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Feeding processed Vitamin A cassava root meals to broiler chickens: performance characteristics, blood indices and antioxidative status

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Abstract: The emerging effects of climate change and the increasing cost and scarcity of grains and other essential feed ingredients have been a major challenge to producers, especially in the tropics and subtropics. To tackle this challenge, other cheap and available alternatives are being explored. This study evaluates the performance of broiler finisher chickens fed different processed cassava UMUCASS 36 (rich in vitamin A) root meals (PCRM) as a substitute for maize (11% protein and over 5% vit. A) in the diets of 108 Arbor Acre (starter) finisher chickens for 21 days. Six diets were formulated and the test diet was supplemented to the birds as partial and whole. The birds were fed T1 as the control, T2 had 25% each of oven-dried and sun-dried cassava root meal, T3 had 25% maize and 25% oven-dried cassava root meal, T4 had 25% maize and 25% sun-dried cassava root meal. In comparison, T5 had only 50% oven-dried cassava root meal, and T6 also had only 50% sun-dried cassava root meal, respectively. Data were collected on the performance characteristics, blood indices, and serum antioxidants of the birds. Performance characteristics of the birds revealed with T4 recorded significant ($p<0.05$) values of 2722.32g, 1559.62g, and 1.61 final weight, weight gain, and FCR, respectively, compared to the results of all other treatments. All test diets did not show any adverse effect on the hematology and serum biochemistry of the birds when compared to the control (0% inclusion level). However, on the serum antioxidant status, T5 and T6 showed better values on the Aspartate aminotransferase and Alanine aminotransferase of the birds. The result on superoxide dismutase and malondialdehyde of the birds revealed that T4 and T6 recorded statistically significant (0.01) higher and lower values respectively. It was concluded that broiler finisher chickens could be fed up to 50% processed cassava root meal showing no acute detrimental effects. More studies are needed to demonstrate the potency of the replacement of maize using processed vitamin A cassava root meal in the diet of broiler chicken.

Keywords: Antioxidant status, blood profile, broiler finisher chickens, performance characteristics, and processed cassava root meal (PCRM).

1. Introduction

Globally, livestock production has been severely faced with several challenges such as climate change and covid-19 pandemic (Obakanurhe et al., 2022). In Africa, especially the Sub-Sahara countries which include Nigeria, animal health and production are impacted negatively by climate change, in addition to feed and water availability. The processing, storing, moving, selling, and consumption of livestock products are all impacted by climate change. Also, the increasing hikes in grains recently have led to the closure of some farms, and migration and have affected farmers' livelihood due to the growing demand for livestock products (Akpodiete *et al.,* 2014; Ofuoku et al., 2016). Animal nutritionists are posed with these challenges to mitigate and proffer possible solutions for the sustainability of the livestock industry.

Cassava (*Manihot esculenta*) is among the energy-feed resources and has been utilized extensively by humans and animals (Tonukari et al., 2015). The plant is a root tuber crop that can thrive on most West African country's soils. The plant can be harvested at 6 months - 1 year at maturity. Several varieties are grown which largely depends on their usage. Some are used as by-products because of the starchy content, while some are as delicacies in our various traditions. The leaves and peels are also nutritious to ruminants and non-ruminants if processed. The root tuber contains some significant quantities of energy, protein, minerals, vitamins, anti-nutritional factors, HCN, and some nutrients.

The UMUCASS 36 cassava root meals had a significant amount of Vitamin A with a maturity time of 6 months. The peculiarity of Vitamin A content, reduced HNC content, improved shelf life, and pro-vitamin A is exceptional in the different varieties.

Vitamin A is an unsaturated monohydric alcohol and it is water-insoluble but fat-soluble because of its metabolites. Its biological functions include; eyesight maintenance, growth and development of cells, antioxidant and improved immune responses, and epithelial and mucous tissue integrity. It is attached to diverse specialized binding protein cells. Most plants contain significant quantities of natural carotenoids that form retinol (Vitamin A) through an enzymatic reaction to form pro-vitamin. Several authors have recognized the efficacy of it in poultry production and better improved their health status. The present study investigated the feeding of processed cassava Vitamin A on the performance, blood indices, and antioxidant status of broiler chicken.

