Carcass, organ and organoleptic characteristics of broiler chickens fed diets containing shea butter (*Vitellaria paradoxa* C. F. Gaertn) cake with or without enzyme supplementation

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Abstract

Although maize remains the primary energy source in broiler chickens, fluctuating costs due to stiff competition for its usage between humans and livestock have driven the search for alternatives like Shea Butter Cake (SBC). The effect of such alternatives on the carcass quality and organoleptic properties requires investigation for consumer acceptability. This study was designed to investigate the maize replacement value of SBC with or without enzyme supplementation on carcass characteristics of broiler chickens. Two hundred and sixteen Ross 308-day-old mixed sex broiler chicks were weighed and distributed into six treatment groups - of thirty-six birds, with four replicates each - involving three replacement levels (0, 10, 20%) of maize with SBC without enzyme and 0, 10, 20% shea butter cake maize replacement with enzyme (Kingphost at 50g/per ton of complete feed and Kingzyme at 200g/ton of complete feed) in a two-by-three factorial arrangement. The data collected on carcass traits, organ, gut morphometry and sensory evaluation of the breast meat were analysed using one-way analysis of variance. Result shows that the highest (p<0.05) value (82.98%) of eviscerated weight was observed in broiler chickens fed 0% shea butter cake without enzyme supplementation (T1), which is similar to the (P<0.05) value (82.05%) observed in birds fed 0% shea butter cake with enzyme supplementation (T4), this result shows influence of enzyme supplementation as another alternative to improve the broiler production. Furthermore, the highest (p<0.05) value (25.51%) of breast meat weight was obtained in broiler chickens fed 0% shea butter cake without enzyme supplementation (T1) while highest value of thigh (12.05%) was also observed in broiler chickens fed 0% shea butter cake without enzyme supplementation (T1). The relative breast meat value (7.20) of the broilers fed 0% SBC without enzyme supplementation is significantly (p<0.05) higher (7.20) for flavour. Broiler chickens fed 10% SBC without enzyme supplementation (T2) and 10% SBC with enzyme supplementation (T5) had the highest (P<0.05) relative pancreas value (0.44%) and relative kidney (P<0.05) value (0.49%), respectively. Whereas, the lowest abdominal fat (P<0.05) value of 0.01% was observed in broiler chickens fed 20% SBC with enzyme supplementation (T6). In conclusion incorporating shea butter cake in broiler chickens' diet at 10% to replace maize enhances the carcass traits, relative prime-cut and meat quality of broiler chickens. However, 20% SBC, particularly with enzyme supplementation, produced minimal abdominal fat deposition. The dietary inclusion of SBC had no significant effect on the overall acceptability of broiler meat. Also feed with enzyme supplementation seem to produce heaviest weight (Kg).

Keywords: Organ characteristic, Gut morphology, Organoleptic properties, Shear butter cake, Enzyme

Caractéristiques de la carcasse, des abats et caractéristiques organoleptiques de poulets de chair nourris avec des régimes alimentaires contenant du tourteau de beurre de karité (Vitellaria paradoxa C. F. Gaertn), avec ou sans supplémentation enzymatique

Résumé

Bien que le maïs reste la principale source d'énergie chez les poulets de chair, la fluctuation des coûts due à la forte concurrence entre l'alimentation humaine et animale pour son utilisation a conduit à la recherche d'alternatives telles que le tourteau de beurre de karité (SBC). L'effet de ces alternatives sur la qualité de la carcasse et les propriétés organoleptiques doit être étudié afin d'évaluer leur acceptabilité par les consommateurs. Cette étude a été conçue pour évaluer la valeur de remplacement du maïs par le SBC, avec ou sans supplémentation enzymatique, sur les caractéristiques des carcasses de poulets de chair. Deux cent seize poussins de poulets de chair Ross âgés de 308 jours, des deux sexes, ont été pesés et répartis en six groupes de traitement – de trente-six oiseaux chacun, avec quatre répétitions par groupe – comprenant trois niveaux de remplacement (0, 10, 20 %) du maïs par du tourteau de beurre de karité sans enzyme et 0, 10, 20 % de tourteau de beurre de karité en remplacement du maïs avec apport enzymatique (Kingphost à raison de 50 g par tonne d'aliment complet et Kingzyme à raison de 200 g par tonne d'aliment complet) selon un plan factoriel 2 × 3. Les données recueillies sur les caractéristiques des carcasses, les organes, la morphométrie intestinale et l'évaluation sensorielle de la viande de poitrine ont été analysées à l'aide d'une analyse de variance à un facteur. Les résultats montrent que la valeur la plus élevée ($p < 0,05$) (82,98 %) du poids éviscéré a été observée chez les poulets de chair nourris avec 0 % de tourteau de beurre de karité sans supplémentation enzymatique (T1), ce qui est similaire à la valeur ($p < 0,05$) (82,05 %) observée chez les volailles nourries avec 0 % de tourteau de beurre de karité avec supplémentation enzymatique (T4), ce résultat démontre l'influence de la supplémentation enzymatique comme autre alternative pour améliorer la production de poulets de chair. Par ailleurs, la valeur la plus élevée ($p < 0,05$) (25,51 %) du poids de la poitrine a été obtenue chez les poulets de chair nourris avec 0 % de tourteau de beurre de karité sans supplémentation enzymatique (T1), tandis que la valeur la plus élevée pour la cuisse (12,05 %) a également été observée chez les poulets de chair nourris avec 0 % de tourteau de beurre de karité sans supplémentation enzymatique (T1). La valeur relative de la viande de poitrine (7,20) des poulets de chair nourris avec 0 % de SBC sans supplémentation enzymatique est significativement ($p < 0,05$) plus élevée (7,20) en termes de saveur. Les poulets de chair nourris avec 10 % de tourteau de beurre de karité sans supplémentation enzymatique (T2) et avec 10 % de tourteau de beurre de karité avec supplémentation enzymatique (T5) présentaient respectivement la valeur relative la plus élevée ($P < 0,05$) pour le pancréas (0,44 %) et pour les reins ($P < 0,05$) (0,49 %). En revanche, la valeur la plus faible de graisse abdominale ($P < 0,05$), soit 0,01 %, a été observée chez les poulets de chair nourris avec 20 % de tourteau de beurre de karité et un apport enzymatique (T6). En conclusion, l'incorporation de tourteau de beurre de karité à raison de 10 % dans l'alimentation des poulets de chair, en remplacement du maïs, améliore les caractéristiques de la carcasse, la proportion relative des morceaux de choix et la qualité de la viande des poulets de chair. Cependant, l'ajout de 20 % de tourteau de beurre de karité, en particulier avec une supplémentation enzymatique, a entraîné un dépôt minimal de graisse abdominale. L'inclusion de tourteau de beurre de karité dans l'alimentation n'a pas eu d'effet significatif sur l'acceptabilité globale de la viande de poulet de chair. De plus, l'alimentation avec supplémentation enzymatique semble permettre d'obtenir le poids le plus élevé (kg).

Mots-clés : Caractéristiques des organes, Morphologie intestinale, Propriétés organoleptiques, Tourteau de beurre de karité, Enzymes

Introduction

Chickens (*Gallus gallus domesticus)* are a globally essential domestic animal due to their nourishing meat that is consumed as food (Eda, 2021), income generation and food security for rural families (Gebre *et al*., 2023). Poultry business is a common practice in most rural and certain urban regions in the developing world, where the demand for the fowls is increasing due to an increase in population, expanding urban areas, and snowballing incomes (Mulugeta *et al*., 2023).

