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Feed intake, growth performance, carcass characteristics and organ sizes of broilers fed baobab seed oilcake supplemented finisher diets

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Abstract

Baobab (*Adansonia digitata* L.) seed oilcake has been proven a potential low-cost and locally available protein source for various livestock diets. A study was conducted to determine growth performance, carcass characteristics and organ sizes of finisher broilers fed a commercial finisher diet supplemented with baobab seed oilcake. Three-week-old ROSS 308 broiler chicks (n = 160) that were reared on a starter and grower commercial diets for the first three weeks were allotted to one of four broiler finisher dietary treatments (10 chicks/pen, four replications/treatment) using a completely randomised design. The broiler finisher diets were: control diet, which was a commercial finisher diet (T1), T2 contained 6 g/kg baobab seed oilcake plus maize mash (BSOCMM) mixed with 114 g/kg commercial finisher diet; T3 contained 18 g/kg BSOCMM mixed with 102 g/kg commercial finisher diet; while T4 contained 30 g/kg BSOCMM mixed with 90 g/kg commercial finisher diet. There were no significant ($P > 0.05$) differences in the growth parameters among the treatments. However, the birds on T2 had a higher feed conversion ratio and average daily gains. Final body weights at day 35 were not significantly ($P > 0.05$) different, but T3 and T4 birds had the highest values numerically. There were significant ($P < 0.05$) differences in the carcass weights and dressing percentages among the treatments. The T4 birds had the highest dressing percentage ($P < 0.05$) compared to T2, which had the lowest. The cut portion yield (thigh, wing, breast and feet) of the carcass were not significantly ($P > 0.05$) different among the treatments. However, the drumstick yield was significantly ($P < 0.05$) different among the treatments. Organ sizes showed no significant ($P > 0.05$) differences among treatments, except for the gizzard and the heart, which differed ($P < 0.05$) among treatments. The study concluded that the inclusion of 6–30 g/kg of BSOC blended with maize mash as partial supplementation to a commercial diet can improve final body weights without negatively affecting the feed intake, feed conversion ratio and carcass characteristics in the broiler.

Keywords: Adansonia digitata (Baobab) seed oilcake, broiler, growth performance, carcass characteristics.

1. Introduction

Generally, the semi-intensive system ought to offer all the nutrients birds require through the feed. Therefore there is a need to improve productivity in the semi-intensive system employed by smallholder poultry production, which requires a steady supply of low-cost feed (Sonaiya, 1990). It has been suggested that a possible way to reduce poultry feed costs is replacing or finding alternatives to conventional feed ingredients with cheaper, efficient and locally available feeds (Kaneko et al., 2002). Smallholder poultry

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producers need to use local feedstuffs, on-farm rationing criteria's in poultry diets as a way to reduce costs and bring them into the mainstream of broiler production (Hafeni et al., 2013). Efficient rations for broilers can be created from local sources. There are four feeding tactics that poultry farmers can adopt depending on the feed resources accessible in the region. The tactics are (a) complete ration formulation using local feed ingredients; (b) free choice of feed ingredients; (c) mixing a concentrated diet with local feed ingredients and (d) dilution of a commercial diet with locally available food products' (Glatz et al., 2009). Implementation of such feeding structures can be accepted as solutions for ensuring the viability of small-scale poultry farming. Hence, smallholder operations can be substantially improved if feeding systems based at least in part on local ingredients can be created as an option to imported complete feed or feed ingredients (Kaneko et al., 2002, Glatz et al., 2009, Hafeni et al., 2013).

Baobab (*Adansonia digitata* L.) seed oilcake has been proven to be a potential low-cost and locally available protein source for various livestock diets for African Agriculture (Oladunjoye et al., 2014). The tree is native to the semi-arid areas of southern Africa (Mwale et al., 2008). Although the baobab seed oilcake contains phytate (2%), oxalate (10%), tannins and saponins (3–7%)—the anti-nutritive factors affecting digestion and nutrient uptake in poultry—their levels are assumed to be low thus cannot cause any detrimental effects in avian species (Chimvuramahwe et al., 2011). In spite of the known nutritive value of *A. digitata* (L.), there is limited literature on its potential as a protein supplement in broilers. The objective of the study was to evaluate the growth performance and carcass traits of broilers fed commercial broiler finisher diet supplemented with baobab seed oilcake and maize mash.

2. Materials and methods

2.1 Description of the study site

The study was conducted at ARC-API (Agricultural Research Council - Animal Production Institute) Irene situated in Pretoria which lies along a longitude of 28°13′ S, latitude of 25°55′ E and height of 1524 m above sea level. It is located in the highveld of South Africa characterised with mean summer temperatures which range between 16 °C at night and 35 °C during the day with mild and dry temperatures in winter ranging from a minimum of 5 °C to a maximum of 20 °C (Acocks, 1988).