2. Materials Methods

2.1. Experimental location

The experiment location was the poultry unit, Department of Animal Production, Dennis Osadebay University, Anwai, Delta State, Nigeria. The poultry house is located at latitude 06.14°N and longitude 06.49°E with an annual temperature of 28-33ºC and a rainy season that spread from March – September (1500-1849mm) (Asaba Meteorological Station, 2023). The poultry house is a deep litter system with dwarf-walled that allowed proper ventilation and the pens were separated with nets into 1m x 2m x 3m respectively.

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2.2. Ethical Approval

This experiment was approved by the Department Board of Studies on the various guidelines on livestock production with file no: 20012/023, Department of Animal Production, Dennis Osadebay University, Anwai, Asaba, Delta State Nigeria.

2.3. Experimental ingredient

The UMUCASS 36 (vitamin A) cassava variety was identified by the Agronomy Department, and the tubers were harvested at 25 weeks old.

2.4. Cassava root processing

The tubers were peeled, washed to remove impurities, and sliced into chips before the various processing methods. The cassava chips were divided into two where one was processed using the oven at 60 ºC for 10 hours while the other was processed by sun-drying it on a flat shelve for 5 days. The processed cassava meals were ground separately before being incorporated with other ingredients to formulate the birds' diets.

2.5. Experimental animals and design

A total of 108 Arbor acre birds of 21-day old with an average mean weight of 1254.58g was used. The birds were randomly allotted into six diets and replicated thrice with six birds. The test diets were fed as whole or partial replacement to maize. The birds were fed T1 as the control, T2 had 50% each of oven-dried and sun-dried CRM, T3 had 50% maize and 50% oven-dried CRM, T4 had 50% maize and 50% sun-dried CRM while T5 had only 100% oven-dried CRM and T6 also had only 100% sun-dried CRM respectively Table 1.

Feedstuff	T1	T2	T3	T4	T5	T6
Maize	55.00	---	27.50	27.50	---	---
Oven-dried cassava	---	27.50	27.50	---	55.00	---
Sun dried cassava	---	27.50	---	27.50	---	55.00
Soyabean meal	18.00	18.00	18.00	18.00	18.00	18.00
Groundnut cake	12.00	12.00	12.00	12.00	12.00	12.00
Wheat bran	14.00	14.00	14.00	14.00	14.00	14.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	2.00	2.00	2.00	2.00	2.00	2.00
Lysine	0.50	0.50	0.50	0.50	0.50	0.50
Methionine	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Premix	0.30	0.30	0.30	0.30	0.30	0.30
	100.00	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated values						
Crude protein%	20.02	19.83	20.05	20.02	19.92	19.88
ME(Kcal/kg)	3190.70	3182.30	3199.45	3216.10	3190.33	3192.04
Available phosphate%	0.86	0.86	0.81	0.78	0.74	0.80
Calcium%	1.87	1.83	1.78	1.82	1.88	1.84
Fat%	2.67	2.56	2.44	2.55	2.35	2.42
Crude fibre%	5.44	5.70	6.50	5.88	6.12	6.22

Table 1 – Percentage composition of broiler finisher chickens diets.

2.6. Proximate analysis of cassava root meals

The department laboratory at Dennis Osadebay University, Anwai, Asaba received samples of cassava root meals for proximate analysis by AOAC's (2015) guidelines. Using the method described by Okpara et al. (2022), the hydrogen cyanide (HCN) content was also examined.

2.7. Blood indices and antioxidant status of birds

Three birds from each replicate were selected on day 42 according to their weight about the mean group weight, labeled, and fasted for seven hours. These birds' jugular veins were used to collect blood samples with syringes, which were then put in the labeled EDTH and unlabeled sample vials. The EDTH bottles were centrifuged at 3000 rpm for 10 minutes to analyze hematological parameters and blood serum and serum antioxidant enzymes were also examined according to Davis and Lewis (1991). The concentrations of serum catalase (CAT), glutathione peroxidize (GPx), and superoxide dismutases (SOD) were calculated using the procedures provided by the manufacturer respectively. A Reflectron Plus 8C79 (Roche Diagnostic, GombH Mannheim, Germany), was used to determine serum biochemical concentrations (total protein, albumin, globulin, aspartate aminotransferase (AST), alanine aminotransferase (ALT), creatinine, cholesterol, and glucose). By using the Jo and Ahn (1998) method, the malondialdehyde (MDA) concentration was assessed.

