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Carcass Characteristics and Organ Weights of Finisher Broiler Chickens Fed Pelletized Diets Containing Different Inclusion Levels of Sundried Cassava (*Manihot esculenta* Crantz) Peels

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Abstract

The study objective was to examine the impacts of pelletized diets which include varying inclusion levels of cassava peels on the carcass characteristics and organ weights of broiler chickens. The study used ninety (90) unsexed day-old Cobb 500 broiler chicks which were randomly assigned to three (3) dietary treatments (T1, T2 and T3) containing 0, 10 and 20% of sun-dried cassava peels respectively as partial substitution for maize with Treatment 1 as the control. Each treatment was replicated three times consisting of 10 birds each in a Completely Randomized Design (CRD). The birds were reared for eight weeks. At week 8, the birds were starved overnight and slaughtered. Data were collected on carcass characteristics and organ weight parameters which included final live weight, eviscerated weight, dressed weight, weights of various cut parts such as head, shank, thighs, wings, neck, breast, back and drumstick. The results revealed that head and thigh weights were significantly (p<0.05) different at 20% inclusion of cassava peel with other carcass traits parameters not having any significant difference (p>0.05) through all treatments. Numerically, broilers fed 10% inclusion of cassava peels recorded the highest values in all parameters with the exception of live weight, breast weight and drumstick weight. However, organ weights were not significantly different (p>0.05) across all treatments. The study concludes that ten percent inclusion of sun-dried cassava peel is potentially the best option in terms of overall meat yield. The inclusion of sundried cassava peels at 10% in broiler diets can improve the carcass yield while a higher inclusion rate (20%) may adversely affect these outcomes.

Keywords: Carcass traits; Organ weights; Finisher broiler chicken; Pellets; Sun-dried Cassava peel

Introduction: The cost of feeding poultry birds accounts for about 70% total cost of production (Babiker *at al*., 2009, Makinde *at al*., 2014). Maize, which is the main energy source in poultry ration contributes about 50 % in poultry feeds (Skinner *at al*., 1992; Van der Klis *at al*., 2010). There is a wide gap between the supply and demand of the ingredients needed to formulate nutritious diet. Most of the ingredients are imported to Nigeria and therefore resulting into high price especially maize. Maize in particular is needed by man and animals thereby necessitating the need for alternatives. The only solution to meet the increasing demand for the supply of energy-based ingredients is by turning to the use of agro-industrial by-products. FAO (2014) reported on the potential utilization of agro-industrial by-products as ingredients capable of reducing feed cost for poultry production. One of the agro-industrial by-products with inherent nutrients to replace maize in livestock feed is cassava peel and was estimated to be about 15 million MT in Africa in 2015 (Okike *at al*., 2015). Cassava (*Manihot esculenta* Crantz) is an important common food for many Nigerians aside from its use as livestock feed, hence, having the potential to promote the economic development and provide food security (Chidozie *at al*., 2019). Cassava is produced in large quantities in Nigeria and its tuber products are consumed for food by animals and humans in sub-Saharan Africa (Ayasan, 2010). Most of the products from cassava did not contain its peels which are usually discarded contributing about 13% of the tuber (Omotosho and Sangodoyin, 2013). The cassava peels which are usually discarded can serve as locally available alternative feed resources that can replace at a cheaper cost without any adverse effect on the production and performance of birds. (De Vries *at al*. 2012; Oladimeji *at al*., 2019). Cassava peel is derived from the processing of cassava tuber to starch. It is a thin fibrous epicarp covering, usually having some cassava root tuber pieces in their lining, which contains about 20% of the tuber (Onyimonyi and Ugwu, 2007). Cassava peel poses a major disposal problem which can be adequately taken care of if exploited properly by biotechnological systems and its use as animal feed (Fasae *at al*., 2007; Onyeonagu and Njoku, 2010) both for the ruminant and non-ruminant animals. It has also served as a major supplementary feedstuff for feeding sheep and goats in most rural communities in Nigeria, despite its limitation of lower crude protein content and poorer methods of conservation and storage that further reduces their nutritional quality.

