

Date	Submitted	Accepted	Published
	8 th July 2024	20 th June 2025	5 th September 2025

EFFECTS OF MAIZE SUBSTITUTION WITH CASSAVA FLOUR IN BROILER DIETS ON CARCASS QUALITY AND MEAT CHARACTERISTICS OF BROILER CHICKEN

Tachie-Menson JW¹, Adu EO¹, Lartey GST^{2*},
Gyamera E², Akorli SY², Arko E¹, Kanyelvilaa V³ and S Akaba⁴



Gamaliel Seth Tawiah Lartey

*Corresponding author email: lateyseth00@gmail.com

¹Department of Crop Science, School of Agriculture, University of Cape-Coast, Ghana

²Department of Animal Science, School of Agriculture, University of Cape-Coast, Ghana

³Teaching and Research Farm, School of Agriculture, University of Cape-Coast, Ghana

⁴Department of Agriculture Economics and Extension, School of Agriculture, University of Cape-Coast, Ghana



ABSTRACT

The poultry industry is facing increasing challenges related to feed cost and availability, particularly for the primary component of poultry diets - maize. Fluctuating prices and competition with human consumption have made maize a concern for poultry farmers. This study investigated the effects of substituting maize with cassava flour in broiler chicken diets on growth rate, carcass quality and meat characteristics. A total of six dietary treatments were formulated (0%, 20%, 40%, 60%, 80% and 100%). Proximate analysis of the feed formulations indicated that the dry matter content remained consistent across treatments, ranging from 86.5% to 86.7%, with moisture content varying slightly between 13.31% and 13.48%. Notably, ash content was highest in the T6 formulation, which consisted of 100% cassava, at 6.06%. The crude protein (CP) content varied significantly, with T1 (0% cassava) exhibiting the highest CP level at 25.3%, while T6 had the lowest at 17.2%. Results showed that chicken fed with higher levels of cassava (60%, 80% and 100%) had lower overall protein content in their carcasses, which may impact meat quality. Five chicken were randomly selected from each replicate for slaughter, and various carcass components were weighed and analyzed. Weekly weight gain was monitored, and data were analyzed using Analysis of Variance (ANOVA) to determine significant differences at a 5% level. The study further revealed that the inclusion of cassava flour influenced the nutritional composition of the carcass. Weekly weight gain was calculated, and findings suggested that broiler chickens on diets with lower maize and higher cassava content had reduced growth rates compared to those on higher maize diets. The study concluded that while cassava can be a suitable alternative in areas where there is heavy dependence on maize, it can effectively replace 40% - 60% maize in broiler diets. There is therefore a need for further investigation into optimal inclusion levels for maintaining growth and meat quality.

Key words: maize, substitution, chicken, proximate, feed, carcass, cassava, flour

Citation: Tachie-Menson JW, Adu EO, Lartey GST, Gyamera E, Akorli SE, Arko E, Kanyelvilaa V and S Akaba Effects of Maize Substitution with Cassava Flour in Broiler Diets on Carcass Quality and Meat Characteristics of Broiler Chicken. *Afr. J. Food Agric. Nutr. Dev.* 2025; **25(7)**: 27231-27245. <https://doi.org/10.18697/ajfand.144.25095>



INTRODUCTION

Poultry farming is essential in meeting the global need for animal protein. Maize, sometimes known as corn, has long been an essential part of poultry diets because of its high starch content, which serves as a major source of energy. In broiler diets, maize is the primary energy source due to its high starch content and high digestibility [1]. However, price instability caused by the growing demand for maize for industrial and human use has affected its availability and affordability, not just for poultry farmers, but also that of ruminants and pigs [2,3]. To continue the sustainability and economic feasibility of broiler production, researchers and poultry farmers have been investigating potential alternatives for this crucial feed component. The development of feed ingredients from by-products that would not otherwise be suitable for human nutrition has been a significant opportunity for animal nutritionists. This process could lower animal feed costs while simultaneously promoting environmental sustainability [4]. Cassava is one of such alternative feed items that has recently drawn attention.

Originally from South America, cassava is now widely distributed in tropical Africa, Southeast Asia, and Central America [5]. While the leaf is a modest source of protein [5,6], cassava is deficient in proteins and other elements [5] and high in carbohydrate. Although slightly less than maize, cassava has a high energy content [5,7].