2.8. Data Collection and Analysis

Performance characteristics of broiler finisher chickens were collected on weight gain, final weight, feed intake, and FCR. Data were also collected on the blood indices and the antioxidant status of the birds at 42 days old. A one-way ANOVA (SPSS 23) was used to evaluate the data collected in a completely randomized design and Duncan Multiple Range Test was used to distinguish the means.

3. Results

The results on the proximate composition of cassava root meals showed that moisture, dry matter, crude protein, crude fiber, ash, and ether extract on oven-dry were 8.79, 27.47, 4.25, 3.68, 3.48, and 0.60%, and sun-dry revealed 7.39, 29.10, 3.85, 4.08, 2.63, and 0.44% respectively. Also, nitrogen-free extract, HCN, and energy on sun-dry and oven-dry cassava meals were 47.73%, 3.15mg/100g and 2942kcal/kg and 48.51%, 2.84mg/100g and 2958kcal/kg.

Proximate (%)	**Oven-dried**	**Sun-dry**
Moisture (%)	8.79	7.39
Dry matter (%)	27.47	29.10
Crude protein (%)	4.25	3.85
Crude fibre (%)	3.68	4.08
Ash (%)	3.48	2.63
Ether extract (%)	0.60	0.44
Nitrogen-free extract (%)	47.73	48.51
HCN (mg/100g)	3.15	2.84
Energy kcal/kg	2,942	2,958

Table 2 – Proximate composition of cassava root tuber (Vitamin A variety).

Table 3 shows the performance of birds on processed cassava root meals. The birds' final weight and weight gain showed on T4 (2722.32g and 1554.62g) was significantly ($p>0.05$) different in comparison to the other groups. The result on feed intake revealed that T2 had a superior value (2554.09g) compared to T1 whose value (2547.63g) was different from T5 and T6 which were statistically similar.

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	SEM	P value
Initial weight (g)	1155.75	1157.21	1152.32	1162.70	1160.29	1164.04	32.11	0.00
Final weight (g)	2652.49^{d}	2645.18^{e}	2689.42^{c}	2722.32^{a}	2714.72^{b}	2.673.12	87.44	0.02
Weight gain (g)	1526.74^{d}	1537.97^{c}	1542.42^{c}	1559.62^{a}	1554.43^{b}	1529.08^{d}	37.02	0.01
Feed intake (g)	2547.63^{b}	2554.09^{a}	2528.48^{d}	2512.94^{d}	2535.94^{c}	2536.11^{c}	82.16	0.05
FCR	1.72^{d}	1.66^{c}	1.64^{b}	1.61^{a}	1.63^{b}	1.66^{c}	0.04	0.02

Table 3 – Performance characteristics of broiler finisher chickens fed experimental diets.

Results on hematology parameters of birds fed experimental diets Table 4 revealed no significant ($p<0.05$) differences. Although some numerical differences exist among the parameters measured.

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**SEM**	**P value**
Hb (g/dL)	14.84	12.33	14.26	11.59	12.35	12.41	5.02	14.20
PCV (%)	23.04	21.41	22.48	24.07	22.22	24.81	10.03	1.25
RBC (x 10^6/mm^3)	12.64	10.72	11.05	14.42	12.67	11.75	7.11	4.11
WBC (x 10^3/mm^3)	101.22	105.83	104.61	105.52	103.18	100.05	22.53	0.31
MCV (fl)	144.54	138.02	138.73	140.66	138.84	137.64	15.03	0,65
MCH (pg)	78.80	72.54	74.11	76.61	73.05	74.28	10.72	10.05
MCHC (g/dl)	52.71	48.22	47.89	50.83	48.20	48.72	14.06	0.21
Creatinine (mg/dL)	0.46	0.42	0.45	0.44	0.44	0.45	0.03	0.38
Uric acid (μmol/L)	411.2	414.5	415.1	413.2	414.4	413.1	24.21	0.50
Urea (mmol/L)	5.40	5.44	5.42	5.43	5.46	5.42	0.05	0.07
TP (g/dL)	5.61	5.50	5.57	5.68	5.48	5.47	0.08	0.09
ALB (g/dL)	1.95	1.89	1.93	1.98	1.90	1.91	0.04	0.12
GLO (g/dL)	1.66	1.61	1.64	1.70	1.58	1.56	0.06	0.14
AST (U/L)	99.11	97.44	94.51	92.69	92.10	90.40	2.50	0.10

