine

and visceral organs. The main cut parts were weighed, recorded, and expressed in g/kg dressed weight and the dressing percentage was calculated.

Data Analysis

Data obtained from all determined parameters were subjected to ANOVA using the PROC MIXED procedure of the SAS package (2014). Means were separated using the Tukey HSD test at $P<0.05$ significant level.

RESULTS AND DISCUSSION

Growth Performance.

The final body weight (FBW) and weight gain (WG) of birds on dietary soybean waste replacement SBW 0 % and SBW 40 % were similar but significantly higher ($p<0.05$) than those birds on SBW 20 and 60 % which were also similar but significantly higher ($p<0.05$) than those birds on SBW 80 % (Table 3). Whereas, the feed intake (FI) of birds on dietary soybean waste replacement (SBW 80 %) was significantly ($p<0.05$) higher compared with those birds on SBW 60, 0, 20, and 40 %. Birds on SBW 60 had significantly higher ($p<0.05$) FI than those birds on SBW 0 %, which in turn were significantly ($p<0.05$) higher than those birds on SBW 20 %. However, the FI of those birds on SBW 40 % was significantly lower ($p>0.05$) compared with those birds on SBW 0, 20, 60 and 80 %. The feed conversion ratio (FCR) of birds on SBW 80 % was significantly ($p<0.05$) higher than those birds on SBW 60, 20, 0, and 40 %. The FCR of birds on SBW 60 % were significantly ($p<0.05$) higher compared with those birds on SBW 20 %, which in turn were significantly ($p<0.05$) higher than those birds on SBW 0 and 40 %. The FCR of birds on SBW 0 and 40 % were similar but significantly ($p<0.05$) lower compared with birds on other treatments.

Nutrient Retention in 4th Week

The total protein (TP) values (Table 4) of birds on SBW 0, 20, and 60 % were similar but significantly ($p<0.05$) higher than those birds on 40 and 80 % diets which had statistically similar ($p>0.05$) values. The crude fibre (CF) values of birds on SBW 40 % were significantly ($p<0.05$) higher than birds on SBW 0, 20, 60, and 80 % diets which had similar ($p>0.05$) values. The ash

Table 3: Effect of Soybean Waste Replacement on Growth Performance of Broiler Chickens.

	Treatments						
Parameters	SBW (0 %)	SBW (20 %)	SBW (40 %)	SBW (60 %)	SBW (80 %)	SEM	P Value
IBW (g/b)	31.91	31.95	31.91	31.95	31.91	0.014	0.14
FBW (g/b)	2380.00[a]	2030.00[b]	2310.00[a]	2000.00[b]	1840.00[c]	0.26	0.001
WG (g/b/d)	54.66[a]	47.33[b]	54.01[a]	46.80[b]	41.80[c]	0.01	0.001
FI (g/b/d)	86.66[c]	86.55[d]	85.46[e]	96.75[b]	97.12[a]	0.008	0.001
FCR	1.59[a]	1.83[b]	1.58[a]	2.07[c]	2.32[d]	0.01	0.001

abcd: Means on the same row with different superscript are significantly different ($p<0.05$)

SEM: standard error of mean, SBW: Soybean waste, Initial body weight (IBM), final body weight (FBW), weight gain (WG), feed intake (FI), feed conversion ratio (FCR). G (gram), b (bird), d(day)

values of birds on SBW 20, 60, and 80 % were similar ($p>0.05$) but significantly ($p<0.05$) higher than those birds on SBW 0 and 40 % diets. Whereas, birds on SBW 0 % were significantly ($p<0.05$) higher in ash compared with birds on SBW 40 % diet. The ether extract (EE) of birds on SBW 0 % was significantly ($p<0.05$) higher than those birds on SBW 40, 60 and 80 % diets. However, the EE of those birds on the SBW 60 % diet was significantly ($p<0.05$) lower than those birds on SBW 0, 20, and 40 % diets. The nitrogen-free extracts (NFE) of birds on SBW 20, 40, and 80 % diets were similar but significantly ($p<0.05$) higher than birds on SBW 0 and 60 % diets. Whereas, the NFE of birds on an SBW 0 % diet was significantly ($p<0.05$) higher than those of birds on a 60 % diet. However, birds on SBW 60 % diet were significantly ($p<0.05$) lower than other treatments including control.

Nutrient Retention in the 8th Week

The total protein (TP) values of birds on SBW 0 %, significantly ($p<0.05$) higher than those birds' 60 % diet. Whereas, birds on SBW 20, 40, 60, and 80 % were similar ($p>0.05$). The ash of birds on the SBW 0, 20, and 40 % diets were similar ($p>0.05$) (Table 5). Birds on o and 60 % SBW diets also had similar ($p>0.05$) ash values. However, birds on 80 % had lower ($p<0.05$) ash values than all the other treatments. The ether extract (EE) of birds on SBW 80 % was significantly ($p<0.05$) higher than those birds on SBW 0, 20, 40, and 60 % diets which had similar ($p>0.05$) values. The nitrogen-free extracts (NFE) of birds on the SBW 60 % diet were significantly ($p<0.05$) higher than birds on SBW 0 and 40 % diets which had similar ($p>0.05$) values.

Table 4: Effect of Soybean Waste Replacement on Nutrients Retention at 4th Week.

Parameters	Treatments						
	SBW 0 %	SBW 20 %	SBW 40 %	SBW 60 %	SBW 80 %	SEM	P-value
Total Protein (%)	62.28[a]	62.07[a]	57.00[b]	63.03[a]	57.21[b]	0.32	<0.0001
Crude fibre	31.20[b]	31.59[b]	33.52[a]	31.87[b]	31.43[b]	0.29	>0.001
Ash (%)	35.00[b]	37.56[a]	31.06[c]	38.24[a]	37.03[a]	0.32	<0.0001
Ether extract	42.23[a]	42.01[ab]	41.90[bc]	41.43[d]	41.61[cd]	0.06	<0.0001
NFE (%)	67.39[b]	70.68[a]	70.05[a]	62.78[c]	70.05[a]	0.36	<0.0001

abcd Means on the same row with different superscript are significantly different ($p<0.05$)

SBW: Soybean waste, NFE (nitrogen free extracts)

Carcass Attributes

The live weight (LW) and bled weight (BLW) of birds on dietary SBW 0 and 40 % were similar and significantly ($p<0.05$) higher than those birds on diets SBW 20, 60, and 80 % (Table 6). Whereas, the LW and BLW of birds on SBW 20 and 60 % were similar but significantly ($p<0.05$) higher compared with those birds on SBW 80 %. The de-feathered weight (DFW) and carcass

weight (CW) of birds on dietary SBW 0% were significantly ($p<0.05$) higher than those birds on all the other treatments. Whereas, the DFW and CW of birds on SBW 40 % were significantly

Table 5: Effect of Soybean Waste Replacement on Nutrients Retention at 8th week.

Parameters	Treatments					SEM	P-value
	SBW 0%	SBW 20 %	SBW 40 %	SBW 60 %	SBW 80 %		
Total Protein (%)	66.00[a]	64.41[ab]	64.30[ab]	63.03[b]	64.40[ab]	0.32	>0.0057
Crude fibre	32.37	32.51	32.41	32.07	33.08	0.40	>0.63
Ash (%)	33.16[ab]	34.06[a]	34.09[a]	32.54[b]	31.03[c]	0.21	<0.0001
Ether extract	42.33[b]	42.02[b]	41.89[b]	42.15[b]	43.57[a]	0.12	<0.0001
NFE (%)	61.67[b]	63.04[ab]	62.96[b]	65.26[a]	63.16[ab]	0.42	>0.006

abcd Means on the same row with different superscript are significantly different ($p<0.05$)

SBW: Soybean waste, NFE (nitrogen free extracts)

($p<0.05$) higher compared with those birds on SBW 20, 60, and 80 %. The DFW and CW of birds on SBW 20 % had significantly ($p>0.05$) higher DFW and CW than those birds on SBW 60 and 80 % diets. Birds on SBW 60 % diet also had significantly ($p<0.05$) higher in DFW and CW than those birds on SBW 80 %. The dressing percentage (D %) of birds on dietary SBW 0 % was significantly ($p<0.05$) higher than those birds on all the other treatments except those on SBW 20 % diets. The D % of birds on SBW 60 % had a lower D % than all the other treatments but similar ($p>0.05$) to the birds on SBW 40 and 80 % diets.

The breast weight (BW) of birds on dietary SBW 0 % were significantly ($p<0.05$) higher than those birds on all the other diets. Birds on SBW 40 and 60 % had similar ($p>0.05$) BW their values were, however, lower than those on other diets. The wing weight (WW) birds on dietary SBW 0 % were significantly ($p<0.05$) higher than those birds on all the other diets. While the birds on SBW 80 % had the least WW and their value was lower than the birds on other diets. Birds on SBW 20 and 60 % had similar ($p>0.05$) WW, their weight was, however, lower ($p>0.05$) than those on SBW 40 %

diet. The thigh weight (TW) of birds on dietary SBW 0 % was significantly ($p<0.05$) higher than those birds on all the other diets. Birds on SBW 20 and 40 % had similar TW, their values were, however, higher than those on SBW 60 %. The birds on SBW 80 % had the least TW value, their value was significantly lower ($p<0.05$) than all the other treatments.

The drumstick weight (DW) of birds on dietary SBW 0 and 40 % were similar but significantly ($p<0.05$) higher than those birds on diets SBW 20, 60, and 80 %. On the other hand, the DW of birds on SBW 60 % was significantly ($p<0.05$) higher compared with those birds on SBW 20 and 80 % diets. The DW of birds on SBW 20 % in turn were significantly ($p>0.05$) higher than those birds on SBW 80 % diets. The back weight (BAW) of birds on dietary SBW 0 % was significantly ($p<0.05$) higher than those birds on diets SBW 20, 40, 60 and 80 %. Conversely, the BAW of birds on SBW 40 % was significantly ($p<0.05$) higher compared with those birds on SBW 20, 60, and 80 %. The BAW of birds on SBW 20 % in turn were significantly higher ($p>0.05$) than those birds on SBW 60 and 80 % diets. Birds on a diet SBW 80 % were significantly ($p<0.05$) higher in BAW than those birds on an SBW 60 % diet.