It has fast become a viable alternative to maize in broiler diets because it has more digestible starch than maize due to its higher amylopectin content [5], fiber, and presence of vital mineral elements [2]. Additionally, its drought resistance and suitability for tropical and subtropical climates makes cassava a reliable feed option in regions where maize yield is inconsistent [8].

Cassava products have long been used for animal feeding under subsistent agriculture in its major areas of production. In earlier years when it was compared to cereals, the inclusion of cassava in poultry diets was reported to depress performance [9] probably due to the presence of HCN and high levels at which it was incorporated. An enzyme called β -glucosidase, which is generated by gut microorganisms, transforms the HCN in such cassava into hydrocyanic acid [10], which is poisonous to animals. It has been demonstrated that a large dose of Hydrogen Cyanide (HCN) inhibits the respiratory chain's cytochrome oxidase [11]. Earlier studies [12] observed satisfactory growth performance in broiler chicks on replacement of maize with cassava at up to 50 -100 g/kg in the diet. There were also some reports with encouraging results, probably due to the balancing of nutrients to meet requirements [13–15], and the use of HCN reducing processes such as the employment of biotechnological techniques (wet and solid-state fermentation),



physical techniques (sun-drying, pelleting, soaking, boiling, and mashing), and feed additive supplementation (enzymes, amino acids, and oil) [5].

In recent years, various trials involving the replacement of maize with cassava have been ongoing, with some researchers recording no significant effect of the replacement on growth performance characteristics [16]. Other studies have found poor body weight gain in broiler chickens fed cassava fortified with palm oil [7], while reduced growth performance rates have also been reported [16,17]. This significant variability in results have been suggested to be a result of differences in origin, parts of the cassava plant, crop age at harvest, dietary makeup and processing techniques [18]. To establish more consistency in data obtained from such studies, there is the need for more trials to be done. This study therefore investigated the impact of using cassava flour as an ingredient in substitution for maize in broiler diets.

MATERIALS AND METHODS

Study Area

This study was conducted at the poultry unit of the Teaching and Research Farm at the University of Cape Coast, Ghana. This location was selected due to its established facilities for poultry research and its representation of local agricultural practices.

Feed ingredient preparation

Cassava tubers (Cape vars variety) were obtained from the University of Cape-Coast Teaching and Research Farm. The tubers were prepared by peeling, washing, and slicing them into smaller pieces. Subsequently, the sliced cassava was oven-dried at 80°C for 24 hours and then milled to a fine powder to be used in the feed formulations.

Experimental Design

A total of 180-day-old Ross chicks were utilized for the study. The chicks were randomly assigned to six dietary treatments (as detailed in Table 1), with ten chicken per treatment and three replicates for each treatment. The dietary treatments varied in cassava inclusion levels, ranging from 0% to 100%.

Diet Formulation

The basal diet was composed of Koudjis Broiler Starter and Finisher Concentrates, purchased from Samnart Goodness and Mercies Ventures, Ashiaman, Ghana. This concentrate constituted 33% of each feed treatment, while maize and cassava together accounted for 67%. The specific feed formulations are detailed in Table 1.



Feeding Regimen

The day-old chicks were initially fed Galdus, a premium micro-pellet starter feed purchased from Koudjis Ghana, *ad libitum* for the first two weeks (14 days). After this period, the chicks were transitioned to the formulated diets, with varying cassava inclusion levels, and were also fed *ad libitum*.

Weighing chicken

Bird weights were taken using an electronic balance. Weekly live weight measurements commenced at the end of the brooding stage (2 weeks). The initial weight (W_1) of the chicken was recorded at this stage. From the third week onward, five chicken were randomly selected from each replicate per treatment for weekly weighing to determine average live weights. Weekly weight gain (WWG) was calculated using the formula: $WWG = W_2 - W_1$, where WWG = Weekly weigh gain, W_2 = Current weight of bird, W_1 = Initial weight of bird.

Proximate Analysis

Feed samples from each treatment, as well as the cassava and maize ingredients, were collected for proximate analysis. The analysis was conducted according to standard methods of the Association of Official Analytical Chemists (AOAC) to assess parameters such as dry matter, crude protein, ash, extract, and crude fiber [19].

Meat Characteristics

At the end of the experimental period, five chicken from each replicate were randomly selected for slaughter. The weights of whole dressed chickens, gizzards, livers and hearts were recorded. Proximate analysis was also conducted on samples of the meat from each treatment group according to standard methods [19].