Technical constraints and high production costs are major challenges faced in the West African poultry sector, especially in Nigeria (Anosike *et al*., 2018). More than 70% of the total cost of operation in animal husbandry is on feed, especially in poultry production (Sunmola *et al*., 2019; Vlaicu *et al.,* 2024). The rising costs of poultry feed, along with the corresponding increase in prices for poultry products like meat and eggs, indicate the necessity of adopting a waste-to-wealth approach for sustainable and environmentally friendly poultry production. The rapid growth of the human population has intensified the competition between humans and livestock for grains such as maize, which is the major source of energy in poultry feeds (Aguihe *et al*., 2020). Grains such as maize constitute more than one-third of the poultry feed and, due to its high price, is becoming more expensive to use at high levels of inclusion in poultry feed (Muhammad *et al*., 2015). Hence, the need to search for an alternative energy source in order to reduce dependence on maize and feed cost (Al-Harthi *et al*., 2018).

In view of this high cost of maize in poultry production and unavailability of the quality maize after dry season, agroforestry by-products that are not consumed by humans when incorporated in poultry feed will contribute to environmental waste management, this agroforestry by-products are available at a low cost and can serve as an alternative to maize in poultry diets (Aguihe *et al*., 2020). One such alternative is the Shea Butter Cake (SBC) (Agbetuyi and Oloruntola, 2020), which is an agroforestry by-product and residue after fat extraction from Shea nuts. Presently shea butter cake does not attract farmers' attention, and its increasing output has become an environmental issue lately (Adebayo *et al*., 2020). Abdul Mumeen *et al*. (2013) documented that the general nutritional value of Shea butter cake was appreciable with 13% crude protein, 23% crude fat, 4% ash, 4% crude fibre, 59% carbohydrates, and 4048KCal/kg metabolizable energy per kilogram. They also highlighted its richness in minerals such as magnesium, potassium, and calcium. Its composition, however, depends on the methods used in the extraction. The SBC is carefully considered as a potential feed ingredient and a backup for maize in poultry diets, based on its composition (Aguihe *et al*., 2017). The presence of anti-nutritive factors, principally the tannins, is a significant nutritive constraint of Shea nut meal for poultry, which is within the range of 98 - 156 grams per kilogram (Agbo and Prah, 2014). The negative impacts of SBC on feed intake and nutrient utilization are linked to the fibrous nature and presence of possible nutrient-limiting factors, particularly tannins (Choi and Kim, 2020), which can cause poor performance (Orogun *et al*., 2015). Consequently, Matthew *et al*. (2017) reported that adopting a processing technique like fermentation has been considered to be an ideal approach that reduces the tannin and saponin contents and equally improves the nutritive value and utilisation. Moreover, application of appropriate supplemental feed additives such as enzymes in feed formulation has been documented to enhance efficient utilization of poor quality feed or agro-industrial residues (Kirkpinar *et al*., 2018; Sunmola *et al*., 2019) and positively impact live weight, feed efficiency, carcass yield, and gut activity by enhancing the microbial balance in chickens' digestive tracts (He *et al* 2019). The study was carried out to assess the impact of enzyme supplementation on carcass evaluation and gut morphology of broiler chickens fed graded levels of SBC as a replacement for maize with or without enzyme supplementation.

Materials and methods

***Experimental site*:** The experiment was carried out at the Poultry Research Unit, Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, situated in the derived savanna zone of southwest Nigeria, and lies on Latitude 8° 8' 31.7940" North of the equator and Longitude 4° 14' 42.6696" East of the Greenwich Meridian. The altitude ranges from 300 m to 600 m above sea level, while the mean temperature and annual rainfall are 27 °C and 1247mm, respectively (Google Earth Map, 2021).

***Test Ingredients*:** The Shea Butter Cake (SBC) was procured from a reputable feed mill at the Durbar area of Oyo town, Oyo State, Nigeria. Treatments 1, 2 and 3 comprised dietary inclusion of Shea butter cake replacing maize at the rate of 0, 10 and 20% by weight, respectively, without enzyme supplementation, while Treatments 4, 5 and 6 comprised dietary inclusion of SBC replacing maize at the rate of 0, 10 and 20% by weight, respectively, with enzyme supplementation (Table 2 and 3).

Table 1: Experimental Layout

Treatments	Diets
1	0% Shea butter cake (SBC), maize replaced without enzyme supplementation
2	10% Shea butter cake (SBC), maize replaced without enzyme supplementation
3	20% Shea butter cake (SBC), maize replaced without enzyme supplementation
4	0% Shea butter cake (SBC), maize replaced with enzyme supplementation
5	10% Shea butter cake (SBC), maize replaced with enzyme supplementation
6	20% Shea butter cake (SBC), maize replaced with enzyme supplementation

***Experimental Animals and Management*:** Two hundred and sixteen 1 day-old Ross 308 Strain of broiler chicks were used for the experiment. The birds were weighed at the commencement of the experiment and randomly distributed into six treatments of four (4) replicates each. Each replicate had nine (9) birds to make a total of 36 birds per treatment. Each replicate was housed in a pen measuring 122 cm x 90 cm x 90 cm in dimension. The birds were offered adequate feed and clean water *ad-libitum* throughout the experiment, which lasted for eight weeks, while all necessary vaccinations and medications were administered appropriately.

Table 2: Gross Composition of Experimental diets for broiler Starters (% DM)

Ingredients	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Maize	54.00	48.60	43.20	54.00	48.60	43.20
Shea Butter Cake	0.00	5.4	10.8	0.00	5.4	10.8
*Fixed ingredients	46.00	46.00	46.00	46.00	46.00	46.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Enzyme	-	-	-	+	+	+
Calculated nutrient values						
ME (kcal/kg)	3066.64	3016.69	2966.74	3066.64	3016.69	2966.74
Crude protein (%)	21.85	22.06	22.27	21.85	22.06	22.27
Ether extract (%)	5.91	5.76	5.62	5.91	5.76	5.62
Crude fibre (%)	3.62	4.25	4.88	3.62	4.25	4.88
Lysine (%)	1.45	1.43	1.42	1.45	1.43	1.42
Methionine (%)	0.60	0.59	0.58	0.60	0.59	0.58
Calcium (%)	1.11	1.11	1.11	1.11	1.11	1.11
Phosphorus (%)	0.83	0.80	0.80	0.83	0.80	0.80

