Carcass Characteristics and Sensory Quality of Broilers Fed on Extruded Sorghum [*Sorghum Bicolor* (L.) Moench] Meal and Exogenous Phytase-Based Diets

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Abstract

The interest in alternative energy sources in diets for sustainable poultry production is increasing. However, there is inadequate information on their effect on broiler production in terms of growth performance and meat quality. This study investigated the effect of extruded sorghum meal (ESM) and exogenous phytase enzyme on broiler carcass characteristics and descriptive sensory quality. A total of 108 day-old Cobb 500® chicks were weighed, grouped in six and randomly placed in deep litter cages. Each cage was randomly assigned one of the six dietary treatments with three replicates: T1 (0% ESM + 0% phytase), T2 (0% ESM + 0.035% phytase), T3 (50% ESM + 0% phytase), T4 (50% ESM + 0.035% phytase), T5 (100% ESM + 0% phytase), and T6 (100% ESM + 0.035% phytase). The grower and finisher diets were offered from days 1-21 and 22-42, respectively. After day 42, all broilers were weighed, and three randomly sampled from each treatment for carcass characteristics and descriptive sensory quality. The carcass weights and the weights of carcass parts were expressed as a percentage of live weight. A total of 10-12 panellists rated the sensory attributes of the meat on a quantitative descriptive analysis scale and just-about-right scale. Data was subjected to two-way analysis of variance in a completely randomized design using the general linear model procedure of the SAS Institute Inc. (version 9.4; 2015). Mean separation was done using Tukey's HSD test at 0.05 level of significance. Results showed that inclusion of ESM above 50% in the diets reduced carcass weights, abdominal fat, and gizzard weight. All sensory attributes were satisfactory. The inclusion of ESM up to 50% and exogenous phytase enzyme did not affect carcass characteristics or descriptive sensory quality. Thus, ESM may be included up to 50% with exogenous phytase enzyme in broiler diets without adversely affecting broiler carcass characteristics and descriptive sensory quality.

Keywords: descriptive, dressing percentage, gizzard, juiciness, tenderness,

Introduction

Despite a lot of attention being drawn to alternative energy sources to maize grain in poultry feeds, maize is still the most commonly used energy cereal in broiler feeds. Maize which is a staple food is demanded for biofuels production in developed countries, creating severe competition and thus increasing its global market price. This affects the sustainability of poultry production, and food and nutrition security, particularly in developing countries. Therefore, this has stimulated interest to evaluate alternative energy sources in poultry diets (Alshelmani et al., 2021).

Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth most important food and feed cereal crop globally, after maize, wheat, rice, and barley (Awika & Rooney, 2004). In comparison with maize, sorghum is drought tolerant and does well under varying soil types. The nutrient composition of sorghum is similar to maize grain (Moritz et al., 2022). Therefore, sorghum is a potential alternative cereal energy source in poultry diets. However, some sorghum varieties contain a high level of tannins, kafirins and phytate which when fed without mitigation adversely affect broiler performance (Moritz et al., 2022; Alshelmani et al., 2021; Awika & Rooney, 2004). The feed efficiency of broilers fed on sorghum is increased through feed processing methods such as extrusion cooking.

Extrusion cooking improves the nutritional value and feed efficiency of poultry feeds. Through this technology, the anti-nutritional factors in sorghum grain are inactivated. Moreover, there is more gelatinization, formation of soluble dietary fibre, and reduction of lipid oxidation (Singh et al., 2007). On the other hand, exogenous phytase optimizes growth, feed intake, feed conversion ratio, and the cost-benefit ratio in broilers fed on sorghum-based diets (Ahmed & Tanveer, 2021). The mechanism involves the destruction of the anti-nutritional properties of phytic acid/phytate, which frees bound phosphorous and other minerals.

Therefore, extruded sorghum meal with exogenous phytase enzyme is a potential alternative to maize grain in broiler diets. However, to determine its potential as an energy source in broiler diets, it is necessary to understand its effects on broiler carcass characteristics and sensory quality. Therefore, this study investigated the effect of extruded sorghum meal and exogenous phytase based-diets on broiler carcass characteristics and sensory quality.