Data Collection and analysis

All data recordings commenced after the second week of the study. Mean values of the collected data were computed and analyzed using analysis of variance (ANOVA) with Genstat Software (version 12.0). Statistical significance was determined at a 5% level and means, and standard deviations were calculated for comparison.

RESULTS AND DISCUSSION

Proximate analysis of feed formulations

The current study observed a significant decline in protein content as cassava inclusion increased, from 25.3% in the control group (0% cassava) to 17.2% in the 100% cassava diet. This result aligns with the findings of a study which noted that the protein content of diets containing high levels of cassava was significantly lower than that of maize-based diets [20]. The decrease in protein levels is critical, as it



underscores the nutritional limitations of cassava, which is known to be deficient in essential amino acids compared to maize [2].

The ash content in the current study ranged from 4.58% in the control diet to 6.06% in the 100% cassava diet. This increase in ash content with higher cassava inclusion corroborates findings from studies which reported that diets with elevated levels of cassava exhibited higher mineral content, reflecting cassava's relative mineral density compared to maize [21]. The increased ash content indicates a greater presence of minerals, which may be beneficial for bone development and overall health in poultry [22].

Moreover, the current study reported a significant decrease in ether extract (oil) content as cassava substitution increased, with the control diet showing 3.31% oil content compared to just 1.05% in the 100% cassava diet. This finding is consistent with the observations from a similar investigation which noted that diets based on cassava typically contained lower fat levels than those based on maize [16]. The reduced fat content in cassava-based diets may influence energy availability and overall feed efficiency, which is a critical consideration for poultry production.

The crude fiber (CF) content in the current study also decreased with higher levels of cassava inclusion, which is consistent with the findings from previous research [20,23]. Increased fiber content can enhance gut health and digestion; however, excessively high fiber levels can impede nutrient absorption and reduce overall feed efficiency.

In conclusion, the proximate analysis of feed formulations in this study confirms previous findings regarding the nutritional profile of cassava compared to maize. The significant variations in protein, ash, oil, and fiber content highlight the necessity of careful dietary formulation when incorporating cassava into broiler diets. Future studies should investigate optimal inclusion levels that maximize the benefits of cassava while minimizing its nutritional deficiencies, ensuring balanced diets that meet the growth and health needs of broiler chickens.

Growth Performance of chicken

The results of the weekly live weight measurements of chicken fed different levels of cassava inclusion in their diets provide valuable insights into the impact of cassava as an alternative feed ingredient in broiler production. The data indicates that as the inclusion of cassava increased from 0% to 100%, there was a notable variation in the average weights of the chicken at different ages, particularly in the 4th, 5th, and 6th weeks. At the 4th week, the average weights showed significant differences, with the control group (T1) achieving the highest weight of 1.6 kg, while groups with higher cassava inclusion (T4, T5, and T6) exhibited lower weights, suggesting that high levels of cassava in the diet may negatively affect growth performance. This



trend continued into the 5th and 6th weeks, when the weight differences became even more pronounced, particularly at 80% and 100% cassava inclusion, which resulted in the lowest average weights.

The current study found that substituting maize with cassava flour in broiler diets resulted in a notable decline in growth rates, particularly at higher inclusion levels of cassava (80% and 100%). Specifically, broiler chickens fed diets containing at least 60% cassava exhibited significantly lower weekly weight gains compared to those on maize-based diets. This finding aligns with previous research which indicated that high levels of cassava in broiler diets could depress growth performance, likely due to the lower protein content and presence of anti-nutritional factors such as cyanogenic glycosides [7]. In contrast, the study by Chang'a *et al.* [16] reported no significant differences in growth performance when cassava replaced maize at moderate levels (up to 40%). This discrepancy suggests that moderate inclusion of cassava can be beneficial or at least acceptable, corroborating the finding in this study, that 20% - 40% cassava inclusion levels did not adversely affect growth compared to the control group. The current study echoes the conclusion of Akinfala *et al.* [20], which emphasized that balanced dietary formulations could mitigate the negative effects of cassava on growth.

Moreover, previous studies such as those by Olugbemi *et al.* [24] and Bhuiyan and Iji [21] also reported reduced growth rates associated with high levels of cassava. In the latter, broiler chickens fed cassava chips demonstrated significantly lower live weights compared to those on maize-based diets. This further supports this study's findings that excessive cassava inclusion hampers growth performance due to its lower protein density and energy content.