**Fixed ingredients:* Soy oil 2.00, Soybean 32.00, Wheat offal 5.00kg, Fish meal 3.00kg, Dicalcium Phosphate 2.00kg, Limestone 1.00kg , Salt 0.25kg, , **Premix 0.25kg, Methionine 0.25kg, Lysine 0.25kg, Enzyme (+): KINGPHOS T (0.00005g/kg of feed) and KINGZYME (0.0002g/kg of feed), Enzyme (-): Without enzyme. T1 = 0% Shea butter cake (SBC), maize replaced without enzyme supplementation, T2 = 10% Shea butter cake (SBC), maize replaced without enzyme supplementation, T3 = 20% Shea butter cake (SBC), maize replaced without enzyme supplementation, T4 = 0% Shea butter cake (SBC), maize replaced with enzyme supplementation, T5 = 10% Shea butter cake (SBC), maize replaced with enzyme supplementation, T6 = 20% Shea butter cake (SBC), maize replaced with enzyme supplementation. ***Premix composition: Vitamin A (IU) 10,000,000.00, Vitamin D3 (IU) 3,000,000.00, Vitamin E (IU) 40,000.00, Vitamin K (Mg) 2,000.00, Vitamin B1 (Mg) 2,000.00, Vitamin B2 (Mg) 5,000.00, Vitamin B6 (Mg) 3,500.00, Vitamin B12 (Mg) 20.00, Niacin (Mg) 60,000.00, Panth Acid (Mg) 10,000.00, Folic Acid (Mg) 1,000.00, Biotin (Mg) 100.00, Choline (Mg) 300,000.00, Manganese (Mg) 80,000.00, Zinc (Mg) 50,000.00, Iron (Mg) 40,000.00, Copper (Mg) 8,000.00, Iodine (Mg) 1,200.00, Selenium (Mg) 200.00, Cobalt (Mg) 250.00, Antioxidant (Mg) 125.00*

DCP: Di-calcium Phosphate

ME: Metabolizable Energy

Table 3: Gross Composition of Experimental diets for broiler Finisher (% DM)

Ingredients	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**
Maize	57.00	51.30	45.60	57.00	51.30	45.60
Shea Butter Cake	0.00	5.7	11.4	0.00	5.7	11.4
**Fixed ingredients	43.00	43.00	43.00	43.00	43.00	43.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Enzyme	_	_	_	+	+	+
Calculated Nutrient ***values***						
ME (kcal/kg)	3045.37	2992.65	2939.92	3045.37	2992.65	2939.92
Crude protein (%)	18.78	19.00	19.22	18.78	19.00	19.22
Ether extract (%)	6.76	6.61	6.45	6.76	6.61	6.45
Crude fibre (%)	3.18	3.85	4.52	3.18	3.85	4.52
Lysine (%)	1.18	1.17	1.16	1.18	1.17	1.16
Methionine (%)	0.51	0.50	0.49	0.51	0.50	0.49
Calcium (%)	2.46	2.46	2.46	2.46	2.46	2.46
Phosphorus (%)	1.00	0.99	0.99	1.00	0.99	0.99

***Fixed ingredients:* Soybean 25.00kg, Soy oil 3.00kg, Wheat offal 4.60kg, Fish meal 2.50kg, Dicalcium Phosphate 2.00kg, Limestone 3.00kg ,Bone meal 2.00kg, Salt 0.25kg, , ***Premix 0.25kg, Methionine 0.20kg, Lysine 0.20kg. Enzyme (+): KINGPHOS T (0.00005g/kg of feed) and KINGZYME (0.0002g/kg of feed), Enzyme (-): Without enzyme. T1 = 0% Shea butter cake (SBC), maize replaced without enzyme supplementation, T2 = 10% Shea butter cake (SBC), maize replaced without enzyme supplementation, T3 = 20% Shea butter cake (SBC), maize replaced without enzyme supplementation, T4 = 0% Shea butter cake (SBC), maize replaced with enzyme supplementation, T5 = 10% Shea butter cake (SBC), maize replaced with enzyme supplementation, T6 = 20% Shea butter cake (SBC), maize replaced with enzyme supplementation.

****Premix composition: Vitamin A (IU) 10,000,000.00, Vitamin D3 (IU) 3,000,000.00, Vitamin E (IU) 40,000.00, Vitamin K (Mg) 2,000.00, Vitamin B1 (Mg) 2,000.00, Vitamin B2 (Mg) 5,000.00, Vitamin B6 (Mg) 3,500.00, Vitamin B12 (Mg) 20.00, Niacin (Mg) 60,000.00, Panth Acid (Mg) 10,000.00, Folic Acid (Mg) 1,000.00, Biotin (Mg) 100.00, Choline (Mg) 300,000.00, Manganese (Mg) 80,000.00, Zinc (Mg) 50,000.00, Iron (Mg) 40,000.00, Copper (Mg) 8,000.00, Iodine (Mg) 1,200.00, Selenium (Mg) 200.00, Cobalt (Mg) 250.00, Antioxidant (Mg) 125.00*

DCP: Di-calcium Phosphate

ME: Metabolizable Energy

Enzymes supplementation: The enzymes used were Kingphos and Kingzyme which are specialized feed additive enzyme products primarily manufactured by Vland Biotech and distributed globally for animal nutrition. Kingphos enzyme is a phytase enzyme additive that helps to unlocks bound phosphorus in plant feed, while Kingzyme is a multi-enzyme complex used to break down non-starch polysaccharides (NSPs) which helps to improve overall digestion in livestock and poultry.

Data Collection:

***Carcass Characteristics*:**

Data on the carcass characteristics were collected on the 49th day of the experiment; four birds per replicate with similar weights to the average of the group were selected for carcass analysis. Feed was withdrawn from the selected birds for 12 hours, while they were given access to water *ad libitum* and afterwards slaughtered by severing the carotid artery and the jugular vein. The slaughtered birds were completely bled and defeathered manually without immersing in hot water to avoid shrinkage of internal organs. The head and shanks were removed and weighed before the birds were eviscerated and organs were removed from the carcass. The dressed weights were recorded and the dressing percentages were estimated by dividing the dressed weight of carcasses by their respective live weights and multiplying by 100. The weights of cut-up parts (wings, neck, thigh, breast and back), organs (lungs, heart, kidney, liver, spleen, pancreas, proventiculus and gizzard) were measured using an electronic scale and the values were expressed as a percentage of the live weight.

***Gut Morphometry* :**

The duodenum, jejunum, ileum, caecum and large intestine of the birds slaughtered at day 49th of the experiment were measured. The live body weight and weight of the digestive tract segments from the crop to the caeca of each bird were determined by weighing the wet tissue having fasted the birds for 12 hours. The length of each of the intestinal segments was determined with a flexible tape on a glass surface to prevent inadvertent stretching (Lentle *et al.*, 1998). The lenght (±0.1mm) of the duodenum from the pyloric junction to the distal-most point of insertion of the duodenal mesentery, the length of the jejunum (from the distal-most point of insertion of the duodenal mesentery to the junction with Meckel's diverticulum), the length of the ileum (from the junction with Meckel's diverticulum to the ileocecal junction) and the sum of the lengths from the ostium to the tip of each caeca was determined according to the method of Aderibigbe (2013).

***Sensory Evaluation*:**

Meat samples (100g) were collected from the breast part of carcasses from each treatment. The samples were washed individually in clean water and packed into labeled polythene nylon bags for identification. The samples were cooked in a water bath at 70 ℃ for 15 minutes without any seasoning. The cooked meat samples were cooled to room temperature and were served in a random order to panelists. Sensory evaluation was performed by 10 semi-trained panelists within the age range of 20 -35years old who were undergraduate and postgraduate students of the Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, Ogbomoso, Oyo State. Water was served after each sample to rinse the mouth to remove traces of the previous sample. The panelists were trained accordingly to assess the sensory properties using a 9-point hedonic scale for the appearance, juiciness, flavour, tenderness, saltiness and overall acceptability (Yetim and Kesmen, 2009). The scale consists of scores 1 to 9, with 1 referring to extremely dislike and 9 as extremely like, as described by Akinwumi *et al*. (2013).