MATERIALS AND METHODS

Ethical Consideration

This study was approved by the Egerton University Research Ethics Committee with approval number EUISERC/APP/224/2023 and the National Commission of Science and Technology of Kenya, with license number NACOSTI/P/23/25493.

Study Site

The study was undertaken at Egerton University in the Tatton Agriculture Park (feeding experiment) and the Department of Dairy and Food Science and Technology (carcass characteristics and sensory quality evaluation). The University is located in Njoro Sub-County, Nakuru County, at 0° 23' S, 35° 55' N. The altitude of the area is 2,238 m above sea level. The temperature of the area averages 21°C and annual rainfall ranges between 900 to 1,020 mm (Egerton University Meteorological Station, 2019).

Experimental Design and Diets

A (3x2) factorial arrangement was used in a completely randomized design to determine the effect of extruded sorghum meal as an energy source at three inclusion levels (0, 50, and 100%) and exogenous phytase at two levels (with or without) on broiler carcass characteristics and sensory quality. There were six dietary treatments (Tables 1 and 2): T1 (0% ESM + 0% phytase), T2 (0 % ESM + 0.035 % phytase), T3 (50 % ESM + 0% phytase, T4 (50 % ESM + 0.035 % phytase), T5 (100 % ESM + 0 % phytase), and T6 (100 % ESM + 0.035 % phytase). Each treatment was replicated three times with six chicks per replicate. The model used was as follows;

$Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + \varepsilon_{ijk}$ *i=1,2,3; j=1,2;*

where;

Y_{ijk} is observation k in level i of extruded sorghum meal and level j of phytase;

μ is the overall mean;

A_i is the effect of level i of extruded sorghum meal;

B_j is the effect of level j of phytase;

$(AB)_{ij}$ is the effect of the interaction of level i of the extruded sorghum meal with level j of phytase;

ε_{ijk} is a random error with mean 0 and variance σ^2.

Table 1. Composition of experimental grower diets

Ingredient (% in the diet)	Dietary treatments					
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
Maize meal	56.4	56.4	28.2	28.2	0.0	0.0
ESM	0.0	0.0	28.2	28.2	56.4	56.4
Soybean meal	33.8	33.8	33.5	33.5	32.8	32.8
Fish meal (*Omena*)[1]	3.8	3.8	3.8	3.8	4.2	4.2
Vegetable oil	3.5	3.5	3.8	3.8	4.1	4.1
DCP	1.2	1.2	1.2	1.2	1.2	1.2
Limestone	0.5	0.5	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5	0.5	0.5
Common salt	0.3	0.3	0.3	0.3	0.3	0.3
Natuzyme®	0	0.035	0	0.035	0	0.035
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis						
CP	23.3	23.3	23.3	23.3	23.3	23.3
ME (kcal/kg)	3155.5	3154.6	3151.8	3150.9	3148.8	3147.9
CF	2.5	2.5	2.5	2.5	2.5	2.5
Analysed composition (g/100g DM)						
CP	23.3±0.13	23.5±0.53	23.6±0.12	23.6±0.13	23.1±0.24	23.5±0.24
Ether extracts	11.9±0.29	12.1±0.61	9.92±0.29	8.80±0.20	9.39±0.06	9.53±0.12
CF	4.39±0.33	3.82±0.47	3.44±0.19	3.15±0.15	2.43±0.39	3.05±0.67

[1]Scientific name: Rastrineobola argentea, common name; silver cyprinid, and it's also called the Lake Victoria sardine or Mukene, [2]variety: 6213; ESM is extruded sorghum meal; DCP is Dicalcium phosphate; The premix per 2.5kg supplied: Vit A 10000000IU, Vit D3 2800000IU, Vit E 25000mg, Vit K_3 2800mg, Vit B_1 2000mg, Vit B_2 7000mg, niacin 40000mg, pantothenic acid 12000mg, Vit B_6 3500mg, folic acid 1000mg, Vit B_{12} 15mg, biotin 80mg, manganese 60000mg, zinc 60000mg, iron 30000mg