Interestingly, results from this study highlight that while the inclusion of cassava at lower levels (20% and 40%) did not hinder growth significantly, the observed negative trends at higher levels could be attributed to the anti-nutritional properties of cassava, which may inhibit nutrient absorption [25]. This aligns with the findings of Tamburawa *et al.* [17], who noted that high levels of cassava meal negatively impacted growth performance and feed conversion efficiency.

Overall, the current study reinforces the notion that cassava can serve as a viable alternative to maize in broiler diets, particularly at moderate inclusion levels. However, it also underscores the importance of careful dietary formulation to avoid the detrimental effects of high cassava inclusion on growth rates, as supported by evidence in this and other studies. Future research should focus on optimizing cassava processing techniques and exploring synergistic effects with other protein sources to enhance growth performance in broiler chickens.



Additionally, the potential economic benefits of incorporating cassava into broiler diets are noteworthy, particularly in regions where maize is subject to price volatility. However, it is imperative that poultry farmers monitor inclusion rates closely to avoid negative impacts on growth performance.

Finally, the variability in results across different studies regarding the use of cassava in broiler diets indicates a pressing need for further research. Continued investigations are essential to optimize dietary formulations that incorporate cassava, thereby enhancing the understanding of its role in poultry nutrition and ensuring sustainable broiler production practices.

Carcass Characteristics and Proximate analysis of Meat

Meat quality characteristics of the chicken were determined as an index for evaluating the impact of maize substitution with different inclusion levels of cassava on chicken. The proximate analysis on the meat showed significant changes in nutritional composition. The current study revealed significant effects of cassava flour substitution on carcass characteristics and the proximate composition of meat in broiler chickens. As the level of cassava inclusion increased, there was a notable decrease in crude protein content and variations in organ weights, particularly liver and gizzard weights. Specifically, the crude protein content decreased from 25.3% in the control diet (0% cassava) to 17.2% in the diet consisting entirely of cassava (100% cassava). These findings are consistent with the work of Morgan and Choct [2], who reported that the protein density of diets is crucial for optimal growth and meat quality in poultry. The decrease in protein levels with higher cassava inclusion suggests that the nutritional deficiencies inherent in cassava, particularly its low levels of essential amino acids like lysine and methionine, may adversely affect meat quality.

In contrast, the study by Akinfala *et al.* [20] found that an inclusion of up to 50% cassava meal did not significantly impact the protein content of carcasses, suggesting that the balance of the overall diet and the presence of complementary protein sources can mitigate the negative effects observed in this study. This highlights the importance of dietary formulation in achieving desired carcass characteristics.

The current study also observed an increase in ash content as cassava inclusion rose, with the highest ash content recorded at 6.06% in the 100% maize substituted diet. This finding aligns with the results reported by Akinfala *et al.* [20], who similarly noted an increase in ash content in chickens fed higher levels of cassava flour. The higher ash content indicates a greater mineral density in the meat, which could be beneficial for bone development and overall health, as suggested by Nutrient Requirements of Poultry (NRC) [22].



However, discrepancies arise when comparing findings on organ weights. While this study indicated that liver weights decreased significantly with increased cassava inclusion, other studies, such as those by Bhuiyan *et al.* [21] reported no significant changes in liver weights when cassava was included in broiler diets. This difference may stem from variations in experimental design, such as the age of the chicken, the specific cassava varieties used, or the overall dietary composition.

Additionally, the gizzard weights in this study exhibited variability with the highest weight observed at 20% cassava inclusion, which could be linked to the dietary fiber content. This finding is in line with Svihus [23], who noted that the physical characteristics of the diet significantly influence gizzard development. In contrast, higher levels of cassava resulted in lower gizzard weights, suggesting that excessive fiber from cassava may not be conducive to optimal digestive function.

Overall, the current study underscores the complex relationship between cassava flour inclusion and carcass characteristics, emphasizing the need for balanced dietary formulations that account for nutritional deficiencies associated with cassava. While moderate levels of cassava can enhance certain carcass traits, excessive inclusion may compromise meat quality and organ development. Future research should explore the effects of supplementary protein sources and processing methods on the nutritional profile of cassava-inclusive diets to optimize meat quality in broiler production.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study provides compelling evidence regarding the effects of substituting maize with cassava flour in broiler diets on growth performance, carcass characteristics and organ development. The findings indicate that moderate levels of cassava inclusion (20% to 40%) can serve as a viable alternative to maize, supporting satisfactory growth rates without significantly compromising overall performance. However, higher levels of cassava substitution (80% and 100%) adversely impacted growth, carcass quality and organ weights, particularly in terms of protein content and liver development.