The abdominal fat weight (AFW) of birds on dietary SBW 60 % was significantly ($p<0.05$) higher than those birds on diets SBW 0, 20, 40, and 80 %. However, the AFW of birds on SBW 0 and 40 % were similar but significantly ($p<0.05$) higher compared with those birds on SBW 20 and 80 % diets. The AFW of birds on SBW 20 % in turn were significantly ($p<0.05$) higher than those birds on SBW 80 % diets.

The intestinal (IW) and gizzard weight (GW) of those birds on the SBW 80 % diet were significantly ($p<0.05$) higher than those birds on all the other diets. The IW and GW of those birds on the SBW 60 % diet were significantly ($p<0.05$) higher than those birds on SBW 0, 20, and 40 % diets. The IW and GW of those birds on SBW 40 % diet were in turn significantly ($p<0.05$) higher than those birds on SBW 0 and 20 % diets. Birds on the SBW 20 % diet had significantly ($p<0.05$) higher values than those birds on the than those birds on SBW 0 % diet. However, birds on diet SBW 0% were significantly lower ($p>0.05$) in IW and GW than those birds on SBW 20, 40, 60 and 80% diets

Table 6: Carcass Traits of Dietary Soybean Waste Supplementation on Broiler Chickens

Parameters	LW (g)	BLW (g)	DFW (g)	CW (g)	D %	BW (g)	WW (g)	TW (g)	DW (g)	BAW (g)	AFW (g)	IW (g)	GW (g)
SBW0 %	2380.00^{a}	2320.00^{a}	2240.00^{a}	2030.00^{a}	85.29^{a}	548.00^{a}	185.00^{a}	311.00^{a}	193.00^{a}	409.00^{a}	43.00^{b}	55.00^{e}	60.30^{e}
SBW20 %	2030.00^{b}	1980.00^{b}	1900.00^{c}	1720.00^{c}	84.72^{ab}	436.00^{c}	146.00^{c}	279.00^{b}	169.00^{c}	368.00^{c}	30.00^{c}	57.00^{d}	71.00^{d}
SBW40 %	2310.00^{a}	2240.00^{a}	2147.33^{b}	1943.33^{b}	84.12^{bc}	500.00^{b}	163.00^{b}	290.00^{b}	193.00^{a}	382.00^{b}	47.00^{b}	60.00^{c}	74.00^{c}
SBW60 %	2000.00^{b}	1940.00^{b}	1860.00^{d}	1670.00^{d}	84.49^{c}	370.00^{d}	144.00^{c}	263.00^{c}	174.00^{b}	308.00^{e}	74.00^{a}	63.00^{b}	76.00^{b}
SBW80 %	1840.00^{c}	1780.00^{c}	1735.00^{e}	1550.00^{e}	84.23^{bc}	377.00^{d}	119.00^{d}	212.33^{d}	150.00^{d}	317.00^{d}	17.00^{d}	67.00^{a}	79.20^{a}
SEM	2.88	2.88	2.66	1.79	0.17	1.69	1.77	2.81	0.57	0.57	0.57	0.57	0.57
P-value	<0.001	<0.001	<0.001	<0.001	0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

^{abcd} means on the same column with different superscript are significantly different (p>0.05)

SBW-soybean waste, SEM-standard error of mean, TRTS-treatments, LW-live weight, BLW-bled weight, DFW-de-feathered weight, CW-carcass weight D-dressing percentage, BW-breast weight, WW-wing weight, TW-thigh weight, DW-drumstick weight, BAW-back weight, AFW-abdominal fat weight, IW-intestinal weight and GW- gizzard weight.

DISCUSSION

Growth Performance

Probably due to greater digestion, absorption, and utilization of nutrients, the growth performance of the birds on SBW 0 and 40 % treatments exhibited higher values of weight gain and ultimately body weight than that of the other treatments. The outcome of this investigation supports the findings of Maidala *et al*. (2019), who found that birds on diets with full soybean meal performed better than birds on diets with soybean sprouts substituted for the soybean meal. The feed conversion ratio of birds on SBW 0 and 40 % was better when compared with other dietary treatments. This is an indication that birds on SBW 0 and 40 % were able to utilize their feed more efficiently than birds on other dietary treatments. The more the content of SBW in the diet, the more the fibre content of the diet. Monogastric animals like broiler chickens cannot efficiently break down fibre diets as compared with ruminants. The result of FCR shown in this study agrees with the observation of Ishola and Atteh (2018), who observed that broiler birds fed with high content of protein plant source converted the feed source more efficiently than those diets with high fibre content.

Nutrient Retention

The superior retention and availability of more proteins in the SBW 0 % diet as compared to the increased content of SBW prevented excessive excretion of nutrient constituents in the digested feed, leading to substantial retention (g/bird) and improved retention efficiency of protein in the form of amino acids in the first 4 weeks of feeding trial as compared with the second (finisher phase) of the broiler chickens feeding trial. The findings of this study support Ishola and Atteh's (2018) conclusion that broiler chicks fed diets high in protein from plant sources converted the feed source more effectively than those fed diets high in fibre. In contrast to the 80.72 % crude protein retention reported by Kwari *et al*. (2004) when broiler diets containing sorrel seed meal were provided, the values of nutrients retained obtained in the current study were lower. For starter and finisher diets, the retention of crude fibre was lower than that of other nutrients. This might be a result of poultry's inability to effectively digest fibre inherent in soybean waste (Bashar *et al*., 2010).

Carcass Attributes

The live weight, bled weight, de-feathered weight, carcass weight, breast weight, wing weight, thigh weight, and back weight performed better in the control treatment compared with other treatments. This could be attributed to the availability of adequate nutrients present in the SBW 0 % diet and the capacity with which the birds in this treatment were able to digest, absorb, and utilize the nutrients which in turn made them build more muscle than the birds in the other treatments. The findings of the present research do not agree with those of Meherunnisa *et al*. (2017), who found no difference in the weight of the gizzard and spleen with increasing amounts of linseed meal fed to broilers. However, high-fibre diets lead to an increase in gizzard weight because fibre is harder to digest than other nutrients and accumulates in the gizzard (Martínez *et al*., 2015). Birds on SBW 80 % had heavier intestinal and gizzard weights compared to birds on other treatments, and the declining carcass weight with increased SBW consumption was likely due to the bulk and high moisture content of the SBW, which increased the weight of the gut contents and the gizzard. The findings of Nguyen *et al*. (2005), who noted that as the soybean waste replacement in the diet of broiler chickens was raised, the intestinal and gizzard weight was also increased, are compatible with the results found in this study.

CONCLUSION AND RECOMMENDATION

The results obtained showed that broiler chickens can perform well in their growth attributes, nutrient retention, and carcass attributes with the replacement level of 40 % soybean waste with soybean meal. As a result, broiler chickens' diets containing soybean meal could be replaced with up to 40 % of soybean waste.

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Original Research Paper

AWARENESS CREATION ON THE IMPORTANCE OF LIVESTOCK DEVELOPMENT IN THE ATTAINMENT OF GLOBAL HEALTH AND SUSTAINABLE DEVELOPMENT GOALS

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ABSTRACT

Livestock (farmed domestic animals) play crucial roles in the attainment of several Sustainable Development Goals (SDGs) of the United Nations. There is also an intricate link between one health (human, animal, and environmental) that is advocated by the World Health Organisation and the Sustainable Development Goals which encompasses environmental, economic, and social issues. Many infectious diseases and new or emerging infectious diseases are zoonotic in origin; this includes the current pandemic known as COVID-19. Animal-source foods will increasingly play a huge role in ensuring basic nutrition and health for humans in the coming years, especially in developing countries where the human population will increase rapidly. Three SDGs (Zero hunger, Good health and well-being, and Responsible consumption and production) will thus be addressed by livestock development. Livestock holds the key to sustainable economic growth, addressing two SDGs (Decent work and economic growth and Industry, Innovation, and Infrastructure). The livestock sector contributes 40% of the Agricultural GDP in developing

countries and the percentage is growing (FAO, 2021). Equitable livelihoods can be achieved by livestock development, covering four SDGs (No poverty, Quality education, Gender equality, and Peace, Justice, and Strong Institutions). Lastly, livestock can help ensure sustainable ecosystems. Six SDGs can be covered (Clean water, Affordable and Clean Energy, Sustainable cities and communities, Climate Action, Life below water, and Life on land). Global livestock development should therefore be given a pride of place, especially considering their envisaged importance in developing countries.

Keywords: Livestock, Sustainable Development, One Health, Developing countries.

INTRODUCTION

One Health typically recognises the importance of human health and its inter-relatedness to the health of animals and that of the environment. The broad definition of one health encapsulates it as the collaborative effort of multiple disciplines working locally, nationally, and globally to attain optimal health for people, animals, and the environment. The phrase, 'one health' as presently used traces its origin to a story about Ebola haemmorhagic fever written by a certain Washington Post journalist, Rick Weiss who himself quoted William Karesh on April 7, 2003. The first known formal organ under which 'one health' came is the One Health Commission, a non-profit organization based in the U.S. (Eussen *et al.,* 2017). This was created out of the joint effort of leaders from multiple disciplines. Organisations such as American Medical Association (AMA), American Veterinary Medical Association (AMVA), the UC Davis one health institute, the United States Department for Agriculture (USDA), the Centre for Disease Control and Prevention (CDCP) the National Oceanic and Atmospheric Administration (NOAA), the American Society for Tropical Medicine and Hygiene (ASTMH) and U.S. National Environmental Health Association are actively backing the movement (Eussen *et al*., 2017).

It is pertinent at this juncture to point out the fact that some similarities exist between One Health and sustainable development goals. Firstly, both are global in outlook, secondly, collaboration (galvanization of local actions) is required for their effective achievement. Thirdly, they are geared towards ecosystem balance. Again, they are relatively new phrases but old concepts. For instance, the recognition that environmental factors can impact human health is traceable to Hippocrates (C.460BCE-C.370BCE), the father of modern medicine. Most of the laws bordering on ceremonial cleanliness handed over unto the Israelites by God as recorded in the Bible took 'one health' into cognizance. Some of these had to do with the manner of meat preparation before consumption, the

kinds of meat that could not be eaten, and environmental cleanliness among others (Exodus 19:10; Leviticus 11: 3-4, 27-28). This is one of the reasons Jews do not consume pork as the pig is considered an unclean animal. Likewise, the sustainable development goals are successor goals to the millennium development goals so to speak. Far beyond this**,** however, the SDGs encompass the three pillars of sustainability (economic, social**,** and environmental respectively). Sustainability is a compound word comprising 'sustain' and 'ability'; the former means to support something by holding it firmly from below while the latter speaks to the natural tendency to do something successfully or well.