Statistical analysis:

All data collected were subjected to analysis of variance appropriate for a 2 x 3 factorial. Treatment means were separated using Duncan's Multiple Range Test as contained in the SAS (2010) package.

Results and discussion

The Carcass characteristics of broiler chickens fed Shea Butter Cake (SBC) with or without enzyme supplementation is presented in Table 4.

Table 4: Relative carcass characteristics of broiler chickens fed Shea Butter Cake (SBC) with or without enzyme supplementation

Parameters (%)	T1	T2	T3	T4	T5	T6	SEM	P-value
Live weight (g)	2175.00^{b}	1362.50^{c}	775.00^{d}	2300.00^{a}	1425.00^{c}	887.50^{d}	43.89	0.03
(% liveweight)								
Bled weight	97.62^{a}	96.45^{b}	93.86^{c}	95.69^{b}	95.97^{b}	93.76^{c}	1.35	0.03
DE-feathered weight	92.60^{b}	91.77^{b}	95.77^{a}	91.77^{b}	89.85^{b}	87.89^{c}	3.63	0.04
Eviscerated weight	82.98^{a}	80.18^{b}	76.67^{b}	82.05^{a}	71.60^{b}	68.92^{c}	8.23	0.03
Carcass weight	70.88	70.40	57.59	60.96	59.31	57.24	10.06	0.09
Head	2.22^{c}	2.65^{b}	3.49^{a}	2.01^{c}	2.61^{b}	2.93^{b}	0.52	0.02
Neck	2.82	3.31	8.63	2.83	3.03	4.25	4.69	0.07
Wing	6.63^{c}	7.93^{b}	8.69^{a}	7.72b	7.95^{b}	8.25^{b}	1.17	0.03
Back	12.90	13.92	12.56	12.49	13.02	11.86	1.88	0.08
Breast	25.51^{a}	22.23^{b}	17.12^{c}	22.14^{b}	20.84^{b}	17.86^{c}	4.13	0.02
Thigh	12.05^{a}	9.73^{c}	9.06^{c}	10.37^{b}	9.96^{c}	8.85^{c}	1.58	0.04
Drum stick	9.99	9.17	9.49	7.54	9.38	8.79	1.55	0.11
Shank	4.25^{b}	4.34^{b}	5.13^{a}	3.48^{c}	4.37^{b}	6.21^{a}	1.30	0.03

^{abc}Means on the same row with different superscripts are significantly different (P<0.05)
SEM: Standard Error of Mean

The result shows that there were significant differences (P<0.05) in final weight, relative bled weight, relative de-feathered weight, relative eviscerated weight, relative head, relative wing, relative breast, relative thigh and relative shank, but no significant (P>0.05) differences were observed in relative carcass weight, neck, back and drumstick of broiler chickens. This result corroborates the findings of Aguihe *et al*. (2017), who reported (P<0.05) significant differences in final live weight, bled weight, breast, thigh, drumstick, wing and back weight of birds fed diet without SBC and birds fed SBC supplemented with multi-strain probiotics. However, Adebayo *et al*. (2020) reported no significant difference (P>0.05) in carcass weight in birds fed diets containing fermented-cooked cake of Shea nut meal.

The broiler chickens fed 0% shea butter cake with enzyme supplementation (T4) had the highest value (2300.00g) of live weight while the lowest live weight (775.00g) was observed in birds fed 20% shea butter cake without enzyme supplementation (T3) which is similar to the value (887.50g) observed in birds fed 20% shea butter cake with enzyme supplementation (T6). This result negates the findings of Adebayo *et al*. (2020), who reported that live weight of birds fed multi-enzyme-supplemented fermented shea butter cake-based diets was similar to that of the control (0% SBC) diet but significantly higher (p<0.05) than the group fed fermented shea butter cake diet. Birds fed 0% shea butter cake without enzyme supplementation (T1) had the highest value (97.62%) of bled weight, while the lowest value (93.76%) was obtained in birds fed 20% shea butter cake with enzyme supplementation (T6). The highest value (95.77%) of De-feathered weight was obtained in broiler chickens fed 20% shea butter cake without enzyme supplementation (T3), while the lowest value (87.89%) was observed in birds fed 20% shea butter cake with enzyme supplementation (T6). The highest value (82.98%) of eviscerated weight was observed in broiler chickens fed 0% shea butter cake without enzyme supplementation (T1) which is similar to the value (82.05%) observed in birds fed 0% shea butter cake with enzyme supplementation (T4) while the lowest value (68.92%) was obtained in birds fed 20% shea butter cake with enzyme supplementation (T6). This result corroborates the findings of Adebayo *et al*. (2020), who reported that the eviscerated weight of birds fed a control diet (0% shea butter cake) was higher ($P<0.05$) compared to birds fed multi-enzyme-supplemented fermented shea butter cake-based diets, an indication that dietary treatments influenced carcass yield and the distribution of cut-up parts. The observed variations in carcass components such as breast, thigh and shank suggest that inclusion of SBC, particularly at higher levels, affected muscle deposition and tissue development. This aligns with the findings of Oladokun *et al*. (2019), who reported that broilers fed diets containing agro-industrial by-products like Shea Butter Cake exhibited reduced carcass yield due to increased dietary fibre and lower nutrient digestibility.

The highest value (4.49%) of head was obtained in Treatment 3, while the lowest value (2.01g) was observed in Treatment 4, which is similar to the value (2.22%) obtained in Treatment 1. Treatment 3 had the highest value (8.69%) of wing weight, while the lowest value (6.63%) was obtained in Treatment 1. The highest value (25.51%) of breast meat weight was obtained in Treatment 1, while the lowest value (17.12%) was observed in Treatment 3, which is similar to the value (17.86%) in Treatment 6. The highest value of thigh (12.05%) was observed in Treatment 1, while the lowest value (8.85%) was obtained in Treatment 6, which is similar to the values (9.73, 9.06 and 9.96%) in T2, T3 and T5, respectively. Treatment 3 had the highest value (5.13%) of shank weight while the lowest value (3.48%) was obtained in Treatment 4.

Significantly ($p<0.05$) high relative breast, relative thigh, relative head, relative shank and relative wing were observed in the birds fed shea butter cake with or without enzyme supplementation diets similar to the control group. This is in accordance with the findings of Fathi *et al*. (2012) and Mutassim (2013) who reported that supplementation of probiotic increased the carcass prime-cuts yield in broilers. The interaction effect of shea butter cake with or without enzyme supplementation and replacement level on relative carcass characteristics of broiler chickens is presented in Table 5.