Cassava peel does not pose a competition problem between humans and animals. If well processed, it will reduce the cost of feeding, increase the gross income of farmers and in the long run increase the consumption of animal-based protein in Nigeria. Cassava peel has helped in reducing cost of feeding in ruminants and pigs for many years (Egbunike *et al*., 2009; Adesehinwa *et al*., 2016). Cassava peel use is limited by its low protein content, large amount of cyanogenic glycoside, phytate and its quick spoilage if left unprocessed (Ogunwole *et al*., 2017; Omode *et al*., 2018). Many studies have been conducted to overcome these constraints while sun-drying remains the most effective method of detoxifying cassava peel (Adeyemo and Sani, 2013; Abu *at al*., 2015).

The production of large quantities of underutilized residues from cassava currently increasing due to the demand for cassava for household and industrial use. Most of these residues are allowed to be wasted which resulted to losses of food and nutrition, and also leads to generation of environmental problems, including the production of greenhouse gases (Latif and Müller, 2015). As a result, proper processing of cassava residues is essential to diminish the toxic compounds and antinutrients to a safe limit for utilization.

Cassava leaves and peels in recent times have become an important ingredient in sheep and goat feeds. This depends largely on its high availability and a progressive demand for alternative energy sources for ruminant production as its effectiveness has been shown to reduce cost of feeding (Fasae *at al*., 2015). These residues are sources of nutrients such as carbohydrates, proteins, vitamins, minerals and phytochemicals of great importance for health and nutrition (Wanapat and Kang, 2013).

Cassava has many essential nutrients. The leaves and roots contain an enormous amount of certain minerals, proteins, amino acids, vitamins, and other nutrients. The root part of the cassava contains 25% to 35% of carbohydrates of fresh weight. The calcium content of the root is higher than many staples (Montagnac *at al*., 2009). Cassava roots contain higher amounts of amino acids like arginine, glutamic acid, and aspartic acid than many tubers (Bayata, 2019). The carbohydrate content of the roots contains small amounts of fructose, sucrose, glucose, and maltose. Cassava roots contain high amount of essential minerals such as iron, calcium, magnesium, potassium, zinc, copper, and manganese. Cassava roots are very low in B vitamins, including riboflavin, thiamine, and niacin but very rich in Vitamin C ranging between 15 to 45 mg per 100g edible portions (Okigbo, 1980). Cassava peel is the major energy based alternative agro-waste product that can effectively replace maize and also reduce cost of production incurred on feeding. The specific intention of this study was to assess the carcass traits and organ weights of broiler chickens fed pelletized feeds containing varying inclusion levels of cassava peels at finisher phase.

Materials and Methods: Description of study area: The study was done at the Poultry Unit of the Teaching and Research Farm, Olusegun Agagu University of Science and Technology (OAUSTECH), Okitipupa, Ondo State, Nigeria. OAUSTECH is found within the rainforest region of Latitude 5º 28' N and longitude 4º 46' E at an elevation of about 200 m above sea level.

Source of experimental materials: The cassava peels used in the experiment were sourced from a cassava processing plant in Okitipupa Local Government Area, Ondo state. Other feed ingredients like maize, soybean meal, wheat offals, groundnut cake, bone meal, premix, methionine, oyster shell and fishmeal were purchased from a feed mill in Okitipupa, Ondo State. The broiler chicks were obtained from Zartech farm, Ibadan, Oyo State.