Table 2: Composition of experimental finisher diets

Ingredient (% in the diet)	Dietary treatments T1	T2	T3	T4	T5	T6
Maize meal	65.0	65.0	32.5	32.5	0.0	0.0
ESM	0.0	0.0	32.5	32.5	65.0	65.0
Soybean meal	24.8	24.8	24.3	24.3	23.7	23.7
Fish meal (*Omena*)[1]	4.5	4.5	4.6	4.6	4.8	4.8
Vegetable oil	3.2	3.2	3.6	3.6	4.0	4.0
DCP	1.2	1.2	1.2	1.2	1.2	1.2
Limestone	0.5	0.5	0.5	0.5	0.5	0.5
Premix	0.5	0.5	0.5	0.5	0.5	0.5
Common salt	0.3	0.3	0.3	0.3	0.3	0.3
Natuzyme®	0	0.035	0	0.035	0	0.035
Total	100.0	100.0	100.0	100.0	100.0	100.0
Calculated analysis						
CP	20.1	20.1	20.1	20.1	20.1	20.1
ME (kcal/kg)	3204.2	3203.3	3203.6	3202.7	3203.1	3202.2
CF	2.4	2.4	2.5	2.5	2.5	2.5
Analysed composition (g/100g DM)						
CP	21.0±0.12	20.8±0.13	20.8±0.31	20.4±0.31	21.7±1.41	19.9±0.14
Ether extracts	10.7±0.19	10.4±0.19	9.69±0.12	9.72±0.18	10.1±0.21	10.0±0.35
CF	5.17±0.05	4.17±0.51	4.48±0.11	4.41±0.07	4.18±0.07	4.17±0.47

[1]Scientific name: Rastrineobola argentea, common name; silver cyprinid, and it's also called the Lake Victoria sardine or Mukene, [2]variety: 6213; ESM is extruded sorghum meal; DCP is Dicalcium phosphate; premix was similar as in the grower diet

Management of Birds

A total of one hundred and eight (108) healthy, mixed-sexes, day-old commercial broiler chicks (Cobb 500 breed) were purchased from the local commercial hatchery (Kenchic® Limited). The chicks were vaccinated against Gumboro and Newcastle diseases at the hatchery. On the first day, the chicks were administered Lemycin® (a water-soluble chick booster containing an antibiotic, glucose, vitamins, and amino acids) and liquid paraffin (to soften and lubricate droppings). The chicks were fed on a standard maize-soybean diet for the first 48 h while acclimatizing to the experimental conditions. On the third day post-hatching, chicks were weighed in groups of six and randomly allocated into eighteen cages. Chicks in each cage were randomly assigned to one of the six diets with 3 replicates. The grower diets were offered 1-21 d and the finisher diets 22-42 d. Water and feed were provided *ad libitum*.

Slaughter Method and Determination of Carcass Characteristics

All broilers were weighed at the end of the feeding experiment to obtain slaughter weight, and three broilers per treatment were sampled randomly for carcass characteristics and sensory quality evaluation. The broilers were starved for 8-10 h but with free access to water before slaughter. The slaughter involved stunning and severing the jugular vein and then allowing blood to drain for five minutes. The slaughtered birds were scalded in hot water (about 50^{o}C) for one minute to allow for the plucking of feathers and manual evisceration. The carcasses were dressed by removing the neck and the shank, chilled at 4^{o}C for 24 h and re-weighed to obtain the cold carcass weight.

The hot-dressed chicken (carcass) was weighed to calculate the dressing percentage by expressing the hot-dressed weight as the percentage weight of live chicken, as described by Maidala et al. (2020).

$$\text{Dressing percentage} = \frac{\text{hot dressed weight (g)}}{\text{slaughter weight (g)}} \times 100$$

The wings, breast, drumsticks, thigh and abdominal fat were removed, weighed, and expressed as a percentage of the weight of the live chicken. The skin between the thigh and the body was cut to expose and dislocate the hip joint (articulation *coxoe*). The tendons and ligaments around the joint were cut to remove the thighs. The thigh and the drumstick were separated at the stipple joint (articulation *genus*). A cut was made in the vertical side of the carcass at the shoulder joint (articulation *humeri*) to remove the wings. The breast was gently separated from the sternum using the tip of the knife.