Table 5. Interaction Effect of replacing maize with shea butter cake on relative carcass characteristics of broiler chickens

		Shea butter cake replacement levels (%)			
Parameters	Ingredients	0%	10%	20%	**SEM**
Live weight (g)	SBC without Enzyme	2175.00^{aY}	1362.50^{b}	775.00^{c}	**31.36**
	SBC with Enzyme	2300.00^{aX}	1425.00^{b}	887.50^{c}	**31.36**
	SEM	**38.42**	**38.42**	**38.42**	
Bled (%)	SBC without Enzyme	97.62^{a}	96.45^{a}	94.29^{c}	**0.69**
	SBC with Enzyme	96.45^{a}	95.97^{b}	93.75^{c}	**0.69**
	SEM	**0.84**	**0.84**	**0.84**	
De-feathered (%)	SBC without Enzyme	92.60	91.76	89.88	**1.23**
	SBC with Enzyme	91.76	89.86	87.89	**1.23**
	SEM	**1.50**	**1.50**	**1.50**	
Eviscerated (%)	SBC without Enzyme	82.98^{a}	80.18^{b}	76.67^{b}	**2.88**
	SBC with Enzyme	82.05^{a}	71.60^{c}	68.92^{c}	**2.88**
	SEM	**3.53**	**3.53**	**3.53**	
Carcass (%)	SBC without Enzyme	70.88	70.40	57.59	**3.78**
	SBC with Enzyme	60.96	59.31	57.24	**3.78**
	SEM	**4.63**	**4.63**	**4.63**	
Head (%)	SBC without Enzyme	2.22^{c}	2.65^{b}	3.49^{aX}	**0.09**
	SBC with Enzyme	2.01^{c}	2.61^{b}	2.93^{aY}	**0.09**
	SEM	**0.11**	**0.11**	**0.11**	
Neck (%)	SBC without Enzyme	2.82	3.31	8.63	**1.94**
	SBC with Enzyme	2.83	3.03	4.25	**1.94**
	SEM	**2.37**	**2.37**	**2.37**	
Wing (%)	SBC without Enzyme	6.63^{c}	7.93^{b}	8.69^{a}	**0.45**
	SBC with Enzyme	7.72^{c}	7.95^{b}	8.25^{a}	**0.45**
	SEM	**0.55**	**0.55**	**0.55**	
Back (%)	SBC without Enzyme	12.90	13.92	12.56	**0.82**
	SBC with Enzyme	12.49	13.02	11.86	**0.82**
	SEM	**0.99**	**0.99**	**0.99**	
Breast (%)	SBC without Enzyme	25.51^{a}	22.23^{b}	17.12^{c}	**1.36**
	SBC with Enzyme	22.14^{b}	20.84^{b}	17.86^{c}	**1.36**
	SEM	**1.67**	**1.67**	**1.67**	
Thigh (%)	SBC without Enzyme	12.05^{aX}	9.73^{b}	9.06^{c}	**0.53**
	SBC with Enzyme	10.37^{aY}	9.96^{b}	8.85^{c}	**0.53**
	SEM	**0.66**	**0.66**	**0.66**	
Drum stick (%)	Breadnut leaf	9.99^{X}	9.17	9.49	**0.62**
	Breadfruit leaf	7.54^{Y}	9.38	8.79	**0.62**
	SEM	**0.75**	**0.75**	**0.75**	
Shank (%)	Breadnut leaf	4.25^{c}	4.33^{b}	5.13^{a}	**0.45**
	Breadfruit leaf	3.48^{c}	4.37^{b}	6.21^{a}	**0.45**
	SEM	**0.55**	**0.55**	**0.55**	

^{abc} Means on the same row with different superscripts are significantly different ($p<0.05$)
^{XY} Means on the same column with different superscripts are significantly different ($p<0.05$)
SEM= Standard error of mean

There was a significant (P<0.05) interaction effect observed on live weight, relative head weight, relative thigh weight and relative drum stick weight.

Broiler chickens fed 0% shea butter cake with enzyme supplementation had a significant (P<0.05) higher live weight (2300.00g) compared with the counterparts fed the same replacement level of shea butter cake without enzyme supplementation, which had 2175.00g. The higher live weight observed in the 0% SBC enzyme supplemented group could be as a result of the cumulative effect of the enzymatic action, including increased digestive enzyme activity, maintenance of beneficial microbial population, and neutralising the effect of feed toxins in the gut environment for improved digestion and nutrient utilization (Chen *et al.* 2013). This finding is in line with the reports of previous research (Nawaz *et al*., 2016) which established higher live weight and better carcass yield in birds fed a diet containing *Lactobacillus and Saccharomyces species.*

Birds fed 0% shea butter cake without enzyme supplementation had significantly (p<0.05) higher weight (12.05 and 9.99%) for relative thigh and relative drumstick weight, respectively, compared with the counterparts fed the same replacement level of shea butter cake with enzyme supplementation. Broiler chickens fed 20% shea butter cake without enzyme supplementation had significantly (p<0.05) higher weight (3.49%) for relative head weight compared with the counterparts fed the same replacement level of shea butter cake with enzyme supplementation. This result contradicts the findings of Aguihe *et al*. (2017), who reported a significantly higher (p < 0.05) breast, thigh, drumstick, wing and back meat yield in the birds fed shea butter cake supplemented with probiotic, which is similar to the control diet group. Furthermore, the result also negates the findings of Fathi *et al* (2012) and Mutassim (2013) who reported that supplementation of probiotic increased the carcass prime-cuts yield in broilers.

The relative organ characteristics of broiler chickens fed diets containing shea butter cake with or without enzyme supplementation are presented in Table 6.

The result shows that dietary treatment had a significant effect (p<0.05) on relative pancreas, relative kidney and relative abdominal fat. However, non-significant (P>0.05) effect was observed on the liver, heart and lungs.

Table 6: Relative Organ characteristics and abdominal fat of broiler chicken fed Shea butter cake with or without enzyme supplementation

Parameters (%)	T1	T2	T3	T4	T5	T6	SEM	P-value
Liver	2.52	2.48	2.29	2.33	2.21	2.34	0.17	0.79
Pancreas	0.29^{c}	0.44^{a}	0.23^{d}	0.32^{b}	0.28^{c}	0.26^{c}	0.02	0.02
Kidney	0.43^{b}	0.29^{c}	0.33^{b}	0.42^{b}	0.49^{a}	0.39^{b}	0.05	0.04
Heart	0.41	0.48	0.48	0.44	0.47	0.48	0.05	0.86
Lungs	0.52	0.55	0.53	0.62	0.63	0.42	0.07	0.33
Abdominal Fat	0.67^{a}	0.28^{b}	0.12^{c}	0.26^{b}	0.23^{b}	0.01^{d}	0.15	0.04

^{abcd} Means in the same row with different superscripts are significantly different (p<0.05)

SEM Standard Error of Mean

This result corroborates the report of Aguihe *et al*. (2020), who observed that shea butter cake had no significant effect on liver, heart and lungs of broiler chickens, implying that shea butter cake had no adverse effect on the development of these organs. Birds fed 10% shea butter cake without enzyme supplementation (T2) had the highest value (0.44%) for relative pancreas, while birds fed 20% shea butter cake without enzyme supplementation (T3) had the lowest value

(0.23%). The increase in the weight of the pancreas suggested an increase in pancreatic activity due to the presence of anti-nutritional factors. However, this result negates the findings of Aguihe *et al*. (2020), who reported that shea butter cake has no significant effect on the pancreas of broiler chickens. The relative kidney weight (0.49%) of broiler chickens fed 10% shea butter cake with enzyme supplementation (T5) is higher, while birds fed 10% shea butter cake without enzyme supplementation (T2) had the lowest relative kidney weight (0.29%). The increase in kidney weight observed in birds fed an enzyme-supplemented diet possibly reflects metabolic adjustments. This result supports the findings of Agbetuyi and Oloruntola (2020), who reported a significant effect on kidney weight in broiler chickens fed shea butter cake. The broiler chickens fed 0% shea butter cake without enzyme supplementation (T1) had the highest value (0.67%) for relative abdominal fat, while birds fed 20% shea butter cake without enzyme supplementation (T6) had the lowest value (0.01%) of relative abdominal fat. This indicates that shea butter cake promotes leaner carcass yield when combined with enzymes.