The observed variations in liver, gizzard and heart weights further underscore the importance of dietary composition in influencing physiological health and digestive efficiency in broiler chickens. The significant decrease in crude protein content associated with increased cassava inclusion highlights the necessity for careful dietary balancing to ensure that nutritional requirements are met. Additionally, the increased mineral content, as indicated by higher ash levels in carcasses fed cassava-inclusive diets, presents both opportunities and challenges for poultry producers, especially in meeting market demands for meat quality.



These results advocate for a strategic approach to diet formulation in broiler production, emphasizing the need for further research to optimize the inclusion of cassava flour while maintaining the nutritional integrity of the diet. Future studies should explore the synergistic effects of dietary additives and complementary protein sources to enhance the overall efficacy of cassava as a feed ingredient. Ultimately, this research contributes to the ongoing efforts to develop sustainable and economically viable poultry production practices, leveraging locally available feed resources to enhance food security and reduce reliance on conventional feed ingredients.

ACKNOWLEDGEMENTS

The authors acknowledge the Directorate of Research, Innovation and Consultancy – University of Cape-Coast (DRIC - UCC) for financing this study.



Table 1: Feed formulations with cassava as substitute for maize

Ingredients	Cassava Inclusion Levels (kg)					
	T1 (0%)	T2 (20%)	T3 (40%)	T4 (60%)	T5 (80%)	T6 (100%)
Maize	67	53.6	40.2	26.8	13.4	0
Cassava	0	13.4	26.8	40.2	53.6	67
Concentrate	33	33	33	33	33	33
Total	100	100	100	100	100	100

Table 2: Proximate composition of cassava, maize and feed formulations (%)

	Cassava	Maize	T1	T2	T3	T4	T5	T6	S.E. D	F. Pr.
DM	86.09	86.83	86.7	86.5	86.6	86.7	86.6	86.6	0.16	0.81
Moisture	13.91	13.17	13.3	13.5	13.4	13.3	13.4	13.4	0.16	0.81
Ash	3.75	1.25	4.58 ^a	5.48 ^{bc}	5.58 ^{bc}	5.40 ^b	5.91 ^{bc}	6.06 ^c	0.16	<.001
CP	4.61	9.25	25.3 ^d	17.5 ^c	16.9 ^b	14.8 ^a	17.1 ^{bc}	17.2 ^{bc}	0.13	<.001
Oil	0.77	3.82	3.31 ^f	2.82 ^e	2.35 ^d	1.92 ^c	1.54 ^b	1.05 ^a	0.07	<.001
CF	4.6	4.04	10.2 ^f	9.64 ^e	8.32 ^d	7.24 ^c	6.23 ^b	5.72 ^a	0.08	<.001
CHO	86.3	81.6	59.7 ^a	64.6 ^b	66.9 ^c	70.7 ^e	69.2 ^d	70.0 ^{de}	0.25	<.001

Means in the same row with different superscripts are significantly different while those with no/similar superscripts indicate no significant differences; F. Pr. = Probability value; DM= Dry Matter; CP = Crude Protein, CF = Crude fiber, CHO = Carbohydrate; T1 = 0% cassava inclusion; T2 = 20% cassava inclusion; T3 = 40% cassava inclusion; T4 = 60% cassava inclusion; T5 = 80% cassava inclusion; 100% cassava inclusion)

Table 3: Weekly live weight of chicken (kg)

AGE (WEEK)	T1	T2	T3	T4	T5	T6	S.E. D	F. Pr.
Initial Weight	0.45	0.42	0.48	0.44	0.45	0.47		
3	0.87	0.85	0.84	0.80	0.81	0.74	0.06	0.432
4	1.6 ^a	1.45 ^{ab}	1.44 ^{ab}	1.32 ^b	1.3 ^b	1.27 ^b	0.09	0.006
5	2.1 ^a	2.07 ^a	1.85 ^{ab}	1.84 ^{ab}	1.72 ^b	1.57 ^b	0.1	<.001
6	2.78 ^a	2.5 ^{ab}	2.48 ^{abc}	2.32 ^{bc}	2.18 ^c	1.84 ^d	0.1	<.001

