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PERFORMANCE RESPONSE, CARCASS EVALUATION AND ECONOMIC BENEFIT OF RABBITS FED SORGHUM OFFAL-BASED DIETS

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ABSTRACT

An eight-week feeding trial was conducted to investigate the performance, carcass quality, haematological indices and economics of production of rabbits fed dietary sorghum offal substitute for maize grain. A total of forty (40) weaned rabbits with a mean weight range of 820-850 g were randomly distributed to five treatment diets where 0, 25, 50, 75 and 100% of sorghum offal replaced maize grain in the gross feed composition to give Diets 1 (control), 2, 3, 4 and 5, respectively. Each treatment diet was replicated eight times with a rabbit taken as a replicate. The determined chemical composition of the experimental diets ranged between 17.12% and17.43% for crude protein (CP), 11.48 and 14.89% for crude fibre (CF), 5.04 and 7.74% for ether extract or fat (EE), 54.17 and 56.41% for nitrogen free extract (NFE) and 3069.35kcal/kg to 3241.17ME(kcal/kg). While the results on performance showed no significant difference (P>0.05) in feed intake by rabbits fed the five test diets, there appeared to be significant decrease (P<0.05) in the weight gain and feed conversion ratio of rabbits fed 50 to 100% sorghum offal-based diets. Carcass cuts that showed significant reduction (P<0.05) at 75 and 100% sorghum offal-based diets are the carcass weight, thigh, loin, shoulder and ribs weights. Organs such as liver, kidney, heart and pancreas weights measured were significantly higher (P<0.05) at 75 and 100% sorghum offal-based diets. Haematological profile such as Packed Cell Volume (PCV), Red Blood Cells (RBC), White Blood Cells (WBC), Mean Cell Volume (MCV) and White Blood Counts such as neutrophil and basophil showed significant difference (P<0.05) at 75% and 100% sorghum offal-based diets. The serum metabolites such as albumin, globulin, cholesterol and urea showed a similar trend of significant difference (P<0.05) at 75% and 100% sorghum offal inclusion compared to other test diets. For economic production, the study revealed an optimum inclusion of sorghum offal at 50% (24.60 g/kg in feed composition) for maize grain in rabbit concentrate feed is possible. Above this level, a loss of ₦23.17 and ₦13.16 was recorded as evidenced by the cost differential and benefit cost analysis.

Key words: Performance, Haematology, Serum, Sorghum offal, Rabbit

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INTRODUCTION

Insufficient supply of feedstuffs at prices farmers can afford continues to plague adequate production and consumption of animal protein in the diets of humans, particularly people in the third world countries. Nigeria is one of such Third World countries where animal protein intake is far below the minimum recommendation of 35 g/head/day [1]. Although proteins can be sourced from plants, the place of animal protein remains unequal, due to its balanced amino acid profile. Rabbits hold a tremendous advantage to bridge the protein malnutrition between the resource-poor African people and the resource-rich citizens. The potential of rabbit meat as a good quality or nutritious food stemmed from its higher protein content, lower fat, lower sodium and cholesterol contents compared with other meat sources such as beef, pork, mutton and chickens [2, 3]. The other advantage of rabbits over other monogastrics is their ability to thrive on green forage, food wastes and agricultural by-products [4, 5, 6].

Maize, a conventional feed source, remains the chief energy source in monogastric feeds. The various uses of maize as human food, animal feed and industrial input resource has placed excessive demands on its utilization, resulting in its high price and thus making its incorporation in livestock feeds less cost-effective [3, 5].

Sorghum offal (*Sorghum bicolor* L. Moench) is fifth in world cereal cultivation [7], where it is used as food for humans and animals. Sorghum belongs to the same family with maize and has equivalent mineral and vitamin density. However, maize is slightly higher in energy content than sorghum [8] while, sorghum contains more crude protein content than maize [9].

In view of the wide cultivation of sorghum and the various uses to which it is put, a lot of waste is generated in the factory one of them being sorghum offal: a milling by-product. This study was, therefore, designed to determine the economic and other benefits of the optimal inclusion levels of sorghum offal in the diets of growing rabbits.

MATERIALS AND METHODS

Experimental site

The location of the experiment was at the Rabbit Unit of the Teaching and Research Farm, Adeyemi College of Education, Ondo, Ondo State, Nigeria. Ondo lies between latitude $07^0 05^1$N and longitude $04^0 55^1$E in the forest zone of Nigeria. The temperature of the area ranged from 22-35^{0}C throughout the year with mean annual rainfall of 1800-3600 cm, which spreads from March to October.

Processing of test ingredient

The sorghum offal used for this study was obtained from pap producers within Ondo town, void of foreign materials, and later sun-dried to reduce the moisture content to about 10%.