This result corroborates the findings of Aguihe *et al*. (2017); Aguihe *et al*. (2020) who reported a decrease in abdominal fat at the inclusion of a fermented shea butter cake diet containing supplemental multi-enzymes and probiotic. The results suggest that enzyme supplementation helps to mitigate the negative effects of shea butter cake on organ hypertrophy while enhancing fat reduction.

The interaction effect of shea butter cake with or without enzyme supplementation and replacement level on relative organ characteristics of broiler chicken is presented in Table 7.

Table 7:Interaction Effect of replacing maize with shea butter cake on relative organ characteristics of broiler chickens

		Shea butter cake replacement levels (%)			
Parameters	Ingredients	0%	10%	20%	SEM
Liver (%)	SBC without Enzyme	2.52	2.48	2.29	**0.14**
	SBC with Enzyme	2.33	2.21	2.34	**0.14**
	SEM	**0.17**	**0.17**	**0.17**	
Pancreatic (%)	SBC without Enzyme	0.29^{b}	0.44^{aX}	0.23^{c}	**0.01**
	SBC with Enzyme	0.32^{a}	0.28^{By}	0.26^{c}	**0.01**
	SEM	**0.02**	**0.02**	**0.02**	
Kidney (%)	SBC without Enzyme	0.43^{b}	0.45^{a}	0.33^{c}	**0.04**
	SBC with Enzyme	0.42^{b}	0.49^{a}	0.39^{c}	**0.04**
	SEM	**0.06**	**0.06**	**0.06**	
Heart (%)	SBC without Enzyme	0.41	0.48	0.48	**0.04**
	SBC with Enzyme	0.44	0.47	0.48	**0.04**
	SEM	**0.05**	**0.05**	**0.05**	
Lungs (%)	SBC without Enzyme	0.52	0.55	0.53	**0.06**
	SBC with Enzyme	0.62	0.63	0.42	**0.06**
	SEM	**0.07**	**0.07**	**0.07**	
Abdominal fat (%)	SBC without Enzyme	0.67^{aX}	0.27^{b}	0.12^{c}	**0.11**
	SBC with Enzyme	0.25^{bY}	0.22^{b}	0.09^{c}	**0.11**
	SEM	**0.13**	**0.13**	**0.13**	

[abc] Means on the same row with different superscripts are significantly different ($p<0.05$)
[XY] Means on the same column with different superscripts are significantly different ($p<0.05$)

There was a significant ($p<0.05$) interaction effect observed on relative pancreatic weight and relative abdominal fat weight. Broiler chickens fed 10% shea butter cake without enzyme supplementation had ($p<0.05$) higher weight (0.44%) for relative pancreatic weight compared with the counterparts fed the same replacement level of shea butter cake with enzyme supplementation. This contradicts the findings of Aguihe *et al*. (2020), who documented a non-significant ($p>0.05$) effect of fermented shea butter cake meal (FSBCM) based diet containing supplemental multienzymes+probiotic (MEP) on the broiler chickens' pancreas.

Birds fed 0% shea butter cake without enzyme supplementation had ($p<0.05$) higher weight (0.67%) for relative abdominal fat weight compared with the counterparts fed the same replacement level of shea butter cake supplemented with enzyme, which had 0.25%. This may be attributed to the reducing effect of enzyme on fat deposition. This result corroborates the findings of Aguihe *et al*. (2020), who reported a decrease in abdominal fat of broiler chickens fed a fermented shea butter cake meal (FSBCM) based diet containing supplemental multienzymes+probiotic (MEP). However, Corcoran *et al*. (2005) documented that fat digestion rate is linked to the rate of gallbladder acids in digestive tract and subsequently the lipid concentration. Meanwhile, it has also been documented that enzyme in diets causes a reduction in gallbladder acids, and this resulted in a decrease in fat digestion (Corcoran *et al*., 2005; Getachew, 2016), and, therefore, could be responsible for decreased abdominal fat deposition in the carcass.

The gut morphology of broiler chickens fed diets containing shea butter cake with or without enzyme supplementation is presented in Table 8.

The result shows that dietary treatment had a significant effect ($p<0.05$) on relative proventriculus, relative large intestine weight, large intestine length, relative caecum weight, caecum length, relative jejunum weight, jejunum length, ileum length, relative ileum weight, duodenum length, relative duodenum weight, relative oesophagus weight, oesophagus length and relative empty gizzard and relative whole gizzard. However, dietary treatment had no significant effect ($P> 0.05$) on relative crop. This contradicts the findings of Aguihe *et al*. (2020) who reported that shea butter cake does not significantly influence both small and large intestine.

Table 8: Gut morphometry of broiler chicken fed Shea butter cake with or without enzyme supplementation

Parameters	T1	T2	T3	T4	T5	T6	SEM	p-value
Crop (g)	0.62	0.56	0.49	0.26	0.42	0.48	0.12	0.79
Proventriculus (g)	0.39^{c}	0.53^{b}	0.65^{a}	0.36^{c}	0.58^{b}	0.48^{b}	0.04	0.02
Large Intestine weight (g)	0.18^{bc}	0.27^{b}	0.34^{b}	0.24^{b}	0.35^{b}	0.71^{a}	0.14	0.03
Large Intestine length (cm)	0.54^{c}	0.63^{c}	1.31^{a}	0.56^{c}	0.97^{b}	1.39^{a}	0.10	0.02
Caecum weight (g)	0.55^{c}	0.94^{b}	1.37^{a}	0.85^{b}	1.05^{b}	1.28^{a}	0.19	0.04
Caecum Length (cm)	1.16^{c}	1.43^{c}	2.56^{a}	1.06^{c}	1.74^{b}	2.24^{a}	0.19	0.02
Jejunum weight (g)	1.92^{c}	2.86^{b}	4.29^{a}	2.03^{c}	2.96^{b}	4.65^{a}	0.47	0.04
Jejunum Length (cm)	5.04^{c}	6.09^{b}	11.91^{a}	4.49^{c}	7.72^{b}	11.95^{a}	0.78	0.03
Ileum weight (g)	1.49^{c}	1.97^{b}	3.19^{a}	1.36^{c}	2.13^{b}	3.37^{a}	0.35	0.04
Ileum/ Length (cm)	4.85^{c}	7.85^{b}	11.43^{a}	4.33^{c}	6.78^{b}	9.72^{b}	1.16	0.04
Duodenum weight (g)	0.68^{c}	0.85^{c}	1.88^{a}	0.71^{c}	1.06^{b}	1.79^{a}	0.18	0.03
Duodenum Length (cm)	1.87^{c}	2.66^{b}	4.64^{a}	1.59^{c}	2.76^{b}	4.15^{a}	0.25	0.04
Oesophagus weight (g)	0.31^{b}	0.41^{a}	0.26c	0.29^{c}	0.38^{a}	0.31^{b}	0.03	0.04
Oesophagus Length (cm)	1.10^{c}	1.38^{b}	1.92^{a}	0.92^{c}	1.34^{b}	1.84^{a}	0.08	0.02
Whole Gizzard (g)	3.06^{b}	3.09^{b}	4.38^{a}	2.34^{c}	3.57^{a}	3.95^{a}	0.22	0.03
Empty Gizzard (g)	2.00^{c}	1.95^{c}	2.49^{a}	1.72^{c}	2.31^{b}	2.37^{a}	0.15	0.02