Role of Livestock in the attainment of the SDGs

In a broad sense, livestock can be defined as animals kept by humans for a useful or commercial purpose. As put forward by Wright (2017), livestock bears a significant correlation with the 17 SDGs grouped under four clusters. These are Livestock and inclusiveness, sustainable economic growth (Goals 8 and 9 respectively), Livestock and equitable livelihoods (Goals 1, 4, 5, 10, and 16 respectively), Animal-source foods for nutrition and health (Goals 2, 3**,** and 12), Livestock and sustainable ecosystems (Goals 6, 7, 11, 13, 14**,** and 15 respectively). Each of these require**s** the building of partnerships which covers goal 17. The first sustainable development goal states clearly: 'End poverty in all its form everywhere'. If the roles played by livestock in the economies of developing nations, particularly and developed countries generally are undermined, realizing the aforementioned worthwhile objective might be impracticable. In low and middle-income countries, an estimated 750 million people rely on small-scale livestock farming to earn a living. This kind of farming (often referred to as smallholder livestock keeping) contributes a huge 40% to the Agricultural Gross Domestic Product in these countries and that proportion is steadily rising. About 70 % of the animal milk consumed by humans in India and Kenya comes from small-scale livestock farming. The second goal: 'End hunger, achieve food security and improved nutrition and promote sustainable agriculture' will only be realized by putting into proper consideration the role of livestock in sustainable agriculture and food production. It is important to restate the fact that animal agriculture makes small-scale food production viable and renewable on every continent. Over a hundred million people who do not own land keep livestock (Mbow *et al*., 2019). Small-scale mixed crop and livestock farms in developing countries are responsible for putting more than half the grain, milk**,** and meat on the tables of the poor and better-off alike. Half of the staple cereal food would not have been produced without inputs from animal manure, traction**,** or sales. There are multiple roles that animal agriculture plays in the hands of small-scale mixed crop and livestock

farmers in ensuring food security and sustaining agricultural production. For instance, they provide 18% of global energy (Kcal) consumption and 25% of global protein consumption. They also provide a source of regular income with which to buy diverse and nutritious foods. From animal manure, one-quarter of the nitrogen used to grow crops in mixed crop-livestock systems worldwide is obtained. The rapid transition that these livestock production enterprises will undergo in the coming decades means they also present the biggest (and perhaps only) opportunity to address the three interlinked high-level recommendations made in the recent livestock report by the UN Committee on World Food Security (Thornton, 2010). These are: improving resource use efficiency, strengthening resilience**,** and improving social equity/responsibility outcomes.

The third SDG states thus: 'Ensure healthy lives and promote well-being for all at all ages'. Livestock will help to rapidly achieve this noble goal because animal-source foods make a significant lifelong difference to the world's most vulnerable people, including the growth and cognitive development of children (FAO, 2018). Animal-source foods provide humans with vital micronutrients (particularly B12) and make other essential nutrients much more 'bioavailable' than plant foods. A regular glass of milk, a little meat**,** or an egg can prevent stunting in the 158 million children currently affected by it as well as improve the cognitive development of children, ultimately greatly benefiting the economies of their nations (FAO, 2018). Eminent nutritional scientists studying the roles of animal-source foods in the first 1000 days of life warn that it will be impossible to reach the 1000-day SDG targets without including animal-source foods (Grace *et al*., 2018). As a result of their perishability, milk, meat**,** and eggs do present particular food safety challenges, especially as up to 90% of these foods are sold in the so-called 'informal' markets of the developing world. This again is an opportunity: novel training and hygiene approaches suited to these traditional markets can make an immense difference to the safety of their products (Grace *et al*., 2018). In East Africa's Kenya and India's state of Assam, over 6 million people have access to safer milk today not because stricter rules and regulations were applied but rather because informal milk processors and sellers were given the training and tools to do so much more safely. Women make up a significant portion of the world's poor livestock keepers and by implication, they (livestock) play unique roles in women's lives (FAO, 2018). This presents a good window of opportunity for achieving gender equality and empowerment for all women and girls (Goal 5). Women who cannot own land, capital, or other major productive resources often can own farm animals, particularly small stock such as goats, chickens**,** and cavies (ILRI, 2018). The benefits

women in developing countries get from their livestock enterprises tend to be invested back into feeding their families and educating their children. A woman's regular income from dairy or poultry often pays for the education of her daughters. Evidence indicates that women's empowerment is hurt rather than helped if men are left out of the picture (ILRI, 2018). Therefore, gender-sensitive and transformative approaches to livestock development need to focus on men as well as women while supporting women in building their social as well as economic capital.

Role of Livestock in Achieving One Health

One Health evolved from the recognition that an interdisciplinary approach is required to understand complex health problems and that the health of humans as well as animals is inextricably linked. In addition, we live in a world that is rapidly changing, complex**,** and progressively more interconnected than ever before (Yitayih, 2017). For instance, the global human population has slightly exceeded 7 billion, with an estimated 30 billion food animals needed to help feed this population and meet its growing demand for protein from animal sources. This convergence of people, animals**,** and the environment has created a new dynamic concept in which the health of each group is profoundly and inextricably linked and elaborately connected (AVMA, 2008). Inherent in this new dynamic is the changing interface between people and animals, including animal products. Diamond (2002) popularized the argument that close contact with livestock differentially improved human immunity to zoonotic diseases, in turn providing advantages to some cultural groups. Livestock keeping is critical for many of the poor people resident in the developing world, often contributing to multiple livelihood objectives and offering pathways out of poverty. The positive effects of livestock keeping include increased access to nutritious animal-source foods such as milk, meat, and eggs in households owning animals, and higher household cash incomes that increase purchase power for food crops, healthcare**,** and education. Consumption of animal source foods provides high-quality protein, essential structural fats, and highly bioavailable essential micronutrients (zinc, iron, calcium, vitamin A, vitamin B-12) that are strongly associated with improved growth, health, and cognitive ability of children (Lannotti and Lesorogrol, 2014) and increased resistance to and recovery from infectious diseases (Hughes and Kelly, 2006). All of these have multiplier effects at the community level through better-nourished children becoming more intelligent, healthier**,** and more productive adults (Randolph *et al*., 2007). It will be out of place though to imply that there are no negative effects of livestock ownership that may worsen human health and nutritional status. The negative effects associated with livestock keeping may include the risk of transmission of zoonotic pathogens from

animals to humans e.g. anthrax, leptospirosis, trypanosomiasis, and rabies, - many of which are neglected (Mableson *et al*., 2014). Also included are food-borne diseases cysticercosis, taeniasis, cryptosporidiosis, brucellosis, development of antimicrobial resistance, and chronic diseases such as cardiovascular disease, cancers, and diabetes associated with excessive consumption of the energy-dense high-level saturated animal source foods (Mableson *et al*., 2014).

In a study by Thumbi *et al*. (2015) to obtain syndromic disease data in animals along with economic and behavioural information for 1500 rural households in Western Kenya, data showed that 93 % of the household owned at least one form of livestock. Digestive disorders, mainly diarrhea episodes, were the most common syndromes observed in cattle, goats**,** and sheep, accounting for 56 % of all livestock syndromes, followed by respiratory illnesses (18 %). In humans, respiratory illnesses accounted for 54 % of all illnesses reported, followed by acute febrile illnesses (40 %) and diarrhea illnesses (5 %). While controlling for household size, the incidence of human illness increased 1.31-fold for every 10 cases of animal illness or death observed (Thumbi *et al*., 2015). Access and utilization of animal-source foods such as milk and eggs were positively associated with the number of cattle and chickens owned by the household. Additionally, health care seeking was correlated with household incomes and wealth, which were in turn correlated with livestock herd size (Thumbi *et al*., 2015). Data obtained from this study helped in gaining an understanding and quantification of the pathways by which human health and welfare are linked to animal health; providing a platform for testing hypotheses related to one-health including scientific inquiries focusing on specific diseases, co-infections**,** and their interactions.

The COVID-19 pandemic further raises questions about the role that interactions between humans and animals play in the context of widespread social distancing and isolation measures. Although the exact source of the current outbreak of COVID-19 is not yet known, it is widely accepted that the spread originally came from an animal, likely a bat (El Sayed and Camel, 2021). Researchers are opening up more information about this virus, and it is now known that it can spread from people to animals in some situations, especially during close contact. People with suspected or confirmed COVID-19 have been advised to avoid contact with animals, including pets, livestock, and wildlife (CDC, 2021). Some of the species that have been noticed to be infected with SARS-CoV-2 are cats and dogs, big cats in zoos or sanctuaries, gorillas in zoos, mink on farms, and a few other mammals. The list is currently inexhaustive, however, pigs can also host coronaviruses. In 2018, researchers described a new bat coronavirus that had killed some 25,000 pigs in southern China.

According to Petrovan *et al.* (2021), the COVID-19 pandemic has alerted the world to risks posed by emerging diseases of zoonotic origin and has prompted widespread concern and interest in acting to prevent future similar pandemics. The rate of zoonotic pathogen emergence reveals that human-induced changes have brought wildlife, livestock**,** and humans into closer and more frequent contact (Morse *et al*., 2012). The proximity of different wild and domestic animal species in a wildlife market setting may enable recombination between more distant coronaviruses and the emergence of recombinants with novel phenotypes (Li *et al*., 2020). This is particularly relevant given that multiple relatives of SARS-CoV-2 and SARS-CoV (the cause of the 2003 SARS epidemic) circulate in wildlife species in Southeast Asia and southern China (Zhou *et al*., 2021). Preventing such situations as well as reducing direct human contact with wild animals appears critical for preventing new coronavirus zoonoses.