Visceral organs (liver, heart and gizzard) were removed and measured in grams using a sensitive electric balance. The small intestine and large intestines were measured in centimetres (cm) using a tailor's flexible measuring tape. The weights of the various organs measured were expressed as a percentage of live weight.

Sensory Quality Evaluation

A total of 10-12 experienced semi-trained panelists aged 25-40 years, who were previously screened and trained, were selected to participate in the sensory evaluation for three days. The panelists learned how to identify and describe chicken sensory attributes. The descriptors and scales used were developed during the training. The sensory evaluation room was organized according to the recommendations of Lawless and Heymann (2010). The panelists evaluated various sensory attributes on both the quantitative descriptive analysis scale (Table 3) and the just about-right (JAR) scale.

Skinless breast muscles (pectoralis major) for the determination of carcass characteristics were thoroughly washed with clean water for sensory evaluation. The breast was chosen because it yields sufficient meat and it is one of the most commercially important chicken parts (Oloo, 2021). Each sample was boiled in a different pot for 45-60 min at 100^{o}C without adding any spice or salt. The samples were then deboned manually, cut into cubes of approximately 2 cm^3 and wrapped in aluminium foil to maintain a warm temperature. Each panelist was presented with 6 pieces every day for three days on white sensory-evaluation plates labelled with 3-digit blinding codes in a completely randomized design (six dietary treatments). The panelists were provided with warm water and biscuits for cleansing the mouth between each tasting.

Table 3. Descriptive of the 9-point hedonic scale used for quantitative descriptive sensory evaluation

	Attribute	Subjective ranking
1	Aroma intensity	(1 =Extremely bland to 9 = Extremely intense)
2	The initial impression of juiciness (moisture release)	(1 = Extremely dry to 9 = Extremely juicy)
3	First bite (initial hardness)	(1 = Extremely tough to 9 = Extremely tender)
4	Cohesiveness of mass	(1=Extremely loose to 9=Extremely compact)
5	Sustained impression of juiciness	(1 = Extremely dry to 9 = Extremely juicy)
6	Muscle fibre and overall tenderness (chewiness)	(1 = Extremely tough, to 9 = Extremely tender)
7	Amount of connective tissue (fibrousness)	(1= Extremely abundant to 9 = none)
8	Overall chicken flavor intensity	(1= Extremely bland to 9 = extremely intense)
9	White colour intensity	(1= None to 9 = Extremely intense)

The just About-Right (JAR) scale was used to evaluate the appropriateness of colour, texture, tenderness, juiciness, taste, flavor and overall acceptability (1 = too little, 5 = too much). The JAR scales were used because they indicate the reaction of consumers towards a specific attribute and can be used for diagnostics and explanation if the overall product appeal is lacking (Lawless & Heymann, 2010).

Statistical Analysis

Data were subjected to a two-way analysis of variance in a completely randomized design using the general linear model (GLM) procedure of the SAS Institute Inc. (version 9.4; 2015). The mean separation was done using Tukey's HSD test at a level of significance of 0.05. Pearson correlation coefficients were tabulated using the Proc Corr procedure to investigate any relationships between the sensory attributes.