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

SEM Standard Error of Mean

The broiler chickens fed 20% shea butter cake with enzyme supplementation (T6) had the ($P<0.05$) highest value (0.71% and 1.39cm) for relative large intestine weight and large intestine length, respectively. This reflects improved intestinal adaptation. The birds fed 20% shea butter cake with enzyme supplementation (T6) had ($P<0.05$) the highest value (4.65% and 11.95cm) for relative jejunum weight and jejunum length, respectively, which is similar to the value (4.29% and 11.91cm respectively) obtained in birds fed 20% shea butter cake without enzyme supplementation (T3). This indicates optimum response of this segment to the dietary treatments. The broiler chickens fed 20% shea butter cake with enzyme supplementation had ($P<0.05$) the highest value (3.37% and 4.15cm) for relative ileum weight and duodenum length, respectively, suggesting expansion of absorptive surface area and significant impact of the enzyme supplementation in the diet. Table 9 summarises the interaction effect of shea butter cake with or without enzyme supplementation at different replacement levels on relative gut morphology of broiler chickens fed different levels of shea butter cake with or without enzyme supplementation.

Table 9: Interaction Effect of replacing maize with shea butter cake on relative gut morphology of broiler chickens

		Shea butter cake replacement levels (%)			
Parameters	Ingredients	0%	10%	20%	**SEM**
Crop (%)	SBC without Enzyme	0.62^{X}	0.56	0.49	**0.10**
	SBC with Enzyme	0.26^{Y}	0.42	0.48	**0.10**
	SEM	**0.12**	**0.12**	**0.12**	
Proventriculus (%)	SBC without Enzyme	0.39^{c}	0.53^{b}	0.65^{aX}	**0.03**
	SBC with Enzyme	0.36^{c}	0.58^{b}	0.48^{bY}	**0.03**
	SEM	**0.04**	**0.04**	**0.04**	
Large Intestine (%)	SBC without Enzyme	0.18^{c}	0.27^{b}	0.34^{bY}	**0.12**
	SBC with Enzyme	0.24^{c}	0.35^{b}	0.71^{aX}	**0.12**
	SEM	**0.14**	**0.14**	**0.14**	
Large Intestine (Cm)	SBC without Enzyme	0.54^{c}	0.63^{bY}	1.31^{a}	**0.09**
	SBC with Enzyme	0.56^{c}	0.97^{Bx}	1.38^{a}	**0.09**
	SEM	**0.10**	**0.10**	**0.10**	
Caecum (%)	SBC without Enzyme	0.55^{c}	0.94^{b}	1.37^{a}	**0.17**
	SBC with Enzyme	0.85^{c}	1.05^{b}	1.28^{a}	**0.17**
	SEM	**0.19**	**0.19**	**0.19**	
Caecum (Cm)	SBC without Enzyme	1.16^{c}	1.43^{b}	2.56^{a}	**0.16**
	SBC with Enzyme	1.06^{c}	1.74^{b}	2.24^{a}	**0.16**
	SEM	**1.90**	**1.90**	**1.90**	
Jejunum (%)	SBC without Enzyme	1.92^{c}	2.86^{b}	4.29^{a}	**0.42**
	SBC with Enzyme	2.03^{c}	2.96^{b}	4.64^{a}	**0.42**
	SEM	**0.47**	**0.47**	**0.47**	
Jejunum (Cm)	SBC without Enzyme	5.04^{c}	6.09^{b}	11.91^{a}	**0.69**
	SBC with Enzyme	4.49^{c}	7.72^{b}	11.95^{a}	**0.69**
	SEM	**0.78**	**0.78**	**0.78**	
Ileum (%)	SBC without Enzyme	1.49^{c}	1.97^{b}	3.19^{a}	**0.31**
	SBC with Enzyme	1.36^{c}	2.13^{b}	3.28^{a}	**0.31**
	SEM	**0.35**	**0.35**	**0.35**	
Ileum (Cm)	SBC without Enzyme	4.85^{c}	7.85^{b}	11.43^{a}	**1.03**
	SBC with Enzyme	4.33^{c}	6.78^{b}	9.72^{a}	**1.03**
	SEM	**1.16**	**1.16**	**1.16**	
Duodenum (%)	SBC without Enzyme	0.67^{c}	0.85^{b}	1.88^{a}	**0.15**
	SBC with Enzyme	0.71^{c}	1.06^{b}	1.78^{a}	**0.15**
	SEM	**0.18**	**0.18**	**0.18**	
Duodenum (Cm)	SBC without Enzyme	1.87^{c}	2.66^{b}	4.64^{a}	**0.22**
	SBC with Enzyme	1.59^{c}	2.76^{b}	4.15^{a}	**0.22**
	SEM	**0.25**	**0.25**	**0.25**	
Oesophagus (%)	SBC without Enzyme	0.31^{b}	0.41^{a}	0.26^{c}	**0.02**
	SBC with Enzyme	0.29^{c}	0.38^{a}	0.31^{b}	**0.02**
	SEM	**0.03**	**0.03**	**0.03**	
Oesophagus (Cm)	SBC without Enzyme	1.10^{c}	1.38^{b}	1.92^{a}	**0.07**
	SBC with Enzyme	0.92^{c}	1.34^{b}	1.84^{a}	**0.07**
	SEM	**0.08**	**0.08**	**0.08**	
Gizzard Whole (%)	SBC without Enzyme	3.06^{b}	3.09^{b}	4.38^{a}	**0.19**
	SBC with Enzyme	2.34^{c}	3.57^{b}	3.95^{a}	**0.19**
	SEM	**0.22**	**0.22**	**0.22**	
Gizzard (%)	SBC without Enzyme	2.00^{b}	1.95^{c}	2.49^{a}	**0.13**
	SBC with Enzyme	1.72^{c}	2.31^{a}	2.37^{a}	**0.13**
	SEM	**0.15**	**0.15**	**0.15**	

[abc] Means on the same row with different superscripts are significantly different (p<0.05)
[XY] Means on the same column with different superscripts are significantly different (p<0.05),
SEM= Standard error of mean

There was significant (p<0.05) interaction effect observed for relative crop weight, relative proventriculus weight and relative large intestine weight. This result negate the report of Yaqoob *et al*. (2022) who documented a non-significant effect of soybean meal replaced with sunflower meal on relative crop weight, relative proventriculus weight and relative large intestine weight of broiler chickens. The broiler chickens fed 0% shea butter cake without enzyme supplementation had significantly (P<0.05) higher weight (0.62%) for relative crop weight compared with their counterparts fed the same replacement level of shea butter cake with enzyme supplementation, which had 0.26%. This suggests that the absence of enzyme supplementation may enhance the efficiency of nutrient absorption in the crop, possibly due to a more favourable microbial environment or reduced competition for nutrients (Sivakanesan *et al*., 2020).