2.2 Preparation of baobab seed oilcake and maize mash

Baobab seed oilcake (BSOC) was bought from Eco products, a company that which is situated in the Limpopo Province of South Africa and processes baobab seeds for its oil. The seeds were extracted from the fruit and then separated from the fruit pulp. The seeds were first decorticated, and then the kernel was put into a screw press. The screw press expelled the oil from the kernel and the seed oilcake (by-product). The seed oilcake was then ground through a 0.15 mm sieve and was tightly packaged in polythene plastic bags, sealed and kept at room temperature until required. The maize was grown at ARC-API and stored in silos. The maize was then taken from the silos and ground through a 0.20 mm sieve and packaged in 50 kg bags and stored until use.

2.3 Diet formulation

The trial was conducted between September and October 2015 (Animal Ethics No.: NKU07-1SCHI01). Four diets were constituted by diluting commercial broiler finisher diet with graded levels (0 g/kg, 6 g/kg, 18 g/kg and 30 g/kg) of BSOC plus maize mash (BSOCMM). The commercial diet was bought from a registered feed company, Meadow Feeds (Randfontein, South Africa). The feed dilution was done at the experimental site with the use of the Pearson square to balance the protein content of the diet, and the diets were mixed using a feed mixer. The proximate composition of the baobab seed oil cake (BSOC) (Table 2 & 4), including dry matter (#930.15), ash (#942.05) and total nitrogen (#954.01) and ether extract (EE; #920.39), were determined according to AOAC (2000) official methods. The chemical composition of the commercial feed that was given to the birds during the first three weeks and of the commercial finisher diet that was used in the treatment diet preparations is shown in Table 1.

Table 1. Composition (g/kg) of commercial basal diets on as fed basis

Parameter	Starter (0-14d)	Grower (15-21d)	Finisher (22-35d)
Protein	200	180	160
Moisture	120	120	120
Fat	25	25	25
Fibre	50	80	70
Calcium	8	7	6
Calcium	12	12	12
Phosphorus	8	6	5
Total Lysine	12	10	9

Table 2. Proximate composition of baobab seed oilcake (BSOC) on a dry matter basis

Constituent	Percentage content (%)
Dry matter	90.86
Moisture	9.14
Ash	4.57
Crude Protein (N x 6.25)	22.86
Fat (ether extraction)	8.13
Fibre (crude)	19.97
Total non-structural carbohydrates	6.94
Neutral detergent fibre (NDF)	42.33
Acid detergent fibre (ADF)	35.93
Acid detergent lignin (ADL)	17.16
Calcium	0.24
Phosphorus	0.66
Energy (MJ/Kg)	0.18

2.4 Experimental design and management of the birds

The study employed a completely randomised design. One hundred and sixty (160) mixed-sex ROSS 308; chicks were used in the trial. The experimental unit was a pen holding 10 birds, and each treatment was replicated four times. The birds were raised on a commercial starter and grower from day 0 to day 21. At 21 days of age, the birds were randomly allocated to the four experimental diets. The control diet was a commercial finisher diet (T1) fed throughout the two-week study period. Treatment 2 contained 6 g/kg BSOCMM mixed with 114 g/kg commercial finisher diet (T2), treatment 3 contained 18 g/kg BSOCMM mixed with 102 g/kg commercial finisher diet (T3), while treatment 4 contained 30 g/kg BSOCMM mixed with 90 g/kg commercial finisher diet (T4). The ratio of the BSOC and maize mash in the prepared treatment diets were as follows: 2:4, 6:12, and 11:19; in treatments T2, T3 and T4, respectively. Cool fresh water was provided *ad-libitum* throughout the experimental period.

2.5 Determination of growth performance

The growth performance parameters of the birds that were determined were weekly body weights (BW), weekly feed intake (FI), average daily feed intake (ADFI), average daily gain (ADG), feed conversion ratio

(FCR) and dressing percentage (DP). At placement in their respective pens, bird body weights per pen were recorded; they were also recorded at the end on day 35. Average daily gains (ADG) was calculated from average weekly body weights, feed intake was calculated as: [feed given during the 14 days of the experiment—feed left in the feed troughs on day 35], average daily feed intake was calculated as: [Feed intake/total days of the trial (14 days)] and feed conversion ratio (FCR) was calculated as [ADFI/ADG].