RESULTS AND DISCUSSION

Table 4: Effects of dietary treatments on carcass characteristics of broilers

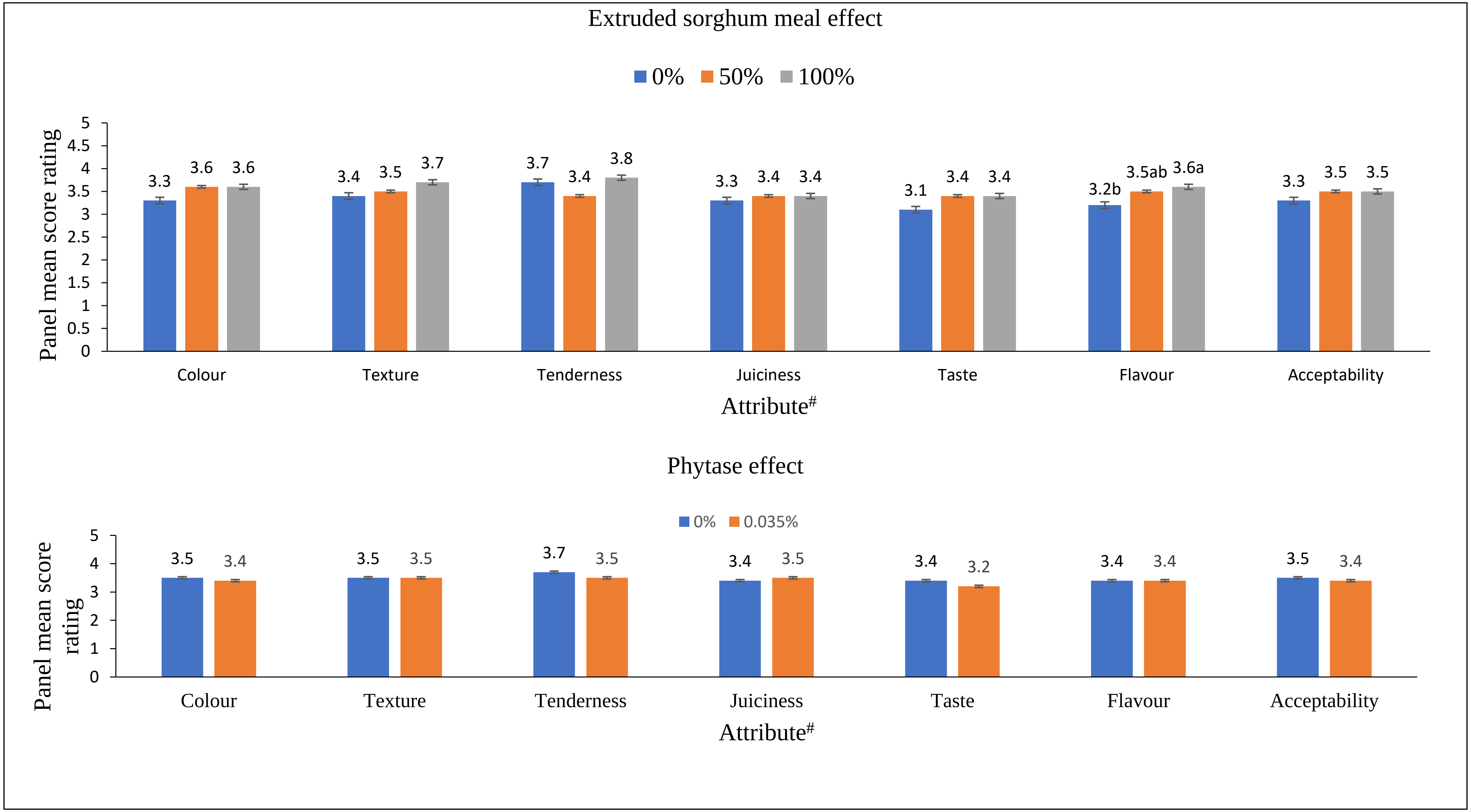
Parameter	ESM effect					phytase effect				ESM× phytase
	0%	50%	100%	SEM	*p*-value	0%	0.035%	SEM	*p*-value	*p*-value
Slaughter weight (g)	1078.2[a]	962.0[a]	395.2[b]	70.3	*	776.6[a]	847.0[a]	57.4	ns	ns
Hot carcass weight (g)	889.7[a]	790.3[a]	320.5[b]	59.1	*	633.7[a]	700.0[a]	48.2	ns	ns
Cold carcass weight (g)	884.2[a]	746.2[a]	318.8[b]	62.2	*	630.1[a]	669.3[a]	50.8	ns	ns
Dressing weight (%)	82.5[a]	81.9[a]	81.0[a]	0.7	ns	81.1[a]	82.5[a]	0.5	ns	ns
Wing weight (%)	9.4[a]	9.9[a]	9.2[a]	0.4	ns	9.5[a]	9.5[a]	0.3	ns	ns
Breast weight (%)	22.4[a]	20.4[a]	19.7[a]	0.8	ns	21.6[a]	20.1[a]	0.6	ns	ns
Drumstick weight (%)	11.3[a]	11.5[a]	9.6[a]	0.6	ns	10.8[a]	10.8[a]	0.5	ns	ns
Thigh weight (%)	13.4[a]	12.2[a]	15.2[a]	2.8	ns	15.3[a]	11.9[a]	2.3	ns	ns
Abdominal fat weight (%)	2.3[a]	1.7[ab]	1.2[b]	0.2	*	1.6[a]	1.8[a]	0.1	ns	*
Liver weight (%)	2.1[a]	2.2[a]	2.6[a]	0.1	ns	2.3[a]	2.3[a]	0.1	ns	ns
Gizzard weight (%)	2.6[b]	3.0[ab]	3.7[a]	0.2	*	3.2[a]	3.0[a]	0.2	ns	ns
Heart weight (%)	0.8[ab]	0.7[b]	0.9[a]	0.1	ns	0.9[a]	0.8[a]	0.0	ns	ns
Small intestine length (cm)	157.0[a]	172.7[a]	146.2[a]	7.3	ns	151.8[a]	165.4[a]	5.9	ns	ns
Large intestine (cm)	27.8[a]	30.0[a]	25.2[a]	1.3	ns	28.7[a]	26.7[a]	1.1	ns	ns