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ALT (U/L)	22.23	20.50	21.01	19.14	17.62	17.74	0.55	0.33
CAT (µ/mg)	14.32	11.22	14.54	16.04	15.82	12.16	0.82	0.05
GPx (U/g Hb)	22.10	18.80	20.01	17.20	19.10	15.40	0.59	0.01
SOD (U/g Hb)	85.20	75.21	72.64	90.27	78.10	69.06	0.79	0.02
MDA (µmol/L)	2.12[a]	1.62[c]	1.77[b]	1.65[c]	1.54[d]	1.34[e]	0.21	0.01

Table 4 – Blood profile of Broilers finisher chickens fed experimental diets.

Obs.: a, b, c, d: Treatment means with different superscripts within the same row are significantly not different at P>0.05; SEM = Standard error of the mean; NS = Not significant. Aspartate aminotransferase (AST), Alanine aminotransferase (ALT), catalase (CAT), glutathione peroxidase (GPx), superoxide dismutase (SOD), malondialdehyde (MDA).

4. Discussion

The recorded values on moisture content showed slight differences with separate values (7.31 - 7.55%) recorded by Okpara et al., 2022 in Nigeria, 5.43–10.87% in Uganda (Manano et al., 2017), and 10.43–11.76% in Zambia (Chisenga et al., 2020). However, these discrepancies could be attributed to the varieties, age at harvest, and other ecological factors. The recorded protein content (3.85 and 4.25%) was slightly comparable to values (2.42 and 2.03%) and 1.21-1.87% reported by Okpara et al., (2022) and Emmanuel et al. (2012) in Nigeria. However, the research values differ from 0.74-1.52% and 1.21-1.87% published by Mangano et al. (2017) and Chisenga et al. (2020). These observed discrepancies could be explained by soil nitrogen and fertility (Agiriga and Iwe, 2016). The values (0.62 and 0.44) on ether extract were comparable to the several authors' results 0.1-0.3, 0.74-1.49, 0.15-0.63, and 0.73 and 0.62% (Charles et al., 2004; Somendrika et al., 2016; Chisenga et al., 2020, Obakanurhe et al., 2022 and Okpara et al., 2022). The higher values documented on ash content could be attributed to the variety and processing techniques while the values recorded on crude fiber were comparable to separate values (3.50% and 4.70%) documented by Okpara et al., 2022 but in contrast to different research carried out by (Sudhir et al., 2019; Chisenga et al., 2020).

The increased feed intake on the test diets revealed the simulation of the GIT through various enzymatic functions of Vitamin A in the diets. Some researchers have demonstrated that poultry could be fed up to 50% cassava root meal without preventing them from gaining weight (Bakare et al., 2021). According to Okpara et al. (2022), birds on higher inclusion of cassava root meal diets recorded significant weight gain and better FCR.