Means in the same row with different superscripts are significantly different while those with no/similar superscripts indicate no significant differences; T1 = 0% cassava inclusion; T2 = 20% cassava inclusion; T3 = 40% cassava inclusion; T4 = 60% cassava inclusion; T5 = 80% cassava inclusion; 100% cassava inclusion

Table 4: Weekly Weight gain of chicken (kg)

WEEK	T1	T2	T3	T4	T5	T6	S.E. D	F. Pr.
3	0.416	0.43	0.362	0.363	0.358	0.273	0.02	0.206
4	1.15 ^a	1.03 ^{ab}	0.96 ^{ab}	0.88 ^{ab}	0.85 ^b	0.8 ^b	0.01	0.004
5	1.65 ^a	1.65 ^a	1.37 ^{ab}	1.4 ^{ab}	1.27 ^b	1.1 ^b	0.01	<.001
6	2.33 ^a	2.08 ^{ab}	2.00 ^{bc}	1.88 ^{bc}	1.73 ^c	1.37 ^d	0.02	<.001

SED = Standard error of difference; T1 = 0% cassava inclusion; T2 = 20% cassava inclusion; T3 = 40% cassava inclusion; T4 = 60% cassava inclusion; T5 = 80% cassava inclusion; 100% cassava inclusion

Table 5: Carcass characteristics of chicken fed with different cassava diets

Organ	T1	T2	T3	T4	T5	T6	S.E. D
Heart weight (g)	10	15	10	10	10	10	0.68
Gizzard weight (g)	50	65	45	45	50	50	1.95
Liver weight (g)	65	45	45	40	45	55	2.05
Nutritional Composition (%)							
DM	30.4 ^a	29.4 ^b	29.2 ^b	28.3 ^c	27.3 ^d	27.2 ^d	0.12
Ash	4.20 ^b	4.49 ^b	4.71 ^{ab}	4.33 ^b	4.85 ^{ab}	5.33 ^a	0.15
Oil/Fat	5.36 ^a	5.15 ^a	4.80 ^b	3.46 ^c	3.30 ^c	2.77 ^d	0.05
CP	79.5 ^a	79.2 ^a	78.4 ^b	76.6 ^c	76.4 ^c	76.4 ^c	0.13
CF	8.86 ^c	8.86 ^c	9.04 ^c	9.36 ^b	9.42 ^b	9.67 ^a	0.05
CHO	3.46 ^d	3.97 ^{cd}	3.978 ^{cd}	4.17 ^c	5.23 ^b	6.63 ^a	0.13

S.E.D = Standard error of difference; Means in the same row with different superscripts are significantly different while those with no/similar superscripts indicate no significant differences; DM= Dry Matter; CP = Crude Protein, CF = Crude fiber, CHO = Carbohydrate; T1 = 0% cassava inclusion; T2 = 20% cassava inclusion; T3 = 40% cassava inclusion; T4 = 60% cassava inclusion; T5 = 80% cassava inclusion; 100% cassava inclusion



REFERENCES

1. **Govoni C, Chiarelli DD, Luciano A, Ottoboni M, Perpelek SN, Pinotti L and MC Rulli** Global assessment of natural resources for chicken production. *Adv Water Resour.* 2021; **154**:103987.
2. **Morgan NK and M Choct** Cassava: Nutrient composition and nutritive value in poultry diets. *Animal Nutrition.* 2016; **2(4)**: 253–61.
3. **Vastolo A, Serrapica F, Cavallini D, Fusaro I, Atzori A and M Todaro** Editorial: Alternative and novel livestock feed: reducing environmental impact. *Front Vet Sci.* 2024.
4. **Adli DN** The effect of replacing fish meal with Sago larvae meal (SLM) on egg production and quality of laying hens. *Livestock Research for Rural Development.* 2021;**33(7)**: 1–8.
5. **Chauynarong N, Elangovan A V and PA Iji** The potential of cassava products in diets for poultry. *Worlds Poult Sci J.* 2009; **65(1)**: 23–36.
6. **Omede AA, Ahiwe EU, Zhu ZY, Fru-Nji F and PA Iji** Improving cassava quality for poultry feeding through application of biotechnology. *Cassava.* 2017; **10**: 241–63.
7. **Uchegbu MC, Ogbuewu IP, Obimara SO and BE Obua** Effect of replacement of maize with cassava root meal fortified with palm oil on performance of starter broilers. *Online J. Anim. Feed Res.* 2011; **1**: 171–175.
8. **NRC.** Nutrient Requirements of Poultry: Nutrient Requirements of chickens. *National Academics Press.* 1994;(Ninth Edition): National Academy Press, Washington, DC.
9. **Machin D and S Nyvold** Roots, tubers, plantains and bananas in animal feeding. *FAO Anim Prod Health Paper.* 1992; **95**.
10. **Adepoju OT, Adekola YG, Mustapha SO and SI Ogunola** Effect of processing methods on nutrient retention and contribution of cassava (*Manihot spp*) to nutrient intake of Nigerian consumers. *Afr. J. Food Agric. Nutr. Dev.* 2010; **10(2)**: 2099-2111. <https://doi.org/10.4314/ajfand.v10i2.53353>
11. **Cardoso AP, Mirione E, Ernesto M, Massaza F, Cliff J, Haque MR and JH Bradbury** Processing of cassava roots to remove cyanogens. *Journal of Food Composition and Analysis.* 2005;**18(5)**: 451–60.