One of the sub-sectors in Nigeria's Agribusiness space that bore the brunt of COVID-19 the most is the Poultry industry. This resulted in a sudden glut, panic sales disrupted business cycles for medium and large-scale poultry farmers among others. It is a well-known fact that as much as 60-70 % of production cost in this industry is attributable to feed and maize as a key component of this constitutes about 40-50 % of the cost (Dei, 2017). The national production of 11.5 million metric tonnes (FAO, 2021) in the year, 2020 was insufficient to meet industry needs; and this was worsened by the Federal Government's ban on maize importation in August 2020. There was the added burden of restricted capacity of farmers to purchase key inputs as the lockdown order was effected to the letter in five of the six south-western states in Nigeria. In Oyo State where movement was permitted in the daytime, there was some ease for farmers but varying levels of difficulties were experienced by different farmers depending on their scale of operation. As a result of these constraints poultry farmers faced, a survey was designed to assess the extent of losses farmers experienced and their attendant coping strategies. This was premised on the fact that should another public health emergency occur in the future, insights gained from this would be used to better plan and effectively tackle it.

A structured questionnaire was designed and shared among residents of various south-western States of Nigeria totaling 2, 011 who are involved in Poultry Farming to varying intensities. Out of this number, only 1, 971 were completed. The consent of respondents was sought before obtaining information and the exercise's purpose was expressly stated. An agreement was reached with each respondent that the identity would not be disclosed during or after the study.

The distribution of this questionnaire was done over six months, November 2020-April 2021. The questions therein were grouped under four different headings viz:

Demography, Level of awareness of respondents about COVID-19 Effects of COVID-19 on respondents and Respondents' strategies for coping with COVID-19. Collated questionnaires were analysed using descriptive statistics.

RESULTS AND DISCUSSION

Table 1 shows that based on demography, males (64.20 %) accounted for a significantly ($P<0.05$) higher number of respondents than females. This might be due to the capital-intensive nature of the poultry sector as it is the most capitalized sector of the livestock sector in Nigeria (Heise *et al*., 2015**).**

Table 1: Gender of Respondents

Gender	**Number**	**Percentage (%)**
Male	1, 273	64.6
Female	698	35.4

Source: Field Survey conducted by Jimoh and Oyeniyi (2021)

Table 2 shows that the most practiced value chain enterprise in the poultry sector was production, with more than half (69.8 %) of respondents engaged in it. Other value chains that respondents engaged in were poultry feed production (11.9 %), poultry product processing (5.6 %), poultry production, marketing and sales (9.5 %), poultry input suppliers (1.6 %), and poultry extension agents (1.1 %). The high number of respondents involved in production might be because this has traditionally been the most well-known value chain and its seemingly low entry point compared to feed production or product processing **(**NEA, 2020).

Table 2: Respondents Involved in Poultry Value Chains Enterprises

Poultry Value Chain	Number of respondents	Percentage (%)
Poultry production	1, 375	69.8
Poultry feed production	235	11.9
Poultry product processing	110	5.6
Poultry production, marketing and sales	188	9.5
Poultry input suppliers	32	1.6
Poultry extension agents	22	1.1

Source: Field Survey conducted by Jimoh and Oyeniyi (2021)

Table 3 shows that 1, 971 respondents were involved; 41.8 % were subsistent poultry farmers, while 58.2 % practiced commercially. Since several respondents were exclusively or partly engaged in poultry production, a flock size of less than 100 was classified as subsistent. It is instructive to note that up to 80 % of those involved in poultry production in Nigeria and many sub-Saharan African countries reside in rural households under extensive or semi-extensive systems, contributing substantially to egg and meat production.

Table 3: Demography on scale of operation of respondents' enterprise

Scale of Operation	Number	Percentage (%)
Subsistent	823	41.8
Commercial	1148	58.2

Source: Field Survey conducted by Jimoh and Oyeniyi (2021)

Table 4 below shows that nearly half (45.6 %) of respondents made direct sales to customers while 16.5 % sold to canteens and quick-service restaurants. Another 17.5 % sold to retailers while 20.4 % sold to wholesalers. The convention is for most poultry farmers to be linked with ready markets or off-takers who are often processors (NEA, 2020)

Table 4: Demography on Marketing/Sales Channels of Respondents

Marketing/Sales Channel	Number	Percentage (%)
Direct sales to consumers	899	45.6
Sales to canteen/restaurants	325	16.5
Sales to retailers	344	17.5
Sales to wholesalers	403	20.4

Source: Field Survey conducted by Jimoh and Oyeniyi (2021)

The level of awareness about the pandemic among respondents was generally high as nearly all respondents (96.7 %) were aware that COVID-19 was declared as a pandemic by the World Health Organisation (WHO) early in 2020, while just 3.3 % were unaware of the development. In addition, 94.9 % of respondents knew that COVID-19 is a viral disease while 5.1 % did not know about this. Also, 92.8 % of the respondents believed that COVID-19 spread through respiratory droplets in the air from coughing and sneezing while just 7.2 believed otherwise. The majority of the respondents believed that COVID-19 can be contacted through physical contact such as shaking hands and hugging infected persons; 88.9 % of them believed that COVID-19 can be contacted through these means while just 11.1 % believed that COVID-19 cannot be contacted through physical contact. Again, 89.6 % reported that the use of face masks, observing personal hygiene**,** and social/physical distancing was effective in preventing COVID-19 while 10.4 % claimed that the use of face masks, observing personal hygiene**,** and social/physical distancing was not effective in preventing COVID-19.

More than half of the respondents (67.75 %) had been observing biosecurity measures before the coronavirus while 32.3 % did not adhere fully to biosecurity measures before coronavirus disease emergence. Quite surprisingly, about 56.6 % of respondents reported that there was no disease outbreak on the farm before the onset of the pandemic while 43.4 % experienced one disease outbreak or the other on their farms before COVID-19. Of the proportion involved in livestock production, 57.2 % of respondents reported improvement in their livestock production over the past 3 months, while 21.4 % did not experience any change in livestock production, 15.7 % experienced retrogression in their livestock production**,** and 5.7 % did not observe any significant difference or simply did not know.

Respondents reported a high loss of animals through shortage of feed (36.4 %), while 26.6 % indicated that lack of access to veterinary service accounted for losses; another 20.6 % of respondents claimed that disease incidence was responsible for loss of animals while 13.1 % affirmed that losses were due to theft. Thus, during COVID-19, animal loss was mostly caused by feed shortages. This is quite understandable because of the restricted vehicular and human movements. Feed shortage topped the three critical factors responsible for poor animal welfare in a similar study conducted in Central Punjab, Pakistan (Hussain *et al*., 2020).

As seen in Table 5, a large proportion of the respondents involved in one value chain or the other in the poultry sector experienced some form of downturn or the other. For instance, 40.4 % of respondents reported a decrease in income while 31.1 % reported severe feed shortage, 2.1% were displaced, 5.5 % experienced social isolation**,** and another 2.9 %, ill-health. Also**,** 4.3 % reported having been in a state of constant fear while 9.5 % reported severe animal loss, 2.2 % reported a rise in criminal activities around their farms**,** and 2 % were said to have been affected in other ways.

Table 5: Effect of Covid-19 on the Livelihood of Different Categories of Poultry Farmers in S/West Nigeria

Effect on Poultry Farmers	**Number of Farmers Affected**	**Percentage (%)**
Decrease in income	796	40.4
Food shortage	612	31.1
Displacement	42	2.1
Social isolation	109	5.5
Ill health	57	2.9
Constant fear	85	4.3
Livestock loss	187	9.5
Increased crime	44	2.2
Others	39	2.0
Decrease in income	796	40.4

Source: Field Survey conducted by Jimoh and Oyeniyi (2021)

About 70.2 % of respondents noticed a change in their enterprise's operation before COVID-19, while 29.8 % did not notice a change in their enterprise's operation before COVID-19. During COVID-19, 75.7 % of the respondents noticed a change in their enterprise's operation, while 24.3 % did not notice a change. Most of these changes were said to be negative such as high feed cost, low sales, reduced access to physical cash, etc. The main positive change some respondents reported was increased attention paid to the birds. Furthermore, the pandemic-induced lockdown adversely restricted access of respondents to feed, vaccines, and other materials as a large number (78.1 %) experienced one or more of these while 21.9% reported that the lockdown did not adversely restrict their access to feed, vaccines, and other materials. Several researchers (Hussain *et al.*, 2020; Uyanga *et al.*, 2021) reported that farmers generally had restricted access to essential supplies such as feed and veterinary services, among other inputs. Respondents devised various means of coping with the pandemic, and this took on various forms, such as self-protection from contracting the viral disease, as seen in Table 6 below. They resorted to isolation (14.8 %), social distancing (30.9 %), spiritual reinforcement (3.1 %), use of nose masks and hand sanitizers (50 %) and others (1.1 %).

Table 6: Respondents' means of self-protection from contracting COVID-19

Health Protective measures	Number of Respondents	Percentage (%)
Isolation	292	14.8
Social distancing	610	30.9
Spiritual reinforcement	61	3.1
Use of nose masks and hand sanitizers	986	50
Others	22	1.1

Source: Field Survey conducted by Jimoh and Oyeniyi (2021)

An aggregate of 83.9 % of respondents sometimes used their vehicles as mobile markets for the sale of farm produce during the lockdown while 16.1 % never adopted mobile marketing for their products. In like manner, 83.6 % of respondents sometimes employed social media for marketing

purposes during the lockdown while 16.3 %, did not resort to such a marketing form. Also, 70.3 % of respondents reported sometimes reducing the price (s) of farm produce to make quick sales while 21.5 % always reduced prices and 8.2 % did not reduce the price at all. About 51.5 % of respondents sometimes preserved farm products for the post-lock-down period, 31.0 % always preserved their farm products while 17.2 % did not preserve farm products. Uyanga *et al*. (2021) reported in another study that poultry product supply chains were disrupted during the lockdown and it is therefore unsurprising that respondents had to find unconventional means of marketing their products. Another 54.3 % of the respondents sometimes provided incentives in the form of palliatives for farmworkers to encourage them during the lockdown, while 28.9 % always provided such incentives and 16.8 % did not provide any incentive. In a bid to further cope, 74.1 % of respondents acquired a livestock insurance policy to cushion the negative effect(s) of the pandemic while 25.8 %, did not acquire a livestock insurance policy.