Table 3. Proximate composition of broiler finisher diets on a dry matter basis

Constituent/%	Dietary treatment			
	T1 n = 40	T2 n = 40	T3 n = 40	T4 n = 40
Crude Protein (N x 6.25)	16.34	16.11	15.14	14.80
Fat (ether extraction)	4.28	3.78	3.58	3.43
Fibre (crude)	5.16	5.21	5.52	5.44
Calcium	0.86	0.64	0.59	0.53
Phosphorus	0.48	0.46	0.42	0.39
Energy (KJ/Kg)	16.55	16.83	16.47	16.94

Table 4. Amino acid composition of the baobab seed oilcake (BSOC) on a dry matter basis

Amino acids	g amino acid/100g sample
Arginine	3.33
Serine	0.67
Aspartic acid	1.25
Glutamic acid	3.46
Threonine	0.44
Glycine	0.65
Alanine	0.63
Tyrosine	0.64
Proline	0.56
Methionine	0.26
Valine	0.88
Phenylalanine	0.75
Isoleucine	0.67
Leucine	1.01
Histidine	0.63
Lysine	1.04
Hydroxyproline	0.06

2.6 Determination of carcass yield

A day before slaughtering, the birds were deprived feed for them to empty their crops; water was still available *ad-libitum*, which was done to determine the live weight at slaughtering accurately. Afterwards, the birds were sacrificed by cervical dislocation followed by a single cut to the throat. The birds were then fully bled, scalded, plucked and washed followed by removal of the head and feet. After preparation of the carcass, the dressing percentage was calculated as [carcass weight/slaughter weight × 100%]. From the slaughtered birds, a sample of four carcasses per treatment was selected at random. Subsequently, the carcasses were manually eviscerated by cutting through the respiratory system and removal of the oesophagus before being placed aside for 45 minutes for dripping and cooling. Afterwards, visceral organs (intestines, liver, heart and gizzards) were removed by hand through an opening that was made around the vent and sternum. The drumsticks, breast, thighs and wings were cut from the joints of the carcasses and through the shoulder area to remove the backbone from the breast. The cut portions and visceral organs were then individually weighed, and the weights expressed as percentages of the live weight.

2.7 Statistical analysis

Analysis of variance (ANOVA) using SAS JMP version 11.0.0 (SAS 2012) was used to determine the treatment effect on broiler performance parameters and carcass characteristics. When significant treatment effects were identified, the treatment means for the significant effects were separated by the least significance difference (LSD) test at $P < 0.05$. The following model was used for the ANOVA:

$Y_{ij} = \mu + T_i + e_{ij}$

Where Y_{ij} = dependent variables (growth performance parameters, carcass characteristics, cut portion yield and organ weights),

μ = overall mean,

T_i = dietary treatment effect (i = 1, 2, 3, 4)

e_{ij}= random error.

Table 5. Effects of dietary treatments on growth performance of broilers during the finisher phase (21–35 d)

Parameters	Dietary treatment T1 (n=40)	T2 (n=40)	T3 (n=40)	T4 (n=40)	SEM	Significance level
Initial Body Weight (d21)/g	1218.5	1093.0	1161.0	1158.8	0.047	NS
Final Body Weights (d35)/g	2198.8	2213.3	2271.3	2271.3	0.051	NS
Feed Intake (g)	1668.7	1652.5	1682.5	1690.0	0.036	NS
Average Daily Intake(g/day)	186.5	208.8	213.8	206.7	0.117	NS
Average Daily Gain (g/day)	80.0	103.4	101.7	99.0	0.012	NS
Feed Conversion Ratio (g:g)	2.415	2.073	2.107	2.233	0.195	NS

[ab] Means in the same row with different superscripts differ significantly ($P < 0.05$); NS: not significant ($P > 0.05$); SEM: Standard error of the mean.

3. Results

3.1 Growth performance

The results of dietary treatment effects on body weights, feed intake, average daily feed intake, average daily gain and feed conversation ratio of the birds are presented in Table 5. There were no significant ($P > 0.05$) differences in all the growth performance parameters among the treatments. Birds that were on T2 (6 g/kg BSOCMM) had lower feed intake than birds that were on T1, T3 and T4. However, the birds on T2 (6 g/kg BSOCMM) had the better feed conversion ratio than birds that were on T1, T3 and T4 though not significantly different. The final body weights at day 35 were not significantly different ($P > 0.05$) amongst all the treatments. Birds that were on T3 (18 g/kg BSOCMM) and T4 (30 g/kg BSOCMM) had the higher final body weights.