Experimental birds and management: A total of 90 cobb day old chicks were obtained from Zartech farm. The experimental birds were housed in deep litter system. The experiment was done for nine weeks. The birds had Light for 24 hours daily, while feed and clean drinking water were provided ad libitum throughout the period of the study. Prior to the arrival of the birds, the brooding house was subjected to thorough washing and disinfection using soap and disinfectant. Drinkers, feeders and other equipment were also cleaned and washed. The open side wall of the pen was properly covered with black polythene nylon to avoid heat loss during brooding. On arrival, the chicks were carefully unboxed and put into the brooding house which had previously been heated few hours prior to the arrival of the birds. The birds were fed with the experimental diets *ad-libitum* for two feeding phases (starter phase and finisher phase). Lamps were fixed to serve as sources of light and charcoal stoves were provided to generate heat during the brooding stage. Daily routine management including feeding, supply of water, observation of the birds and record keeping as well as occasional management practices including medication, vaccination and changing of the bedding material (wood shavings) were carried out.

Processing of cassava peels and other feed ingredients:Fresh cassava peels obtained were sun-dried for 5 days. The cassava peels were dried on polythene nylon. The sundried cassava peels were used for feed formulation. The sundried cassava peels, maize and soybean meal were milled using the hammer mill after which they were mixed with all other ingredients and the mixture was conveyed to the pelletizing machine where it was pelletized.

Experimental diets: A total of three (3) dietary treatments (T1, T2 and T3) were formulated for the experiment. Diet 1 (T1) was the control diet with 0% sun-dried cassava peels, diet 2 (T2) contained 10% sun-dried cassava peels while diet 3 (T3) contained 20% sun-dried cassava peels. The cassava peel was included at the same levels (0%,10% and 20%) for both starter and finisher diets.

Duration of the study: The study was conducted for eight (8) weeks. It started on the 1st of February, 2024 and ended on the 28th of March, 2024. The broilers were raised from day-old to eight (8) weeks.

Carcass analysis: After the rearing and feeding trial period, one bird from each replicate was randomly selected and starved overnight. The fasted weights of the selected birds were taken and recorded after which they were slaughtered by cutting the jugular vein with a sharp knife. The slaughtered birds were scalded in warm water for about a minute and manually de-feathered. The carcass was carefully eviscerated and dressed to determine carcass characteristics. Live weight, dressed weight, eviscerated weight were measured and recorded. Organs like empty gizzard, heart, intestine and liver were removed and weighed separately. Carcass cut parts include back, breast, drumstick, head, neck, shank, thigh and wings were cautiously separated and weighed. The dressing percentage was calculated using the formula:

$$\text{Dressing percentage (\%)} = \frac{\text{Dressed weight}}{\text{Live weight}} \times 100$$

Statistical Analysis: Data were analysed by using one-way Analysis of Variance (ANOVA) of Statistical Analysis System (SAS, 2004) and the means were differentiated using Duncan Multiple Range Test of the same software at 5% level of significance.