Promoting Public Understanding

It is perhaps surprising that One Health has gained so little mainstream traction among biomedical professions. This is despite a succession of global disease problems such as highly pathogenic avian influenza, severe acute respiratory syndrome, Ebola haemorrhagic viral disease, and Bovine spongiform encephalopathy which all had their origins in animal populations and are linked with agro-ecological change (Rahman *et al.*, 2020). A possible explanation is that separate animal and human health agencies responsible for disease prediction, prevention, and control have been embedded in many developed countries since the 19th century with institutional barriers impeding horizontal collaboration. The resulting gulf between human and animal health, caused by disciplinary conventions and cultures rather than scientific rationale has divided medicine in two (Kamani *et al.*, 2015). In Africa however, where people's lives are intimately related to the health and productivity of livestock and the natural environment, the situation is different. National medical and veterinary institutions are still maturing, which presents African health professionals with an opportunity to build on an instinctive understanding of the connectivity between people, animals, and their environments, and to 'leapfrog' barriers imposed by more well-established and rigid institutional systems. If this succeeds, African scientists and African institutions have the opportunity to become world leaders in One Health (Kamani *et al*., 2015).

In the agricultural sector, information is one of the major resources to increase food production, and effective information delivery service greatly enhances agricultural development. However, in

a situation where information about new methods of production rarely reaches peasant farmers, the majority of whom have very little or no formal education, it becomes necessary to adopt alternative methods to adequately meet these demands. Such an approach should provide the information needed to solve their problems, and also motivate them to accept changes and adopt improved practices (Sam, 2011). Peasants are largely involved in the bulk production of food (crops and livestock) in developing countries. Their inability to sustain increased food production levels over the years can be attributed to factors such as the lack of reliable information that will help them adjust their farm management practices. To overcome this problem, they have to be provided with the requisite knowledge to enable them to increase their output, and thereby increase their earnings from farming activities. A blend of indigenous communication tools such as village debates, town criers, traditional musicians, and exchange visits as well as information communication technologies such as computers, internet and mobile phones, newspapers, radio, television, and landline telephony will help address this gap. Furthermore, efforts should be made to ensure wild-life farming is safe and legal, whilst also putting in place measures to reduce wildlife–livestock–human interfaces in and around farms and wild places. Also, animal hygiene and health standards for livestock and farmed wild animal production should be significantly increased. This is in addition to enforcing biosecurity on livestock farms through routine surveillance.

Sustainable livestock production will require the long-term application of a One Health approach with its focus on mitigating health risks at the interfaces between animals and humans in different ecosystems. It will stimulate the joint working of multiple interests in pursuit of most of the sustainable development goals.

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Original Research Paper

COMPARATIVE EFFECTS OF ORGANIC WASTES AND NPK FERTILIZER ON GROWTH, YIELD OF CARROT AND SELECTED SOIL CHEMICAL PROPERTIES IN THE RAINFOREST AGROECOLOGY OF NIGERIA

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ABSTRACT

The high cost and scarcity of mineral fertilizers in Nigeria awakes interest in research into the potential of organic wastes in enhancing soil productivity. Field experiments were conducted in the 2019 and 2020 cropping seasons to evaluate the potentials of poultry manure (PM), cocoa pod husk (CPH), and NPK 15:15:15 fertilizer in enhancing growth, root yield of carrot and soil nutrients status at Igba village (07^0 07^1N, 04^0 52^1 E) southwest Nigeria. The treatments involved control, 5and10 tha^{-1} PM, 5 and 10 t ha^{-1} CPH, 100 and 200 kg ha^{-1} NPK fertilizer. The seven treatments were laid out in a randomized complete block design and treatments were replicated three times. The soil at the site was acidic (pH 5.5), sandy in texture, and low in nitrogen (0.12 g kg^{-1}) and organic carbon (9.2 g kg^{-1}). Poultry manure, CPH, and NPK fertilizer significantly ($p < 0.05$) enhanced growth, leaf nutrients content, root yield of carrot, and soil nutrients status relative to the control. There were no significant ($p > 0.05$) differences in the effects of 10 t ha^{-1} PM and 10 t ha^{-1} CPH on growth parameters, leaf nutrients content, root yield characteristics of carrot, soil pH, exchangeable bases, total N, available P, and organic carbon. The effects of 10 t ha^{-1} each of PM and CPH on growth and root yield parameters of carrot compared favourably with 200 kg ha^{-1} NPK in the first cropping season but in the second cropping season, PM and CPH amended plots out-yielded NPK fertilizer amended plots. Poultry manure and CPH enhanced growth, leaf nutrients content, root yield characteristics of carrot, and soil nutrients status on a long-term basis than NPK fertilizer. The use of cheap and locally available PM and CPH is therefore recommended for the use of peasant farmers in the production of carrot.

Keywords: Comparative, Organic wastes, Root yield, Growth and Soil nutrients.

Introduction

Carrot (*Daucus carota L.*) is a popular root vegetable in high demand in Nigeria. The demand for carrots has exceeded its supply most especially in southern Nigeria, thereby, resulting in its high cost. Carrot production is mainly in northern Nigeria probably because of the favourable weather conditions for its production in certain periods of the year in some parts of northern Nigeria. In southern Nigeria, carrot production is not popular among the farmers, perhaps because of insufficient agronomic information about carrot production and as well as the weather conditions of southern Nigeria. The need to increase carrot production in Nigeria through agronomic research cannot be overemphasized. In general, one of the problems of low crop production in Nigeria is attributed to the low soil nutrient status. Also, the poor performance of crops is attributed to the low input crop production practices and the severe crop environmental stresses (Adeleye and Ayeni, 2010), Among crop production practices that could influence the growth and performance of crops is crop fertilization. In Nigeria, the low carrot yield has been attributed to the lack of high-yielding varieties as well as low soil nutrient status (Ahmed *et al.,* 2014). To obtain high yield and quality of carrots, good soil fertility is required. The need for improved soil management practices has led to external inputs from organic and inorganic sources to enhance soil productivity and high crop yield. The use of chemical fertilizer has been found to increase crop yield significantly for only a few years but in the long run leads to a decrease in crop yield due to the degradation of soil's physical and chemical properties (Adeoye *et al.*, 2008), The use of inorganic fertilizer recently in Nigeria is low due to its high cost, scarcity, poorly developed infrastructure for fertilizer distribution, marketing and the low economic situations of the peasant farmers. Hence, there is a need for comparative studies of the potential of cheap and locally available organic materials with inorganic fertilizers in combating soil fertility and crop production problems.

The use of cocoa pod husk (CPH) has been successfully tried as a bio-fertilizer for maize (Ayeni, 2010 and Akanbi *et al.*, 2014). It has been reported that the use of cocoa pod husk fertilizer does not contain substances that will pose environmental and human health risks (Campos-Filho *et al*., 2017), The increasing popularity of CPH as a bio-fertilizer for soil management justifies further investigation to ascertain that its application could enhance favourable soil properties and performance of carrot. In Nigeria, a huge amount of poultry manure (PM) is generated every year

and heaped on dumpsites. Incorporating poultry manure into the soil for crop production has been found beneficial. Poultry manure has been found to improve soil's physical, biological, and chemical properties and enhance high-crop production (Adeniyan, 2008, Adeleye *et al.*, 2010., Amusan *et al.*, 2011).

In southwest Nigeria, research information on poultry manure in carrot production is scanty, hence, there is a need to further investigate the potential of poultry manure in enhancing soil nutrients status and yield of carrot. The present study aimed at evaluating the relative effects of poultry manure (PM), cocoa pod husk (CPH), and NPK 15: 15: 15 fertilizers on growth, leaf nutrients content, root yield of carrot, and soil chemical properties on an Alfisol in the rainforest agro-ecological zone of southwest Nigeria.

Materials and Methods

Description of the Site

Field experiments were carried out in the 2019 and 2020 cropping seasons at Igba village, Ondo (Latitude 07^0 07^1 N, Longitude 04^o 52^1 E) in the rainforest zone of southwest Nigeria. The mean annual rainfall is about 1670 mm. The site enjoys a bimodal rainfall pattern with early rain occurring between March to July and late rain between August to October with five (5) months of dry season. The mean relative humidity is about 69 %, and the sunshine hours vary from 2.5 to 7hr and appeared lowest in July, August and September. The mean monthly temperature at the site of the field experiment is 27^0 C (FDACSA, 2021). The soil is sandy in texture and slightly acidic and classified as OxicTropuldalf (Alfisol) derived from quart, gneiss, and schist (Akinbola *et al.*, 2009), The site is located in the lowland rainforest agro-ecological zone of Nigeria with a semi-deciduous vegetation. The site has been previously cultivated for arable crops such as cassava, maize, and cocoyam and it has been under fallow for two years before the commencement of the field experiment. The monthly average air temperature, rainfall, and humidity at the site of the field experiments from sowing to harvesting (June – September) in 2019 and 2020 are shown in Table 1.

Table 1: Monthly Average Air Temperature, Rainfall and Relative Humidity at Igba Site from Sowing to Harvesting in 2019 and 2020

Month	Temperature ^{0}C		Rainfall (mm)		Relative Humidity (%)	
	2019	2020	2019	2020	2019	2020
June	25.28	25.02	14.42	12.80	92.72	93.16
July	24,72	24.12	9.07	8.52	92.59	92.68
August	24,52	23.81	6.64	1.47	91.97	89.04
September	24.81	24.46	15.08	15.00	93.23	92.22

Source: Department of Aviation, Climatological Station, Akure, Ondo State (2021)

Treatments and Experimental Design

The treatments involved control, 5 t ha^{-1}, 10 t ha^{-1} PM, 5 t ha^{-1}, 10 t ha^{-1} CPH, 100 kg ha^{-1}, and 200 kg ha^{-1} NPK 15:15:15 fertilizer. Treatments were laid out in a randomized complete block design (RCBD) with three replications. A land area measuring 14 m by 8 m was used. The site was manually cleared, packed, and divided into three blocks and each block was demarcated by a 0.5 m wide alley way. Each block was further divided into seven plots of 2 m by 2 m, and each plot demarcated by 0.5 m wide alley way. Each plot was made into raised beds using traditional hoes. The raised beds were thoroughly pulverized and raked free of stones. The treatments were randomly assigned to the plots. Dried and ground PM and CPH were uniformly spread on the assigned plots and incorporated into the soil using a traditional hoe five (5) days before planting of carrot seeds while NPK 15:15:15 fertilizer was broadcasted on the assigned plots two (2) weeks after emergence of carrot seedlings. The carrot seeds were sown directly into the prepared beds by drilling in rows spaced 20 cm apart, which were later thinned three (3) weeks after the emergence of carrot seedlings to attain spacing of 20 cm apart. Weeding and other cultural operations were the same for all the treatments and were attended to regularly.