3.2 Carcass characteristics, cut yield and organ sizes

The effects of dietary treatments on slaughter weight, carcass weight, dressing percentage, cut portion yield and the relative weights of the liver, gizzard, heart and intestines are presented in Table 6. There were no significant ($P > 0.05$) differences in the slaughter weights among treatments. However, significant ($P < 0.05$) differences were observed on the carcass weight and the dressing percentage among the treatments. Birds from treatment T4 had significantly higher ($P < 0.05$) carcass weight than T2. However, both treatments did not differ ($P > 0.05$) with T3 (18 g/kg BSOCMM) and T1 (0 g/kg BSOCMM).

Table 6: Effects of dietary treatments on carcass characteristics, cut yield and organ size of broilers

Yield, % Body Weight	Dietary treatment				SEM	Significance level
	T1 (n=4)	T2 (n=4)	T3 (n=4)	T4 (n=4)		
Carcass characteristics						
Slaughter Weight (g)	2486.3	2634	2628.8	2776.1	0.11	NS
Carcass Weight (g)	2014.0ab	1849.8b	2034.5ab	2303.0a	0.11	*
Dressing Percentage (%)	80.9a	70.4b	77.1ab	83.1a	2.7	*
Cut yield						
Thigh (%)	5.13	5.72	6.18	5.92	0.45	NS
Wing (%)	3.22	3.16	3.68	3.8	0.22	NS
Drumstick (%)	4.46a	4.01ab	3.98b	4.12ab	0.15	*
Breast (%)	24.7	23.8	29.6	29.3	1.95	NS
Feet (%)	3.61	4.32	3.69	3.65	0.29	NS
Organ size						
Liver (%)	2.26	2.04	2.57	2.48	0.19	NS
Gizzard (%)	2.24bc	1.95c	2.64ab	2.99a	0.19	*
Heart (%)	4.23b	3.23b	3.48b	5.98a	0.65	*
Intensities (%)	2.99	2.7	3.11	3.25	0.18	NS

[ab]Means in the same row with different superscripts differ significantly ($P < 0.05$); * = $P < 0.05$, NS = not significant ($P > 0.05$); SEM = Standard error of the mean.

T2 was significantly ($P < 0.05$) lower than T4 but did not differ ($P > 0.05$) with T1 and T3. Treatments; T4, T1, and T3, had similar dressing percentages ($P > 0.05$). The dressing percentage of T2 was significantly ($P < 0.05$) lower than T4 and T1 but did not differ ($P > 0.05$) with T3. There was a significant ($P < 0.05$) difference in drumstick percentages among treatments. The treatments; T1, T4 and T2 had similar drumstick percentages ($P > 0.05$) while T3 was significantly ($P < 0.05$) lower than T1 but did not differ ($P > 0.05$) with T4 and T3. There were no significant ($P > 0.05$) differences in thigh, wing, breast and feet weights among treatments. Organ sizes showed no significant differences ($P > 0.05$) among treatments, except for the gizzard and the heart. T4, T3 and T1 had similar gizzard percentages ($P > 0.05$), but T4 significantly differed ($P < 0.05$) with T1. T2 gizzard percentage was significantly ($P < 0.05$) lower than T4 and T3 percentages but did not differ with T1 gizzard percentage. Additionally, T1, T3, and T2 had similar heart percentages ($P > 0.05$). However, T4 was significantly ($P < 0.05$) higher than T1, T3 and T2. No significant ($P > 0.05$) differences were observed among dietary treatment in liver and intestines.

4. Discussion

4.1 Growth performance

Baobab seed oilcake is a good source of protein, essential amino acids, minerals and other elements necessary for the growth of chickens. The CP and fat content of baobab seed oilcake determined in this study was higher than the values reported by Madzimure et al. (2011), whose values were 16.9% CP and 5.26% ether extract. The lysine and methionine content of the baobab seed oilcake determined in this study was lower than the values reported by Osman (2004). The variation in the values could have been attributed to differences in stage of maturity of the seeds at harvest and or agro-climatic conditions of the region the baobab trees were growing. On the other hand, the values obtained in this study verify that while the baobab seed oilcake contains moderate to high levels of protein, it has a high fibre content that may negatively impact on its utility as an alternative feed ingredient for avian species (Sebola et al., 2015). Decorticating of the baobab seeds dramatically increases the protein content of the oilcake hence a difference in CP (22% vs 16.9%) values in this study, and this is similar to other studies reported in the literature (Madzimure et al., 2011).