[a, b] means in the same row with different superscripts are significantly different ($p < 0.05$); * is significant at $p < 0.05$; ns is not significant at $p < 0.05$; ESM is extruded sorghum meal; SEM is the standard error of the mean.

Table 5: Descriptive sensory attributes scores of broiler breast meat as influenced by dietary treatments on a hedonic scale

Attribute[#]	ESM effect					phytase effect				ESM× phytase
	0%	50%	100%	SEM	*p*-value	0%	0.035%	SEM	*p*-value	*p*-value
Aroma intensity	5.4[b]	5.9[ab]	6.3[a]	0.181	*	6.1[a]	5.6[b]	0.147	*	ns
The initial impression of juiciness (moisture release)	5.9[a]	6.2[a]	6.4[a]	0.178	ns	6.3[a]	6.0[a]	0.145	ns	ns
First bite (initial hardness)	4.5[a]	5.1[a]	5.2[a]	0.229	ns	5.1[a]	4.8[a]	0.187	ns	ns
Cohesiveness of mass	5.7[a]	6.0[a]	5.9[a]	0.209	ns	5.9[a]	5.8[a]	0.171	ns	ns
Sustained impression of juiciness	5.5[b]	6.1[ab]	6.6[a]	0.209	*	6.0[a]	6.1[a]	0.170	ns	ns
Muscle fibre and overall tenderness (chewiness)	5.4[b]	6.0[b]	7.1[a]	0.212	*	6.2[a]	6.1[a]	0.173	ns	ns
Amount of connective tissue (fibrousness)	5.7[a]	5.9[a]	6.2[a]	0.208	ns	6.1[a]	5.8[a]	0.170	ns	ns
White colour intensity	5.9[a]	5.5[ab]	4.9[b]	0.213	*	5.7[a]	5.2[b]	0.174	*	ns
Overall chicken flavor intensity	5.5[b]	5.9[ab]	6.3[a]	0.190	*	6.0[a]	5.8[a]	0.156	ns	ns

[a, b] means in the same row with different superscripts are significantly different ($p < 0.05$); [#]Sensory attributes evaluated on a scale from 1 to 9, where 1 is lowest intensity and 9 is highest intensity; * is significant at $p < 0.05$; ns is not significant at $p < 0.05$; ESM is extruded sorghum meal; SEM is the standard error of the mean.