Pre-Treatment Soil Analysis

Pre-treatment soil surface (0 -15 cm) samples were collected using a soil auger, air-dried, and sieved using 2 mm mesh, and bulked and processed for routine chemical analysis of the initial soil characteristics. Soil particle size distribution was determined using the hydrometer method. Soil pH was determined at a 1:2 soil-water ratio using a glass electrode pH meter. Organic carbon was

determined by dichromate oxidation method, total nitrogen by Kjeldahl digestion auto analyzer method, available P was extracted by Bray-1-method, and P in the extract was determined colorimetrically. Exchangeable cations by 1.0N NH_40Ac extraction. Calcium, magnesium, and manganese in the extract were determined by atomic absorption spectrophotometry. Cation exchange capacity was determined by the summation of NH_40Ac – extractable cations plus 1.0N KCl extractable acidity.

Growth and Yield Parameter

Ten carrot stands were randomly selected per plot and tagged for the estimation of growth and yield parameters. Leaf length, number of leaves per stand, and plant height were measured at 80 days after sowing of carrot seeds. Leaf length was measured using a meter rule, plant height was measured in cm from the ground level to the top of the shoot using a meter rule, while the leaves were counted. Shoot fresh weight was determined using a weighing balance, and the shoot dry weight was determined by oven drying 10 stands per plot to constant weight at 65^0 C. Root fresh weight was determined using a weighing balance in g per stand. Root diameter was measured at the widest middle portion of the root using a vernier caliper. The number of forked, cracked, and rotten roots were counted separately on a treatment basis as malformed roots, and percentage was calculated from the number of harvested roots. Root dry weight was determined by oven-drying roots to constant weight at 65^0 C. Marketable root yield was determined by weighing roots with no deformities like cracks, forking, malformation, and spots.

Leaf Nutrients Analysis

At harvest, matured leaves were collected from five (5) stands per plot, washed in water, oven-dried at 65^0 C for 48 hours, and ground for routine chemical analysis. The nutrients in the ash were then brought into the solution by the addition of 10 % HCl. Leaf N was determined using the Kjeldahl digestion method, phosphorus was determined colorimetrically by the vanadomolydate method, K by flame photometer, and Ca and Mg were determined by AAS (AOAC, 2000).

Post-harvest Soil Chemical Analysis

At the end of each cropping season, another set of soil samples (0 -15 cm) were collected on a treatment basis and per replicates and also processed for chemical analysis. Soil

pH was determined at a 1:2 soil water ratio using a glass electrode pH meter. Organic carbon was determined by dichromate oxidation method, total nitrogen by Kjeldahl digestion auto analyzer method, available P was extracted by Bray-1-method, and P in the extract was determined colorimetrically. Exchangeable cations by 1.0N NH_40Ac extraction. Calcium, magnesium, and manganese in the extract were determined by atomic absorption spectrophotometry. Cation exchange capacity was determined by the summation of NH_40Ac – extractable cations plus 1.0N KCl extractable acidity.

Data Analysis

Data on soil chemical properties, leaf nutrients content, growth, and yield parameters were subjected to analysis of variance using the Statistical Analysis System Institute Package – General Linear Model (SAS, 2000). Means were compared using Duncan's Multiple Range Test at a 5 % level of significance where the F-ratio was significant.

Results

Initial Soil Properties

Data on the initial physical and chemical properties of the experimental soil are presented in Table 2. The soil was acidic (pH 5.5.), high in sand particles, low in total nitrogen (0.12 g kg^{-1}), organic carbon (9.2 g kg^{-1}), available P (8.0 mg kg^{-1}), ECEC, exchangeable bases and high in micronutrients. The soil was sandy in texture.

Growth Parameters

The relative effects of poultry manure (PM), cocoa pod husk (CPH), and NPK 15:15:15 fertilizer on the growth parameters of carrots are shown in Table 3. Relative to control, plant height, leaf length, and shoot dry matter were significantly ($P<0.05$) influenced by PM, CPH, and NPK fertilizer. The number of leaves was not significantly ($P>0.05$) influenced by the soil amendments in the study. The plots amended with 200 kg ha^{-1} NPK fertilizer in the first cropping season (2019) had the best growth parameters in terms of plant height and, leaf length. However, the growth parameters of carrots in plots treated with 10 t ha^{-1} each of PM and CPH compared favourably in

most of the carrot growth parameters measured with that of the plots amended with 200 kg ha^{-1} NPK fertilizer in the first cropping season. There were no significant ($P>0.05$) differences in the growth parameters of carrots for plant height, leaf length, and leaf number in plots amended with 5 t ha^{-1} PM and 5 t ha^{-1} CPH in the first cropping season. The lowest growth parameters came from the control plots at both cropping seasons.

Table 2: Initial Soil Physical and Chemical Properties at the Site of Experiment

Parameter	Value
Sand (g kg^{-1})	942
Silt (g kg^{-1})	15
Clay (g kg^{-1})	43
Textural Class	Sandy
pH (H_2O) (1:2)	5.5
Organic carbon (g kg^{-1})	9.2
Total nitrogen (g kg^{-1})	0.1
Available phosphorus (mg kg^{-1})	8
Ca (cmol kg^{-1})	1.7
Mg (cmol kg^{-1})	0.3
Na (cmol kg^{-1})	0.4
K (cmol kg^{-1})	0.2
Exch. Ac. (cmol kg^{-1})	0.1
ECEC (cmol kg^{-1})	2.8
B. Sat (%)	96
Mn (mg kg^{-1})	18
Fe (mg kg^{-1})	27
Cu (mg kg^{-1})	3
Zn (mg kg^{-1})	4

Exch. Ac = Exchangeable acidity, ECEC – Effective cation exchange capacity, B.Sat = Base saturation

There were relative improvements in the growth parameters of carrots in plots amended with PM and CPH during the second cropping season (2020), while there were reductions in the growth characteristics of carrots in plots treated with NPK fertilizer in terms of plant height, leaf length

and shoot dry matter. The growth characteristics of carrots, such as plant height, leaf length, leaf number, and shoot dry matter in plots treated with 10 t ha^{-1} each of PM and CPH were not significantly (P>0.05) different in the first cropping season. The mean plant height value for the two cropping seasons for 5 t ha^{-1} PM was 45.95 cm, while that of 10 t ha^{-1} PM was 52.83 cm. 5 t ha^{-1} CPH had a mean value of 47.71 cm for the two cropping seasons and 10 t ha^{-1} CPH had a means value of 48.39 cm for the two cropping seasons. The mean plant height for the two cropping seasons for 100 kg ha^{-1} NPK fertilizer was 45.36 cm, while that of 200 kg ha^{-1} was 45.92 cm.

Table3: Relative Effects of Poultry Manure, Cocoa Pod Husk and NPK 15:15:15 Fertilizer happening Growth Characteristics of Carrot

Treatment (t ha^{-1})	Plant height (cm)		Leaf length (cm)		Number of leaf		Shoot dry matter (%)	
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Control	44.31c	38.42d	28.91d	25.41d	7.12a	7.41a	9.10b	8.13c
PM_5	45.52b	46.41b	36.02b	36.72b	7.51a	7.66a	7.97c	8.87c
PM_{10}	52.61a	53.12a	36.81b	37.21b	7.54a	7.89a	10.12a	9.28b
CP_5	47.53b	48.01a	38.62b	39.12a	7.49a	7.64a	9.12b	9.21b
CP_{10}	48.29a	48.52a	37.21b	39.91a	7.51a	7.59a	10.45a	10.56a
F_{100}	48.00a	42.72c	34.12c	27.28d	7.44a	7.10a	8.87c	8.71c
F_{200}	51.60a	40.25c	40.91a	34.43c	7.64a	6.80b	10.00a	8.11c

Means with the same letter in a column are not significantly different at p>0.05.
CP_5 = 5 t ha^{-1} CPH, CP_{10} = 10 t ha^{-1} CPH, F_{100} = 100 kg ha^{-1} NPK fertilizer, F_{200} = 200 kg ha^{-1} NPK fertilizer

Root Yield Parameters

The effects of poultry manure (PM), cocoa pod husk (CPH), and NPK 15:15:15 fertilizer on carrot root yield characteristics are presented in Table 4. Relative to control, PM, CPH, and NPK fertilizer significantly (P<0.05) influenced carrot root yield parameters at both cropping seasons. The root length, root diameter, root yield, root dry matter, and percent deformed roots increased with the increasing levels of the inputs. In the first cropping season (2019), there were no significant (P>0.05) differences in root yield characteristics of carrots such as gross root yield, deformed roots, marketable root yield, and root dry matter in plots amended with 10 t ha^{-1} PM, 10 t ha^{-1} CPH and 200 kg ha^{-1} NPK fertilizer. However, in the second cropping season (2020), there were significant (P<0.05) differences in carrot root yield characteristics in plots amended with 10 t ha^{-1} PM, 10 t ha^{-1} CPH, and 200 kg ha^{-1} NPK fertilizer. There were no significant (P> 0.05) differences in carrot

root yield characteristics in plots amended with 10 t ha^{-1} PM and 10 t ha^{-1} CPH at both cropping seasons.