The results of this study were consistent with the findings of Mwale et al. (2008) and Chimvuramahwe et al. (2011) who reported that BSOC could be included up to 10% in diets of avian species as a protein source without any adverse effects. In the current study, the inclusion level of BSOC plus maize mash up to 30 g/kg was acceptable to the birds since no detrimental effects on feed consumption and conversion rate were noted. These results contradict with the results of Chimvuramahwe et al. (2011) who noted a decline in feed intake at inclusion levels higher than 10%. This can be attributed to the fact that the birds in the current study were introduced to the diets when they were old enough to consume the treatment diets since the birds were introduced to the treatment diets when they were in their fourth week of growth. The body weights results show that the dietary treatments positively affected the birds because there was a gradual increase in body weights of birds on T2, T3 and T4 as shown in Table 3 and 5, though not significantly different across all treatments. There was a gradual increase in feed intake of birds on T1 (0 g/kg inclusion) to T3 (18 g/kg inclusion) diets but a decline of feed intake of birds on T4 (30 g/kg inclusion) Table 5. This can be attributed to the high fat content of BSOC as shown in Table 2. The findings are consistent with Saulawa et al. (2014) and Sebola et al. (2015) who reported that as energy increases within the diet chickens regulate their energy needs by adjusting the feed intake. A reduction in feed intake of diets with high energy was supported by Bale et al. (2013) who showed an inverse correlation of feed intake to dietary energy increases in broilers.

The highest feed intake obtained in birds fed T3 (18 g/kg BSOCMM) (Table 3 & 5) can be due to the palatability of the diet's and its nutrient composition (Mwale et al., 2008). The uniformity and high feed intake of feed across all the treatments could be attributed to the developed gastro-intestinal tract of the chickens. Research has proven that the digestibility of feeds in avian species significantly improves with age. Pal and Sigh (1997) reported that the protein and energy requirement for growth and development in broilers increases with age; as a result, broilers increase their feed intake to satisfy their protein and energy requirements. According to, feed intake is a critical factor that has the most influence on both the body weight gain and feed conversion rate in meat-type poultry. This is noted in the study by the observation that the more the birds consumed, the more they gained in weight and the more was the effect on feed conversion rate. Body weight gain of broilers was high in those birds fed T2 (6 g/kg BSOCMM), and this may be attributed to the higher feed intake value and better-feed conversion rate reported for these birds.

4.2 Carcass characteristics, cut yield and organ sizes

The slaughter weight, yields and relative weights of the liver and intestines of broilers at 35d were not affected by dietary treatments, except for the carcass weight, dressing percentage, drumstick, gizzard and heart. The results showed that the inclusion of BSOC plus maize mash in the diets slightly improved carcass percentage, as shown in Table 6. In addition, increases in the thigh and breast percentage were detected for birds fed a diet supplemented with BSOC plus maize mash. In terms of drumstick percentages, it could be observed that birds on the control diet had higher percentage compared with others that were fed the diluted diets (Fathi et al., 2012). According to Uchegbu et al. (2004), carcass yield is an indication of the utilisation and quality of the ration; it would seem in this study all the chickens on the different treatment diets effectively utilised their feed as evidenced by their significantly relatively high dressing percentages and drumstick values. Significantly, higher values were observed for percentages on gizzard and heart in particular birds that were on T4. For the high gizzard weight, it can be as a result of the additional bulk and higher volume of digester staying in the gastrointestinal tract during enzymatic digestion. Significant differences that were noted on the heart percentages might probably be owing to higher physiological activities of the heart triggered by the presence of anti-nutritional factors of the BSOC and their concomitant effects (Uchegbu et al., 2004). Since the BSOC has relative amounts of anti-nutritional factors. According to Jiménez-Moreno et al. (2010), dietary fibre in poultry diets increases passage rate of digester through the digestive tract as well as the physical capacity of the gastrointestinal tract in birds. Nevertheless, it might also impair the function of the gizzard and performance of birds if finely ground (Nkukwana et al., 2014). As a result, it may be speculated that the significance noted on the gizzard percentages might have been because of some part of the diet is too fine for the birds. The relatively higher CF, ADF, and NDF levels of the BSOC may also support this deduction.

5. Conclusion

The dietary blending of a commercial feed with baobab seed oilcake plus maize mash at levels ranging between 6-30 g/kg in the feed of finisher diets slightly altered the nutrient composition of the diets. Growth performance, carcass characteristics and yield results signify that supplementation of commercial finisher diets with baobab seed oilcake (BSOC) plus maize mash notably improved feed utilisation efficiency and final body weights in broiler chickens used in this study. These findings indicate that BSOC can be used as a potential low-cost feed resource for poultry. This also implies that poultry producers can use the BSOC to their advantage and reduce costs. Feed intake peaked at dilution levels of 18 g/kg and 30 g/kg signifying that BSOC blended with maize mash as a partial supplement to a commercial diet at these levels can be done to reduce feed costs and improve performance and carcass characteristics of broiler chickens.

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