#the scale ranged from 1 to 5, (1 = too little, 5 = too much); a, b means in the same attribute with different letters are significantly different ($p < 0.05$)

Figure 8. JAR scores for broiler sensory attributes as influenced by the dietary treatments

Table 6. The correlation coefficients of the sensory attributes on the hedonic scale rating

	AI	**IJ**	**FB**	**MC**	**SI**	**CH**	**F**	**C**	**OCF**
Aroma intensity (AI)	1.0000	0.28357^{*}	0.12636^{ns}	0.30576^{*}	0.39394^{*}	0.2646^{*}	0.28219^{*}	0.19711^{*}	0.49762^{*}
Initial juiciness (IJ)		1.0000	-0.0631^{ns}	0.35556^{*}	0.57661^{*}	0.13171^{ns}	0.20279^{*}	-0.0103^{ns}	0.16553^{*}
First bite (FB)			1.0000	0.21013^{*}	0.01432^{ns}	0.28819^{*}	0.13022^{ns}	0.04138^{ns}	0.12615^{ns}
Mass cohesiveness (MC)				1.0000	0.36529^{*}	0.03797^{ns}	0.53942^{*}	0.1329^{ns}	0.22175^{*}
Sustained impression (SI)					1.0000	0.32057^{*}	0.35568^{*}	0.11969^{ns}	0.48197^{*}
Chewiness (CH)						1.0000	0.00216^{ns}	0.13382^{ns}	0.23083^{*}
Fibrousness (F)							1.0000	0.20849^{*}	0.42861^{*}
Colour (C)								1.0000	0.20375^{*}
Overall chicken flavor (OCF)									1.0000

*is significant at $p< 0.05$; ^{ns} is not significant at $p< 0.05$

Table 7. The correlation coefficients of the sensory attributes on the JAR scale

	Colour	**Texture**	**Tenderness**	**Juiciness**	**Taste**	**Flavor**	**Acceptability**
Colour	1.0000	0.28233^{*}	0.17928^{*}	0.25634^{*}	0.44183^{*}	0.42610^{*}	0.50170^{*}
Texture		1.0000	0.28081^{*}	0.13863^{ns}	0.25416^{*}	0.32244^{*}	0.28593^{*}
Tenderness			1.0000	0.14442^{ns}	0.16113^{*}	0.26086^{*}	0.20528^{*}
Juiciness				1.0000	0.40055^{*}	0.40203^{*}	0.42987^{*}
Taste					1.0000	0.54344^{*}	0.69405^{*}
Flavor						1.0000	0.59670^{*}
Acceptability							1.0000

*is significant at $p< 0.05$; ^{ns} is not significant at $p< 0.05$

Carcass Characteristics

As shown in Table 4, the ESM significantly affected broiler carcass characteristics while exogenous phytase enzyme did not affect the broiler carcass characteristics.
The inclusion of ESM in the diet influenced the broiler slaughter weights, hot carcass weights and cold carcass weights. Inclusion at 50% did not affect slaughter weight, hot dressed weight and cold dressed weight compared to control but they were decreased at 100% inclusion. The reduction in the carcass traits at a 100% inclusion level was attributed to higher levels of dietary anti-nutritional factors (tannins, kafirins and phytate) which adversely affected feed intake, weight gain, and feed efficiency during the feeding period (Zarei et al., 2022). This agrees with the work of Moses et al. (2022), where there was a reduction in hot carcass weights, and cold carcass weight in broilers fed on red sorghum-based diets compared to those fed on white sorghum-based diets. However, in the current study, the dressing percentage was not affected as was the case in Moses et al. (2022) study.

The abdominal fat decreased by 48% when ESM completely replaced maize in the diet. This was attributed to low crude fat in ESM compared to maize which reduced abdominal fat accumulation in broilers. This was consistent with the findings of Adamu et al. (2012), who observed a 77 % reduction in abdominal fat in broilers fed on yellow sorghum-based diets. Similarly, Cherian et al. (2002) observed a reduction in abdominal fat in broilers fed on sorghum-based diets. There was an ESM-phytase interaction effect for the abdominal fat of the broilers.