The plots amended with 10 t ha^{-1} each of PM and CPH out-yielded the plots amended with 200 kg ha^{-1} NPK fertilizer. The plots amended with 5 t ha^{-1} PM compared favourably with the plots treated with 5 t ha^{-1} CPH in most carrot root yield characteristics measured at both cropping seasons. In the second cropping season, there were slight increases in carrot root yield parameters in plots amended with PM and CPH compared to the first cropping season. In contrast, there were reductions in carrot root yield parameters in plots amended with NPK fertilizer. Also, there was a reduction in deformed root yield in the second cropping season across the treatments compared with the first cropping season. At both cropping seasons, control plots consistently had the poorest carrot root yield characteristics. The mean gross root yield for the two cropping seasons for 5 and 10 t ha^{-1} PM were 19.85 t ha^{-1} and 22.62 t ha^{-1}, respectively. Also, for 5 and 10 t ha^{-1} CPH were 20.30 and 22.33 t ha^{-1}, respectively. While the mean gross root yield values for 100 and 200 kg ha^{-1} NPK fertilizer were 18.90 and 19.36 t, respectively. The mean values of marketable root yield for 5 and 10 t ha^{-1} PM were 18.65 and 21.90 t ha^{-1}, respectively, and also, for 5 and 10 t ha^{-1} CPH were 19.79 and 21.88 t ha^{-1}, respectively. While the mean marketable root yield for 100 and 200 kg ha^{-1} NPK fertilizer were 17.13 and 18.74tha^{-1}, respectively.

Table 4: Relative effects of Poultry Manure, Cocoa Pod Husk and NPK 15:15:15 Fertilizer on Yield Characteristics of Carrot

Treatment (t ha^{-1})	Root length (cm)		Root diameter (cm)		Root dry matter (%)		Gross root yield (t ha^{-1})		Deformed roots (%)		Marketable yield (t ha^{-1})	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Control	9.91c	9.12c	1.60c	1.48d	8.92b	8.21c	18.41c	15.46d	2.50b	1.58c	17.94c	15.22d
P_5	10.97b	11.18a	1.74b	1.78b	10.31a	10.61a	19.21b	20.50b	3.48a	2.19a	18.52b	18.78b
P_{10}	12.60a	12.98a	1.84a	1.90a	10.59a	10.62a	22.43a	22.85a	2.74b	1.72b	21.79a	22.01a
CP_5	10.61b	10.83b	1.69c	1.72b	11.25a	11.48a	20.01b	20.60b	3.10a	1.95b	19.38b	20.19a
CP_{10}	11.14b	11.36a	1.87a	1.91a	10.23a	10.54a	22.21a	22.64a	3.20a	2.02a	21.49a	22.18a
F_{100}	11.38a	9.90b	1.77b	1.50c	10.74a	9.13b	21.01a	16.80c	3.20a	2.02a	17.80c	16.46c
F_{200}	11.98a	9.58b	2.05a	1.64c	11.44a	9.15b	21.42a	17.12c	3.26a	2.05a	20.71a	16.77c

Means with the same letter in a column are not significantly different at $p>0.05$.
P_5 = 5 t ha^{-1} PM, P_{10} = 10 t ha^{-1} PM, CP_0 = 0 t ha^{-1} CPH, CP_5 = 5 t ha^{-1} CPH, CP_{10} = 10 t ha^{-1} CPH, F_{100} = 100 kg ha^{-1} NPK fertilizer, F_{200} = 200 kg ha^{-1} NPK fertilizer

Leaf Nutrient Contents

The relative influence of PM, CPH, and NPK 15:15:15 fertilizer on leaf nutrient contents is presented in Table 5. The data in the table indicated that leaf nutrient contents were significantly ($P < 0.05$) influenced by PM, CPH, and NPK fertilizer. The leaf N, P, K, Ca, and Mg were significantly higher in plots amended with PM, CPH, and NPK fertilizer compared with the control plots. The leaf N, P, K, Ca, and Mg increased with the increasing rates of PM, CPH, and NPK fertilizer. During the first cropping season (2019), the leaves N, P, and K in plots amended with NPK fertilizer were better than their corresponding contents in carrot leaves in plots amended with PM and CPH. The leaf N, P, K, Ca, and Mg in plots treated with 10 t ha^{-1} PM and plots amended with 10 t ha^{-1} CPH compared favourably with those of the carrot leaves in plots amended with 200 kg ha^{-1} NPK fertilizer in the first cropping season.

The leaf N, P, K, and Ca in carrot leaves in plots amended with NPK fertilizer and the control plots decreased in the second cropping season (2020) compared with their leaf contents in the first cropping season. Carrot leaves in the control plots had the lowest contents of N, P, K, and Ca when compared with carrot leaves in plots amended with NPK fertilizer, CPH, and PM. In the second cropping season, there were slight improvements in the leaf nutrient contents of carrots in plots treated with PM and CPH. The mean leaf N for the two cropping seasons for 5 and 10 t ha^{-1} PM were 0.64 and 0.68 %, respectively, while the mean leaf N in plots with 5 and 10 t ha^{-1} CPH were 0.64 and 0.65 %, respectively. The leaf N mean values for 100 and 200 kgha^{-1} NPK fertilizer were 0.57 and 0.62 %, respectively. Also, the mean leaf P for 5 and 10 t ha^{-1} PM were 0.62 and 0.73%, respectively, while the mean leaf P for 5 and 10 t ha^{-1} CPH were 0.61 and 0.71 %, respectively, and the mean leaf P for 100 and 200 kg ha^{-1} NPK fertilizer were 0.61 and 0.64 %, respectively.

Postharvest Soil Chemical Properties

Tables 6 and 7 show the relative effects of PM, CPH and NPK 15:15:15 fertilizer on soil chemical properties at the end of 2019 and 2020 cropping seasons. At harvest, PM, CPH and NPK fertilizer had significant ($P \leq 0.05$) different effects on soil pH, total organic carbon, total N, available P, exchangeable bases (Ca, Mg, K, Na), exchangeable acidity and the micronutrients (Mn, Fe, Cu, Zn), at the end of first cropping season (2019), 10 t ha^{-1} PM had the highest soil pH, exchangeable bases (Ca, Mg, K), ECEC, total N, total organic carbon and available P, followed by 10 t ha^{-1} CPH.

There were no significant (P > 0.05) differences in the effects of 10 t ha^{-1} PM and 10 t ha^{-1} CPH on soil pH, exchangeable bases, ECEC, total organic carbon, total N and available P at the end of the first cropping season (2019). The effect of 5 t ha^{-1} PM and 5 t ha^{-1} CPH compared favourably with 100 kg ha^{-1} NPK fertilizer on soil pH, exchangeable K, exchangeable acidity, total N and total organic carbon. The control plots had the lowest soil pH, exchangeable bases, ECEC, total N, total organic carbon, available P, and the highest exchangeable acidity and micronutrients (Mn, Fe, Cu, Zn).

Table 5: Relative Effects of Poultry Manure, Cocoa Pod Husk and NPK 15:15:15 Fertilizer on Leaf Nutrients Content of Carrot

Treatment (t ha^{-1})	N		P		K		Ca		Mg	
	(%)									
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Control	0.62b	0.62c	0.57d	0.48d	5.65c	5.42b	0.43b	0.41c	0.13b	0.12c
P_5	0.62b	0.65b	0.62c	0.62b	6.25b	6.51a	0.53a	0.55a	0.14a	0.14b
P_{10}	0.66a	0.70a	0.66b	0.79a	5.79c	6.53a	0.53a	0.63a	0.14a	0.16a
CP_5	0.64a	0.65b	0.59c	0.62b	5.88c	6.10a	0.51a	0.58a	0.13b	0.14b
CP_{10}	0.65a	0.64b	0.64b	0.71a	6.10b	6.39a	0.56a	0.56a	0.14a	0.15a
F_{100}	0.62b	0.52c	0.61c	0.61b	6.05b	5.91b	0.50a	0.49b	0.13b	0.13b
F_{200}	0.67a	0.58d	0.69a	0.59c	6.78a	6.28a	0.54a	0.49b	0.13b	0.12c

Means with the same letter in a column are not significantly different at p>0.05.
P_5 = 5 t ha^{-1} PM, P_{10} = 10 t ha^{-1} PM, CP_5 = 5 t ha^{-1} CPH, CP_{10} = 10 t ha^{-1} CPH, F_{100} = 100 kg ha^{-1} NPK fertilizer, F_{200} = 200 kg ha^{-1} NPK fertilizer

At the end of the second cropping season (2020), there were increases in soil pH, total organic carbon, available P, exchangeable bases, while there were significant reductions in exchangeable acidity, total N and the micronutrients in plots amended with PM and CPH. Also, there were significant reductions in total N, total organic carbon and available P in plots amended with NPK fertilizer compared with the first cropping season. Highest rate of PM consistently resulted in elevated soil pH, exchangeable bases, ECEC, total organic carbon, total N and available P. There were no significant (P > 0.05) differences in the effect of 5 t ha^{-1} PM and 5 t ha^{-1} CPH on soil pH, exchangeable Mg, ECEC, total organic carbon, available P and the micronutrients. At both cropping seasons, control plots and the plots amended with NPK 15:15:15 fertilizer had relatively lower soil pH when compared with the plots amended with PM and CPH.

Table 6: Relative Effects of Poultry Manure, Cocoa Pod Husk, NPK 15:15:15 Fertilizer on Soil Chemical Properties (2019 cropping season)

Trt (t/ha)	pH	Ca	Mg	K	Na	Ex.AC	ECEC	Base Sat.	Total N %	Total Org. C	Av.P	Mu	Fe Mg/kg	Cu	Zn
		Cmol/kg													
Control	5.57b	3.04c	1.69c	0.47c	0.41a	0.11a	5.72c	98.01a	0.13c	1.68c	16.91a	19.61a	16.41a	2.89a	2.99a
PM_5	5.90b	3.65a	1.77b	0.56b	0.38b	0.09b	6.45b	98.61a	0.15a	1.89b	23.32c	17.03b	15.02b	2.67b	2.68b
PM_{10}	6.27a	3.93a	1.80a	0.62a	0.39b	0.08c	6.82a	98.81a	0.15a	2.09a	27.71a	16.62c	13.61d	2.65b	2.52b
CP_5	6.06a	3.69a	1.76b	0.59a	0.39b	0.09b	6.52a	98.61a	0.14b	1.91b	23.41c	16.81c	14.42c	2.69b	2.61b
CP_{10}	6.02a	3.78a	1.83a	0.61a	0.41a	0.09b	6.71a	98.71a	0.15a	2.07a	26.52a	16.13c	14.61c	2.54b	2.55b
F_{100}	5.88a	3.48b	1.78a	0.56b	0.39b	0.09b	6.30b	98.51a	0.14b	1.92b	25.21b	17.81b	15.22b	2.73a	2.72a
F_{200}	5.91a	3.68a	1.80a	0.59a	0.40a	0.09b	6.58a	98.61a	0.14b	2.02a	25.64b	18.52a	15.71b	2.84a	2.76a