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Experimental diets

Five diets were formulated in which sorghum offal replaced maize grains at graded levels of 0, 25, 50, 75 or 100% (representing 0, 11.94, 24.60, 35.62 or 47.56 g/kg, respectively, in the gross feed composition), for diets 1, 2, 3, 4 or 5, respectively, as shown in Table 1. The five diets and the test ingredient were analyzed for their proximate composition [10].

Management procedure for experimental animals

While the animals were managed according to the provisions of International Guidelines Principles of Biomedical Research involving animals [11], the right to conduct the experiment was given by the Animal Care Unit of the Animal Production Unit, Department of Agricultural Science, Adeyemi College of Education, Ondo, Ondo State, Nigeria. Forty weaner rabbits of cross-breed types aged 7 to 8 weeks with group mean weight ranging between 820 and 850 g were randomly distributed to five dietary treatment groups in a completely randomized design experiment with 8 rabbits (replicates) to each of the five treatment diets. The rabbits were intensively managed in individual cages measuring 48 x 42 x 45 cm with facilities for drinking, feeding and faecal collection. The cage stands were immersed in an insecticidal solution (Gammalin 20) prior to the commencement of the study to prevent crawling insects and other reptiles such as snakes from getting to the animals. The rabbits were made to undergo one week adaptation period in their individual cages. They were served their respective experimental diets with clean water supplied *ad libitum* but with no records taken on feed intake and weight changes. The essence of this was to allow the animals adjust to the diets and their new environment. After the one week adaptation period, records were taken on daily feed intake and weekly weight changes. Prior to the commencement of the experiment, the rabbits were treated against internal and external parasites by subcutaneous injection of Promectin® (VEDCO, Inc., Lenex, KS, USA) (0.2 mL/rabbit). A broad spectrum anti biotic (Oxycare®, Belleville,Illinois, USA) L.A) was also administered at the rate of 0.2 mL/rabbit.

Data collection

Data on daily feed intakes were determined by subtracting the leftovers (orts) from the feed offered to each rabbit. The weight changes were calculated as the difference in the weight from the previous week. Feed conversion ratio was calculated as the ratio of the feed intake to the weight gain.

Digestibility trial

Faecal samples were collected daily for the last five days of the experiment, oven-dried at 80^0C until a constant weight was attained. Dried samples were then allowed to cool in glass desiccators to prevent trapping of moisture from the surrounding atmosphere. The dried samples were analyzed for their proximate composition fractions [10].

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Digestibility of nutrients was determined as:

$$\text{Apparent digestibility} = \frac{\%\text{ nutrient in feed x FI} - \%\text{ nutrient in faeces x FO}}{\%\text{ nutrient in feed x FI}} \times \frac{100}{1}$$

Where: FI = feed intake (on dry matter basis); FO = faecal output (on dry matter basis).

Economic implication

Cost of feed was calculated based on the prevailing market price of feed ingredients at the time of the experiment. The sorghum offal was obtained taking into consideration the haulage, labour and processing costs involved. From the cost/kg of diet, the quantity of feed consumed for the experimental period per unit weight gain gave the cost of feed/kg weight gain. Cost differential was calculated by deducting cost/kg weight gain of the test diet from the cost/kg weight gain of the control diet, while the relative cost-benefit was cost differential divided by the cost/kg weight gain of the control diet in percentage.

Carcass evaluation and organ weights

The animals were fasted for 12h and weighed to determine the slaughter weight and fasting loss before slaughtering. Six rabbits were selected from each treatment group to determine the carcass cuts and organ weights. Killing was done according to the guidelines of the World Rabbit Science Association (WRSA). Bleeding was done by hanging the rabbits head down after the removal of the head. The fur was removed by scalding. Evisceration was carried out immediately by removing the viscera and intestine. The weight of the dressed carcass, head, tail and other internal and external offal were taken.

Haematological variables and serum metabolites

Six rabbits, randomly selected from each treatment group, were bled by puncturing the ear vein with sterile syringes and allowing free flow of blood into labeled universal bottles. One half of the blood samples mixed with the anti-coagulant ethylene diamine tetra acetic acid (EDTA) were used to determine the packed cell volume (PCV), red blood cells (RBC), white blood cells (WBC) counts, and haemoglobin concentration (Hb). The other half of blood samples not mixed with EDTA was used for the measurement of the various serum biochemical parameters.

Data analysis

Data collected were subjected to one-way analysis of variance as completely randomized design using the SAS package [12]. Where significant differences were observed, the means were separated using Duncan's Multiple Range Test of the same statistical software.

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RESULTS

The results on the chemical composition of the test ingredient (sorghum offal) and experimental diets are shown in Table 1. The analyzed DM, CP, NFE and ME (kcal/kg) showed no significant difference (P>0.05) across the dietary treatments while, CF and ash contents were significantly higher (P<0.05) at 75% and 100% sorghum offal-based diets than Diets 1 to 3 (P>0.05). Although no significant difference (P>0.05) was recorded for ME across diets, it varied numerically from 3083.47 to 3241.17 ME (kcal/kg) and showed linear decrease in value with increased sorghum offal inclusion.