Results and Discussion: The results of the proximate composition of diets formulated with varying levels of sundried cassava peels replacing maize is presented in table 3. These diets, labeled as T1, T2, and T3, represent different formulations where T1 is the control (100% maize), T2 involves 10% replacement with sundried cassava peel, and T3 involves 20% replacement with sundried cassava peel. The proximate composition includes ash, moisture, ether extract, crude fibre, crude protein, and Nitrogen-Free Extract. Ash content reflects the mineral composition of the diets. The ash content is highest in T3 (11.84%) and lowest in T2 (9.58%), with T1 (10.70%) falling in between. The significant increase in ash content in T3 suggests that the replacement of maize with sundried cassava peel leads to a higher mineral content, possibly due to the mineral-rich nature of cassava peels. This could be beneficial in providing essential minerals to the diet. Moisture content is lowest in T2 (7.07%) and highest in T3 (10.69%), with the overall mean at 8.34%. The increase in moisture content with higher sundried cassava peel inclusion (T3) could indicate that cassava peels retain more water than maize. This might affect the storage and shelf life of the feed, as higher moisture content can lead to spoilage if not managed properly. The ether extract is highest in T2 (8.65%) and lowest in T3 (7.57%). The relatively stable ether extract content across the diets suggests that sundried cassava peel does not significantly alter the fat composition when replacing maize. However, the slight decrease in T3 might indicate a marginal reduction in energy density, as fat is a concentrated energy source. There is a substantial increase in crude fibre content from T1 (6.65%) to T3 (18.69%). The significant increase in crude fibre with higher sundried cassava peel inclusion indicates that cassava peels contribute a higher fibre content than maize. This could have implications for digestibility; while fibre is important for gut health, excessively high fibre content can reduce the digestibility of the diet and the efficiency of nutrient absorption. Oyebimbe *et al.* (2006) investigated that high fibre diets usually tend to hinder protein utilization. Crude protein decreases significantly from T1 (20.40%) to T3 (15.68%). This confirms the findings of Ewa *et al*., (2019). The reduction in protein content with increasing sundried cassava peel levels is a critical observation, as protein is essential for growth and maintenance. Cassava peels likely have lower crude protein content compared to maize, leading to a dilution effect in T2 and T3. This decrease could impact animal performance, particularly in growth and production. Nitrogen-Free Extract is highest in T2 (49.19%) and lowest in T3 (35.55%). The reduction in NFE with increased sundried cassava peel inclusion is expected, as cassava peels are generally lower in starch than maize. This decrease could affect the energy provision of the diet since carbohydrates are a primary energy source. The lower NFE in T3 might require compensatory energy sources to maintain the energy balance of the diet.

The result of the carcass characteristics of broiler chickens fed pelletized diets with varying inclusion levels of cassava peels is presented in Table 4. All the traits were not statistically significant ($p>0.05$) across all treatments except for head and thigh. The values for head and thigh in treatment 3 (T3) were statistically significant ($p<0.05$) from treatments 1 and 2 (T1 and T2). Numerically, birds fed 20% sundried cassava peel recorded the lowest weights in all parameters across all treatments. All carcass traits parameters were not significantly ($p>0.05$) affected by cassava peel inclusion except for head and thigh weights. Live weight decreases as the level of cassava peel increases. T1 (control with 0% inclusion of sun-dried cassava peel) had the highest live weight while T3 (20% inclusion of sun-dried cassava peel) had the lowest. This suggests that higher levels of cassava peel in the diet might not provide sufficient nutrients to support optimal growth in poultry. This could be due to the fibrous nature of cassava peel, which might lower the energy density of the feed or reduce feed intake and nutrient absorption. The eviscerated and dressed weights were highest in T2 (10% cassava peel) and lowest in T3. T2's higher dressed weight suggests that 10% cassava peel might be a viable level that doesn't compromise growth or yield significantly, and may even enhance it slightly. However, the reduction in T3 indicates that too much cassava peel may impair nutrient utilization, leading to less muscle development and lower overall yield. T2 had the highest dressing percentage, while T3 had the lowest. The dressing percentage is an indicator of how much of the live bird weight is converted into carcass weight. A higher dressing percentage in T2 suggests that a moderate inclusion of cassava peel (10%) is beneficial as observed by Ewa *et al*., (2015). However, at 20% cassava peel, the decrease in dressing percentage implies that a larger portion of the bird's weight is non-carcass components (e.g., feathers, offal), likely due to poorer growth and muscle development. Thigh weight is significantly affected by the inclusion of cassava peels which is not in agreement with findings by Ewa *et al*., (2015) Thigh weight was highest in T2, while T3 showed the lowest weight and breast weight was highest in T1 with T3 having the lowest value. The high value in the thigh weight of the control diet is in agreement with studies by Oladimeji e*t al*., (2020) and Abu *et al*., (2015). Thighs and breast are among the most valued parts of poultry. The higher thigh and breast weights in T2 further support the idea that 10% cassava peel can be beneficial. The significant reduction in T3 indicates that excessive cassava peel could lead to reduced muscle development in these areas, possibly because the higher fibre content limits energy and protein availability for growth. Wings, Drumstick and Neck weights followed a similar pattern, with weights being highest in T1 or T2 and lowest in T3. These results reinforce the trend that higher cassava peel content might reduce the overall quality and weight of these parts, likely due to reduced digestibility and nutrient availability. The shank weights were consistent between T1 and T2 but decreased in T3 and head weight was highest in T2. Significant difference ($p<0.05$) was observed in head weight which was also observed by Adekeye *et al*., (2021) when they replaced maize with High Quality Cassava Peels (HCPQ). While these parts (head and shank) are less economically important, their reduction in T3 indicates a general trend of poor growth and development in birds fed with 20% cassava peel. The back weight, which is consistent across treatments, suggests that not all parts are equally affected by dietary changes. The significant reduction in all measured carcass trait parameters in T3 indicates that 20% cassava peel is too high, potentially leading to malnutrition, reduced growth, and poorer overall carcass quality. The fibre content and possible anti-nutritional factors in cassava peel at this level could hinder nutrient absorption and utilization, thereby affecting the birds' development.