Means with the same letter in a column are not significantly different at ($p>0.05$).
P_5 = 5 t ha^{-1}, P_{10} = 10 t ha^{-1}, CP_5 = 5 t ha^{-1}, CP_{10} = 10 t ha^{-1}, F_{100} = 100 kg ha^{-1} NPK fertilizer, F_{200} = 200 kg ha^{-1} NPK fertilizer.
Trt = Treatment, Ex. AC. = Exchangeable acidity, ECEC = Effective cation exchange capacity, Base sat = Base saturation, Total organic C = Total organic carbon, Av. P = Available phosphorus

Table 7: Relative Effects of Poultry Manure, Cocoa Pod Husk, NPK 15:15:15 Fertilizer on Soil Chemical Properties (2020 cropping season)

Trt (t/ha)	pH	Ca	Mg	K	Na	Ex.Ac.	ECEC	Base Sat.	Total N %	Total Org. C	Av.P	Mu	Fe Mg/kg	Cu	Zn
		Cmol/kg													
Control	5.69b	3.29c	1.72c	0.48d	0.41a	0.10a	6.00c	94.68a	0.10d	1.62c	15.12d	17.80a	14.72a	2.68a	2.75a
PM_5	5.97b	3.61b	1.82a	0.58b	0.41a	0.10a	6.52b	98.44a	0.12c	1.92b	24.66b	17.73a	14.92a	2.68a	2.64a
PM_{10}	6.44a	3.97a	1.87a	0.63a	0.40a	0.08c	6.65a	98.83a	0.13b	2.13a	28.51a	15.88b	13.82b	2.59a	2.50b
CP_5	6.29a	3.84a	1.84b	0.62a	0.41a	0.09b	6.79a	98.66a	0.13b	1.96b	23.92b	16.15b	14.10a	2.60a	2.54b
CP_{10}	6.28a	3.95a	1.91a	0.63a	0.43a	0.09b	7.00a	98.71a	0.14a	2.13a	28.54a	15.68b	13.98b	2.48b	2.47b
F_{100}	5.85b	3.61b	1.75b	0.52c	0.40b	0.09b	6.38b	98.47a	0.10d	1.80b	22.43c	16.43b	14.92a	2.56a	2.62a
F_{200}	5.78b	3.63b	1.86a	0.59b	0.41a	0.09b	6.57b	98.56a	0.11c	2.00a	20.61c	17.41a	13.62b	2.67a	2.67a

Means with the same letter in a column are not significantly different at ($p>0.05$).
P_5 = 5 t ha^{-1}MP, P_{10} = 10 t ha^{-1}PM, CP_5 = 5 t ha^{-1}CPH, CP_{10} = 10 t ha^{-1}CPH, F_{100} = 100 kg ha^{-1} NPK fertilizer, F_{200} = 200 kg ha^{-1} NPK fertilizer.
Trt = Treatment, Ex. AC. = Exchangeable acidity, ECEC = Effective cation exchange capacity, Base sat = Base saturation, Total organic C = Total organic carbon, Av. P = Available phosphorus.

Discussion

The sandy nature of the soil at the site of the experiments could have led to the leaching of the essential soil nutrients. Sandy textured soils are susceptible to high leaching, which was probably responsible for the low nutrient status of the soil at the site of the experiments. Based on the critical level of nutrients established for arable crop production in southwestern Nigeria by Aduayi *et al*. (2002), the soil at the site of the field experiment is deficient in N, P, K, Ca, Mg and Organic

carbon, but high in micronutrients. Therefore, a supplementary supply of plant nutrients from external sources would enhance optimum performance of carrots in the studied soil.

The positive response of carrot growth parameters in plots amended with PM, CPH, and NPK fertilizer could be due to the nutrients supplied to the soil by these soil amendments. The result conforms with the finding obtained by Alice *et al.* (2014) that organic and inorganic fertilizer application had a significant influence on the growth parameter of carrots. The low carrot growth parameters in the control plots imply that supplementary nutrients from external sources will enhance growth and yield of carrot. Improvements in the growth parameters of carrots obtained in the second cropping season in plots amended with PM and CPH could be due to the residual effects of PM and CPH. These agree with the view of Zingore *et al.* (2007) that the value of organic manures as bio-fertilizers extends considerably beyond the first year of application. The high response of carrot growth to NPK fertilizer in the first cropping season might be due to the high concentration and readily available forms of N, P, and K in the fertilizer. Also, reductions in the growth parameters during the second cropping season might be a result of exhaustion and leaching of the applied nutrients attributed to the sandy nature of the soil at the site of the field experiment. The yield parameters of carrots increased with the increasing levels of PM, CPH, and NPK fertilizer. This positive response of carrots in terms of root yield might probably be due to the low initial nutrient status of the experimental soil and the nutrients released to the soil by the inputs. The results conform with the finding of Idem *et al*. (2012) that crops respond more to fertilizer application in soils with extreme low nutrient content than in soils of high nutrient reserve. The reductions in yield parameters of carrots in the second cropping season in plots amended with NPK fertilizer in the first cropping season is an indication that NPK fertilizer does not enhance sustainable carrot production sustainably due to its poor residual effect and its adverse effect of increasing soil acidity. In contrast, improvements in root yield parameters of carrots in plots amended with PM and CPH at the second cropping season imply that they can sustain improved carrot root yield and soil productivity overtime. These observations conform with the results reported by Zakir *et al.* (2016) and Rahman *et al.* (2018) that the fertilizer efficiency of organic manures is more lasting than the inorganic fertilizer.

The percentage of malformed roots increased with increasing levels of the inputs, and deformed roots might be due to the improved soil moisture and nutrient contents of the amended plots. The

improved moisture and nutrient contents might be responsible for the enhanced biological activities in the soil, which might be responsible for the increased percentage of malformed roots. This view is in line with the finding of Khairul *et al.* (2015) that the percentage of rotten roots increased due to higher N levels in organic manure amended plots. The reduction in the percentage of malformed roots at the second cropping season compared with the first cropping season might be attributed to the low soil moisture content as a result of the low rainfall in the July and August 2020 cropping season as against relatively high rainfall in July and August 2019 cropping season. Reduction in percentage of malformed roots might be because no treatment was applied in the second cropping season. This view is in line with the report of Alice *et al.* (2014) that too much water in the soil during the period of root expansion suppressed the storage root enlargement of carrots. The low root yield (15.46 – 22.85 t ha^{-1}) obtained in the study compared with the reported root yield range of 30-60 t ha^{-1} in Europe (WCM, 2013) might be attributed to the conditions including low initial nutrients status, acidic nature of the soil of the experimental site and the high monthly temperature range of 24.12 – 26.12^{0}C during the growing period of carrot (May – September). The influence of temperature on the root growth of carrots is critical. Hailu *et al.* (2008) and Alarm *et al.* (2010) documented that temperature above 25^{0}C limit carrot root yield and favour shoot growth than storage root growth. The favourable comparison between carrot root yield in organic manured plots and NPK-treated plots in the first cropping season might partly be due to the balance of nutrition provided by the organic manures. In support of this view, Ahmed *et al.* (2014) and Khairul *et al.* (2015) attributed the better performance of carrots in organic manured plots to the balanced nutrition provided by the manure.

The improvements in the leaf N, P, K, Mg, and Ca in plots amended with PM and CPH in the second cropping season could be attributed to their residual effect. This view agrees with the finding of Eghball *et al.* (2004) that organic manure helps in the gradual release of its nutrients into the soil, while the low leaf N, P, and K in the second cropping season in plots amended with NPK fertilizer in the first cropping season could be because these nutrients leached down the soil profile. Therefore, NPK fertilizer could not guarantee carrot production on a sustainable basis. Improvement in soil pH, total N, total organic carbon, available P, exchangeable bases, reductions in exchangeable acidity, and the micronutrients in plots amended with PM and CPH could be related to the nutrient composition of PM and CPH. In support of this view, Iremiren and Ipinmoroti (2014) and Iradhatullah *et al*. (2014) have reported that PM and CPH are composed of high-nutrient elements that are available for the growth of crops when added to the soil. These improvements in

nutrient status imply that they are suitable soil fertilizer management for the sustainable production of carrots. In support of this view, Akanbi *et al*. (2014) found that CPH increased soil pH, N, P, Ca, and Mg, and reduced micronutrients. Also, Akande and Adediran (2004) found that poultry manure significantly increased soil pH, N, P, K, Mg, and Ca. The improvements in nutrient status in the second cropping season in plots previously amended with PM and CPH in the first cropping season could be attributed to the slow release of nutrients from the organic manures that prevented the nutrients from being leached down the soil profile. Hence, PM and CPH have a significant residual effect on soil fertility status. In support of this view, Adeoye *et al*. (2008) observed that organic manures provide nutrients slowly but maintain uniformity of supplying available nutrients throughout the growing season and have a residual effect on the soil nutrient status. Reductions in exchangeable K, total N, and available P in plots amended with NPK fertilizer in the previous cropping season could be due to the rapid rate of mineralization of NPK fertilizer that might have enhanced the rapid rate of nutrients release to the soil and their subsequent loss through leaching.

The higher soil pH in plots amended with PM and CPH might partly be due to the calcium supplied to the soil by the PM and CPH, making them suitable liming materials. In support of this, recent studies have shown that PM and CPH increased soil pH, organic carbon, N, P, and CEC (Mbah and Mbagwu, 2006; Ayeni *et al*., 2008). The lower soil pH in plots amended with NPK fertilizer might be attributed to the acid-producing N and P components of ammonium and sulphur contents of the materials in the formulation of NPK 15:15:15 fertilizer. This view conforms with the report of Azizi *et al*. (2016) that as the ammonium N in ammonium-based nitrogen fertilizer undergoes nitrification, hydrogen ions are released, resulting in increased soil acidity.

Conclusion

The findings in this study indicated that poultry manure and cocoa pod husk as bio-fertilizer enhance soil nutrient status, growth, and root yield of carrots on a long term basis than NPK 15:15:15 fertilizer. Therefore, these cheap and locally available organic wastes could replace the high cost and scarce mineral fertilizers in enhancing soil productivity and carrot production in the rainforest agro-ecological zone of southwest Nigeria.

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