Several authors have documented that poultry significantly converts β-carotene to vitamin A. Since the precursors of vitamin A are present within the diet, the body's ability to absorb them depends on feed intake and GIT absorption. When employing processed cassava root tuber meals in chicken production, some researchers have documented no negative effects (Bakare et al., 2021; Okpara et al., 2022). However, T4 outperformed oven-dried cassava meal and maize diet in terms of feed intake, weight increase, and FCR. This significant weight gain recorded could be attributed to the increased CP (Chrystal et al., 2020; Saleh et al., 2021) and ME (Abu Hafsa et al., 2020) concentrations which have been demonstrated to improve bird's weight gain, for muscles growth. Several researchers have observed higher vitamin A intakes led to broilers' higher weight gain and improved general performance (Khoramabadi et al., 2014; Langi et al., 2018; Zhu et al., 2018). According to previous research, processing techniques including heating and sun-drying decreased the cyanide level of cassava up to 95%, making it more suitable for incorporation in chicken feeds (Oke 1996; Nweke and Ezuma 1998). It has been observed that at heat stress, Vitamin A is impaired, poor immune system, and the nutrient requirement of the birds is affected. The better FCR of birds fed processed cassava root meals was T4. The higher performances of the birds on T4 and T5 may be due to the diets' less coarse makeup and lower cyanide levels.

According to Mitruka and Rawnsley (1977) and Schalm et al. (1975), the PCV levels from this investigation were within the typical range of 22-25% for chickens that appeared to be in good health. The PCV results indicate no anemic status. The Hb values recorded were within the range reported by several authors that opined the nutritive potentials of diets and improved immune status of birds Adejumo (2004). Hb aids the movement of oxygen from the lungs down the veins to various body regions till it circulates to break down nutrients and produce energy for bodily functions. The critical biological processes of growth, development, reproduction, and other productive functions may be hindered or diminished due to a decline in hemoglobin (Hb), a symptom of a reduction in nutrition metabolism and utilization. The RBC and WBC values (10.72-14.42 x 10^6/mm^3 and 100.05 – 105.52 x 10^3/mm^3) recorded were within the normal range of healthy birds. These results reported are similar to an earlier study on RBC but slightly different from the WBC results reported by Okpara et al., 2022. Their report where processed cassava root tuber was assigned to birds revealed that birds showed no deteriorating effects. The discrepancy observed in the WBC values could be adjudged to higher inclusion levels. In comparison to T1, the birds that consumed the test meals did not possess significantly greater urea levels (p>0.05). This implies that kidney damage from hydrogen cyanide or other toxic compounds was not caused by the meal, most likely because the right amount was produced during fermentation. According to Ibrahim *et al.* (2020) and Natarajan et al. (2023), high serum urea levels may signal a higher activity of specific enzymes or kidney impairment brought on by an infection or tissue damage. Table 4 showed that the creatinine values of the birds on the test diets were not substantially (p>0.05) different from T1. The increased creatinine concentration is indicative of metabolic processes that commonly occur as the birds develop that trigger muscle injury and disintegration. These findings, however, are in line with earlier studies by Ahamefule *et al.* (2006) who likewise recorded values within the normal range and reported no significant rise in creatinine levels. The processed cassava root meal revealed no significant (p<0.05) differences in the birds' serum parameters on processed cassava root meals recorded. All the test groups of birds had comparable blood levels of the liver enzymes ALT and AST.

Table 4 shows the anti-oxidative enzyme activity of breast meat of the bird assigned to experimental diets at various inclusion levels. Treatment meals had a statistically significant ($p>0.05$) positive impact on all of the anti-oxidative enzyme activity parameters that were examined. The SOD, GPx, and CAT values revealed significant ($p<0.05$) differences across the treatments. The SOD, GPx, and CAT are examples of oxidative stress parameters that serve as important indicators for determining the level of oxidative stress. MDA is a biomarker of oxidative stress that is extensively utilized. The result on the SOD and MDA of the birds revealed that T4 and T6 recorded higher and lower values. These results could be adjudged that the test diet poses no stress but improves the oxidative status of the birds to convert the required nutrients into weight gain. The carotenoid content in the test diets was observed to be responsible for retarding the oxidation of lipids in both raw and cooked meat by reducing MDA formation (Qaisrani et al., 2015). However, there has been scanty research on the use of this variety of cassava root meal on birds MDA.

5. Conclusion

Birds on experimental diets showed significant weight gain with improved FCR. Also, the test diet revealed a significant effect of vitamin A as an antioxidant on the oxidative status of the chicken meat. It was noticed that birds were fed up to 100% processed vitamin A cassava root meals without any adverse effects.

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