12. **Tejada HL and S Brambilla** Investigation of nutritional value of cassava for the chick. *Técnica Pecuaria en México*. 1969; **3**: 329–33.
13. **Ravindran V** Utilization of Cassava (*Manihot esculenta crantz*) leaves in animal nutrition. 1993.
14. **Tewe OO** Detoxification of cassava products and effects of residual toxins on consuming animals. Roots, tubers, plantains and bananas in animal feeding (D Machin and S Nyvold, editors) *FAO Animal Production and Health Paper*. 1992; **95**: 81–98.
15. **Khajarern S and JM Khajarern** Use of cassava products in poultry feeding. Roots, Tubers, Plantains and Bananas in Animal Feeding Rome, Italy: FAO. 1992.
16. **Chang'a EP, Abdalh ME, Ahiwe EU, Mbagu S, Zhu ZY, Fru-Nji F and PA de Iji** Replacement value of cassava for maize in broiler chicken diets supplemented with enzymes. *Asian-Australas J. Anim. Sci.* 2020; **33(7)**: 1126.
17. **Tamburawa MS, Abubakar Z, Salisu N, Wudil AA, Hassan AM, Ibrahim U, Zango MH, Nasir M, Umar AM and SS Sa'idu** Effect of Dietary Utilization of Cassava Root (*Manihot esculenta*) Meal on Growth Performance and Carcass Characteristics of Broiler Chickens at Finisher Phase. *Nigerian Journal of Animal Science and Technology (NJAST)*. 2019; **2(2)**: 63–71.
18. **Ogbuewu IP and CA Mbajiorgu** Meta-analysis of substitution value of maize with cassava (*Manihot esculenta Cratz*) on growth performance of broiler chickens. *Front Vet. Sci.* 2022; **9**: 997128.
19. **Thiex N** Evaluation of Analytical Methods for the Determination of Moisture, Crude Protein, Crude Fat, and Crude Fiber in Distillers Dried Grains with Solubles. *J. AOAC Int.* 2009; **92(1)**: 61–73.
20. **Akinfala EO, Aderibigbe AO and O Matanmi** Evaluation of the nutritive value of whole cassava plant as replacement for maize in the starter diets for broiler chicken. *Livestock Research for Rural Development*. 2002; **14(6)**: 23–30.
21. **Bhuiyan MM and PA Iji** Energy value of cassava products in broiler chicken diets with or without enzyme supplementation. *Asian-Australas J. Anim. Sci.* 2015; **28(9)**: 1317.



22. **NRC Nutrient Requirements of Poultry.** Nutrient Requirements of chickens. National Academics Press. 1994;(Ninth Edition): National Academy Press, Washington, DC.
<https://books.google.com/books?id=bbV1FUqRcM0C&pg=PT13>
23. **Svihus B** The gizzard: Function, influence of diet structure and effects on nutrient availability. *Worlds Poult. Sci. J.* 2011; **67(2)**: 207–23.
24. **Olugbemi TS, Mutayoba SK and FP Lekule** Effect of Moringa (*Moringa oleifera*) inclusion in cassava-based diets fed to broiler chickens. *Int J Poult Sci.* 2010; **9(4)**: 363–7.
25. **Aro SO** Improvement in the nutritive quality of cassava and its by-products through microbial fermentation. *Afr. J. Biotechnol.* 2008; **7(25)**.