The result of the organ weight of broiler chickens fed pelletized diets with varying inclusion levels of cassava peels is shown in Table 5. All parameters show no statistical significance (p>0.05) across the three treatments. Numerically, birds fed 10% cassava peels recorded the lowest values for all parameters except for intestine (98.33g). No organ studied in this work was significantly influenced by dietary inclusion of sundried cassava peel. Similar observation was made by Oladimeji et al., (2020) in their work replacing maize with cassava peel product-based diets and Haladu and Sonaiya, (2017) in their work replacing maize with sorghum, millet or 'acha'. The liver weight decreases as the inclusion level of cassava peel increases. This could suggest that higher levels of cassava peel in the diet may reduce liver size, possibly due to changes in nutrient absorption or metabolism. The heart weight remains the same for T1 and T2 but significantly decreases at the T3 level (20% cassava peel). This might indicate that higher cassava peel inclusion has a negative impact on heart size, potentially due to stress or nutrient limitations. The intestine weight decreases with cassava peel inclusion, particularly in T2. The reduction in intestine weight might suggest changes in digestive efficiency or nutrient absorption with cassava peel diets. The empty gizzard weight increases with the inclusion of cassava peel, particularly at the 10% level (T2). This might indicate an adaptation of the gizzard to the increased fibre content from cassava peels, which could lead to a larger, more muscular gizzard.

Conclusion: This study concludes that cassava peel can be incorporated into poultry diets at an inclusion level of 10%. An increase in the inclusion rate will adversely affect the carcass traits and organ weight of broiler chickens. Inclusion at 10% will have a significant reduction on the cost of production and indirectly maximize the profits made by the farmers from broiler production.

Recommendation: Given the potential nutrient limitations at higher inclusion levels of cassava peel, future studies should investigate fortifying the diet with additional protein, vitamins, or minerals.; Future research could compare cassava peel with other agricultural by-products (e.g., wheat bran, rice bran or maize cobs) to evaluate its relative effectiveness and economic value as a feed ingredient.; While this study focuses on a specific poultry type, further studies should be conducted on other poultry species, such as turkeys, ducks and guinea fowls, to see if the results are consistent.

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Table 1: Gross composition of experimental starter diets.

Ingredient	T1(0%)	T2(10%)	T3(20%)
Cassava peel	0	10	20
Maize	46	36	26
Soybean meal (SBM)	21.1	21.1	19.95
Groundnut cake (GNC)	15	15	15
Fishmeal	2	2	2
Wheat offal	10.95	10.95	11
Bone meal	2	2	2
Oyster shell	2	2	3
Salt	0.25	0.25	0.25
Premix	0.25	0.25	0.25
Methionine	0.2	0.2	0.3
Lysine	0.25	0.25	0.25
Total (kg)	100	100	100

T1=0% cassava peel. T2=10% cassava peel. T3= 20% cassava peel

Table 2: Gross composition of experimental finisher diets.