The broilers fed on ESM-based diets had relatively heavier gizzards than those fed maize-based diets. The development of the gizzard is stimulated by bigger feed particle size (Yan et al 2022; Nir et al., 1994). During milling the particle size reduction depends on several factors including the type of grain and hardness of the endosperm. Although milling of the experimental diets was done using the same hammer mill under similar conditions, the rate of particle size reduction in maize and ESM may have varied (Amerah et al., 2007). ESM particles were likely coarser than maize. This observation suggests that during milling, different sieve sizes may be necessary depending on grain type to achieve the desired particle size distribution. The coarseness of feed particles has been found to stimulate an increase in the relative weight of the gizzard in broilers (Idan et al., 2023; Moses et al., 2022; Yan et al., 2022). However, the other parameters were not affected by dietary treatments ($p > 0.05$).

Sensory quality

Broiler sensory attributes scores in hedonic and just-about-right scales were summarized in Table 5 and Figure 1, respectively. The correlation coefficients were presented in Tables 6 and 7. The inclusion of ESM in the diets enhanced aroma intensity, the sustained impression of juiciness; chewiness, and overall chicken flavor but reduced the white colour intensity of the meat. The incorporation of exogenous phytase increased aroma intensity and reduced white colour intensity. There was an increase in aroma and overall chicken flavor intensity in the meat of broilers fed on ESM-based diets. Aroma and flavor in meat depend on species, age, fatness, type of tissue, locality, gender, diet and method of cooking (Oloo, 2021; Webb et al., 2005). The increase in aroma/flavor in the current study may be attributed to the antioxidant properties of sorghum polyphenols (Awika, 2003). During storage of meat, lipids may be oxidized causing off-flavors (cardboard, painty, fishy, and warmed-over flavor) which are not liked by consumers (Lawless & Heymann, 2010). The antioxidants in ESM may have prevented lipid oxidation during storage thus retaining the natural aroma and overall chicken flavor. Similar findings are documented by Waters et al. (2018).

The breast meat of broilers fed on ESM was chewier than those fed maize-based diets. The toughness of meat is influenced by three types of muscle protein; connective tissue protein, myofibrils, and sarcoplasmic proteins. The main structural protein in connective tissue, collagen, affects the toughness of meat (Asghar et al., 1985). The amount of collagen in the muscle increases as body fat decreases (Purwanti et al., 2019), which may have increased chewiness in the meat of broilers fed on ESM-based diets. This was consistent with the work of Lyon et al. (2004) where broilers fed on sorghum-based diets scored higher for chewiness than those fed on maize-based diets.

The white colour intensity was reduced in the breast meat of broilers fed on ESM-based diets due to the presence of a red pigment, 3-deoxyanthocyanidins, in the ESM (Xiong et al., 2022). This confirms the findings of Cabral et al. (2018) where the meat colour of chicken fed on sorghum bran was darker than those fed the control.

The effect of exogenous phytase in reducing the aroma and white colour intensity was not clear in the current study. Although the enzyme breaks down phytate to liberate bound phosphorus and other minerals, it was not clear if this hydrolysis formed sensory active molecules. Similar results where the enzyme influenced the sensory quality of meat were found by Yasar et al. (2018).
In the hedonic scale, the most notable correlations were between, initial juiciness and sustained impression of juiciness (r= 0.58). The two, are descriptors of juiciness. The mass cohesiveness and fibrousness which describe texture were also correlated (r= 0.54). In the JAR scale, the overall acceptability was more correlated to taste (r= 0.69), flavor (r= 0.60) and colour (r= 0.50). Thus, taste, flavor, and colour were the most important attributes relied upon by the panelists to decide on the acceptability of the broiler meat. Flavor and taste were closely correlated (0.54). Colour was correlated with all sensory attributes analyzed thus it influenced the way the panelists perceived the other attributes (Lawless & Heymann, 2010).

CONCLUSION AND RECOMMENDATION

The inclusion of ESM as an energy source at 50% did not affect broiler carcass characteristics and sensory quality. Therefore, ESM may conveniently replace 50% of maize in broiler diets.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Egerton University through the Tatton Agricultural Park for providing the poultry housing for the feeding experiment and the Department of Dairy and Food Science and Technology for providing facilities, machinery and personnel which made this study successful.

CONFLICT OF INTEREST

The authors declare no conflict of interest for this article.

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