Birds fed 20% shea butter cake without enzyme supplementation had significantly (p<0.05) higher weight (0.65%) for relative proventriculus weight compared with their counterparts fed the same replacement level of shea butter cake with enzyme supplementation, which had 0.48%. This result further supports the notion that enzyme supplementation may alter the digestive physiology of broiler chickens. The proventriculus plays a critical role in the digestion of feed, and a heavier proventriculus may indicate improved feed utilisation or a response to higher fibre content in the diet (Moran, 2009).

Broiler chickens fed 20% shea butter cake with enzyme supplementation had significantly (p<0.05) higher weight (0.71%) for relative large intestine weight compared with their counterparts fed the same replacement level of shea butter cake without enzyme supplementation, which had 0.34%. This finding could imply that the addition of enzymes facilitates the breakdown of complex carbohydrates, leading to increased fermentation and nutrient absorption in the large intestine (Kiarie *et al*., 2013). The enhanced gut health and nutrient availability in birds receiving enzyme supplementation may contribute to better overall growth performance, as reflected in other studies highlighting the benefits of enzyme use in poultry diets (Selle and Ravindran, 2007).

The organoleptic properties of broiler chickens fed diets containing shea butter cake with or without enzyme supplementation is presented in Table 10.

Table 10: Organoleptic properties of broiler chickens fed Shea Butter Cake (SBC) with or without enzyme supplementation

Parameters (%)	T1	T2	T3	T4	T5	T6	SEM	p-value
Colour	6.80^a	5.70^b	6.10^b	6.80^a	6.00^b	5.00^c	0.44	0.02
Flavour	7.20^a	6.10^b	5.30^c	6.10^b	6.00^b	6.00^b	0.44	0.03
Juiciness	6.70	5.90	6.00	6.00	5.60	6.70	0.50	0.08
Tenderness	6.70	6.00	5.70	5.70	5.90	5.60	0.53	0.06
Overall Acceptability	6.50	6.50	6.20	6.20	5.40	6.90	0.52	0.09

[abc]Means on the same row with different superscripts are significantly different (P<0.05)
SEM: Standard Error of Mean
Diet 1= control diet

The dietary treatment did not significantly influence (P>0.05) the sensory properties of the broiler chicken breast meat except colour and flavour (P<0.05).

Broiler chickens fed 0% shea butter cake with enzyme supplementation had (T4) had higher (P<0.05) value (6.80) for colour which is similar to the value (6.80) obtained in broilers 0% shea butter cake without enzyme supplementation, while birds fed 20% shea butter cake with enzyme supplementation had the lowest (P < 0.05) value (5.00) for colour. This result suggests that high inclusion of SBC may affect the pigmentation or oxidative stability of meat colour, possibly due to variations in dietary fat composition or pigment precursors. Similar findings were reported by Adebayo *et al.* (2020) and Oladunjoye and Olorode (2011), who observed that increasing levels of unconventional feed ingredients such as shea butter cake and palm kernel cake reduced carcass colour intensity in broilers. Amaefule *et al.* (2011) also reported that diets high in fibrous by-products could alter muscle colour through changes in fat deposition and feed metabolite composition.

Broiler chickens fed 0% shea butter cake without enzyme supplementation (T1) had (P<0.05) a higher value (7.20) for flavour, while birds fed 20% shea butter cake without enzyme supplementation had (P<0.05) the lowest value (5.30) for flavour. The reduction in flavour with increasing SBC inclusion might be associated with residual shea butter odour, which could impart a less desirable taste when used excessively. However, moderate inclusion level of 10% shea butter cake with enzyme supplementation (T5) maintained acceptable flavour scores comparable to the 0% shea butter cake with enzyme supplementation (T5). These findings agree with Ojewola *et al.* (2004) and Esonu *et al.* (2006), who reported that moderate incorporation of agro-industrial by-products in poultry diets did not adversely affect meat flavour, especially when supplemented with enzymes to improve nutrient digestibility and reduce anti-nutritional effects.

Table 11 summarises the interaction effect of shea butter cake with or without enzyme supplementation at different replacement levels on organoleptic properties of broiler chickens fed different levels of shea butter cake with or without enzyme supplementation.

Table 11: Interaction Effect of replacing maize with shea butter cake on organoleptic properties of broiler chickens

		Shea butter cake replacement levels (%)			
Parameters	Ingredients	0%	10%	20%	**SEM**
Colour	SBC without Enzyme	6.80^{a}	5.70^{c}	6.10^{b}	**0.35**
	SBC with Enzyme	6.80^{a}	6.00^{b}	5.00^{c}	**0.35**
	SEM	**0.44**	**0.44**	**0.44**	
Flavour	SBC without Enzyme	7.20^{aX}	6.10b	5.30c	**0.36**
	SBC with Enzyme	6.10^{bY}	6.00b	6.00b	**0.36**
	SEM	**0.44**	**0.44**	**0.44**	
Juiciness	SBC without Enzyme	6.70	5.90	6.00	**0.41**
	SBC with Enzyme	6.00	5.60	6.70	**0.41**
	SEM	**0.50**	**0.50**	**0.50**	
Tenderness	SBC without Enzyme	6.70	6.00	5.70	**0.43**
	SBC with Enzyme	5.70	5.90	5.60	**0.43**
	SEM	**0.53**	**0.53**	**0.53**	
Overall acceptability	SBC without Enzyme	6.50	6.50	6.20	**0.42**
	SBC with Enzyme	6.20	6.40	6.90	**0.42**
	SEM	**0.52**	**0.52**	**0.52**	

[ab] Means on the same row with different superscripts are significantly different ($p<0.05$)
[XY] Means on the same column with different superscripts are significantly different ($p<0.05$)
SEM= Standard error of mean

There was a significant ($P<0.05$) interaction effect observed for flavour of broiler chicken breast meat fed shea butter cake with or without enzyme supplementation. Broiler chickens fed 0% shea butter cake without enzyme supplementation had significant ($P<0.05$) higher value (7.20) for flavour compared to their counterparts fed shea butter cake with enzyme supplementation, which had 6.10. The higher flavour score in chickens fed shea butter cake without enzymes suggests that the natural compounds present in shea butter may have contributed positively to the flavour profile because shea butter is known for its unique fatty acid composition, which could enhance the palatability of the meat (Long *et al*., 2020). This result supports the findings of Mir *et al*. (2017), who documented that the flavour of poultry meat is significantly influenced by the diet composition, with some unconventional feeds like shea butter cake potentially offering unique flavour characteristics. However, the result of this study suggested that the inclusion of enzymes in the diet influences the breast meat flavour. This could be attributed to the possibility that enzymes alter the breakdown of certain flavour compounds in the feed, thus impacting the overall sensory properties of the broiler chicken breast meat (Ali *et al*., 2025).

Conclusion

It was concluded that incorporating shea butter cake in broiler chickens' diet at 10% to replace maize enhances the carcass traits, relative prime-cut and meat quality of broiler chickens and diet four with enzyme supplementation produces the larges weight gain, this establishes the role of enzyme in the broiler production. However, 20% SBC, particularly with enzyme supplementation, enhanced SBC utilisation with minimal abdominal fat and enhanced digestive efficiency.

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