Ingredient	T1(0%)	T2(10%)	T3(20%)
Cassava peel	0	10	20
Maize	46	36	26
Soybean meal (SBM)	16.1	16.1	14
Groundnut cake (GNC)	13	13	13
Fishmeal	2	2	2
Wheat offal	15.95	15.95	16.95
Bone meal	3	3	3
Oyster shell	3	3	4
Salt	0.25	0.25	0.25
Premix	0.25	0.25	0.25
Methionine	0.2	0.2	0.3
Lysine	0.25	0.25	0.25
Total (kg)	100	100	100

T1= 0% cassava peel. T2= 10% cassava peel. T3= 20% cassava peel

Table 3: Proximate composition of experimental diets

Parameters (%)	T1(0%)	T2(10%)	T3(20%)	SEM	p- value
Ash	10.70^{b}	9.58^{c}	11.83^{a}	0.41	0.0002
Moisture	7.27^{b}	7.07^{b}	10.69^{a}	0.75	0.0009
Ether extract	8.33^{a}	8.65^{a}	7.57^{b}	0.21	0.026
Crude fibre	6.65^{b}	7.93^{b}	18.69^{a}	2.42	0.0003
Crude protein	20.40^{a}	17.60^{b}	15.68^{c}	0.86	0.0001
NFE	46.65^{a}	49.19^{a}	35.55^{b}	2.66	0.0009

^{abc}: Means in the same row with different superscript are significantly different ($p<0.05$)

T1=0% inclusion of cassava peel, T2=10% inclusion of cassava peel, T3= 20% inclusion of cassava peel, SEM= Standard Error of Mean, NFE= Nitrogen Free Extract

Table 4: Carcass characteristics of finisher broiler chickens fed varying inclusion levels of cassava peels

Parameters	T1(10%)	T2(10%)	T3(20%)	SEM	p- value
Final live weight (g)	1350.00	1310.00	1181.00	47.96	0.37
Eviscerated weight (g)	843.33	871.66	738.33	32.91	0.24
Dressed weight (g)	693.33	716.66	606.66	28.18	0.27
Dressing percentage (%)	51.44	54.76	50.43	1.32	0.44
Head (g)	56.66[a]	58.33[a]	46.66[b]	2.32	0.05
Shank (g)	63.33	63.33	58.33	3.11	0.80
Thigh (g)	135.00[a]	138.33[a]	111.67[b]	5.20	0.04
Wing (g)	110.00	111.67	98.33	4.16	0.42
Neck (g)	31.66	33.33	26.66	2.11	0.47
Breast (g)	241.66	226.66	203.33	11.77	0.47
Back (g)	200.00	203.33	200.00	8.88	0.99
Drumstick (g)	133.33	128.33	115.00	6.14	0.52

[ab]: Means in the same row with different superscript are significantly different ($P<0.05$).
T1=0% inclusion of cassava peel. T2=10% inclusion of cassava peel. T3= 20% inclusion of cassava peel. SEM= Standard Error of the Mean

Table 5: Organ weight of finisher broiler chickens fed varying inclusion levels of cassava peels

Parameters	T1(0%)	T2(10%)	T3(20%)	SEM	p- value
Liver (g)	36.66	33.33	25.00	2.88	0.26
Heart (g)	8.33	8.33	5.00	0.87	0.22
Intestine (g)	120.00	93.33	98.33	6.60	0.23
Empty gizzard (g)	23.33	31.66	29.66	1.89	0.17

T1=0% inclusion of cassava peel, T2=10% inclusion of cassava peel, T3= 20% inclusion of cassava peel, SEM= Standard Error of Mean.

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Carcass Characteristics and Organ Weights of Finisher Broiler Chickens Fed Pelletized Diets Containing Different Inclusion Levels of Sundried Cassava (*Manihot esculenta* Crantz) Peels