The performance response of rabbits fed sorghum offal-based diets as shown in Table 2 revealed significant difference (P<0.05) in the final live weight and total weight gain of the experimental rabbits. Rabbits fed Diets 3, 4 and 5 (50% and above sorghum offal-based diets) were significantly lower (P<0.05) in average weight gain when compared to the control diet. While the control diet recorded the highest weight gain (25.36g/d), Diet 5 recorded the lowest (15.68 g/d) weight gain.

The average feed intake, though not statistically different (P>0.05) decreased numerically with increased sorghum offal inclusion. The non-significant difference could be due to the similar CP and energy values of the experimental diets (Table 1). Feed conversion ratio was poor with increased sorghum offal substituted for maize, particularly at 75 and 100% sorghum offal-based diets, as the values tend to be higher with successive inclusion of sorghum offal (2.49 to 3.77).

The economic production of rabbits fed sorghum offal-based diets as shown in Table 2 revealed a decrease up to 50% sorghum offal-based diets (26.60 g/kg in the gross feed composition). Above this inclusion level, there appeared to be an increase in production cost as evidenced by the ₦218.01 on 75% sorghum offal-based diet as against ₦189.42 to ₦194.84 for rabbits on 0 to 50% sorghum offal-based diets. The cost differential analysis showed improved savings of ₦5.42 at 50% sorghum offal-based diet over the control diet. At 75 and 100% sorghum offal inclusion, ₦23.17 loss and ₦13.16 loss, respectively were incurred. The benefit cost analysis also showed corresponding losses of ₦11.89 and ₦7.12, respectively, at 75 and 100% sorghum offal-based diets.

The results in Table 3 showed no significant difference (P>0.05) across the test diets in the slaughter weight, carcass yield, limbs, neck, head, skin and carcass length. In contrast, significant differences (P<0.05) were observed in the fasting loss, carcass weight, thigh, shoulder, loin, ribs and tail weights, particularly at 75 and 100% sorghum offal-based diets. The organ weights such as intestine, lung and kidney fat showed no significant difference (P>0.05) among the test diets (Table 4). Rabbits fed the control diet and up to 50% sorghum offal-based diets recorded similar (P>0.05) liver, kidney, heart and pancreas weights, but at 75 and 100% sorghum offal-based diets, these parameters recorded significantly higher (P<0.05) values over other test diets.

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On haematological indices (Table 5), the PCV, RBC, WBC, MCV and WBC differential counts such as neutrophils and basophils recorded significantly higher ($P<0.05$) values at 75 and 100% sorghum offal-based diets as against 0 to 50% sorghum offal-based diets ($P>0.05$). Blood indices such as MCH, MCHC, Hb, eosinophils, lymphocytes, monocytes were similar ($P>0.05$) for rabbits fed the various dietary treatments.

Results on serum biochemical characteristics (Table 6) showed that while the albumin/globulin ratio, blood glucose, total serum protein and creatine were not significantly affected ($P>0.05$), albumin, globulin, cholesterol and urea were significantly influenced ($P<0.05$) at 75 and 100% sorghum offal-based diets substituted for maize grains.

The apparent nutrient digestibility as shown in Table 7 revealed significant differences ($P<0.05$) in all the nutrients, except the fat, which recorded similar values ($P>0.05$). Digestibility of nutrients decreased with increased inclusion of sorghum offal. The reference diet and Diet 2, in most cases, recorded higher value over other test diets, although, similar nutrients digestibility ($P>0.05$) were observed for dry matter, crude protein and crude fibre, on rabbits fed Diets 1, 2 and 3. Conversely, nutrients digestibility for gross energy, ash and carbohydrate decreased significantly ($P<0.05$) at 50% and above sorghum offal-based diets over the reference (control) diet and Diet 2 ($P>0.05$). Nutrients in the reference diet and Diet 2 and in some cases Diet 3 were significantly better ($P<0.05$) utilized than those of Diets 4 and 5. The decreased nutrients digestibility coupled with reduction in weight gain at higher sorghum offal inclusion suggest that these nutrients are not available for utilization by the animals.

DISCUSSION

The CP range (17.32 to 17.54%) for the treatment diets is ideal for rabbit production [13]. The CF content for diets 4 and 5 (14.69 and 15.32%, respectively) were higher than the 14% reported for growing rabbits [14]. The linear decrease in metabolizable energy along the experimental diets may not be unconnected with the concomitant increase in crude fibre with increasing level of sorghum offal inclusion. The 10.25% CP recorded for sorghum offal in this study was higher than the 7.80% observed by Uko *et al*. [4], but similar to the 10.50% reported by Adeniji and Ehiemere [15]. Similarly, the CF and ash contents were higher than the values 13.50 vs 7.60 and 6.17 vs 4.50, respectively [4]. The high NFE fraction might account for the appreciable quantity of energy value (2259.70ME kcal/kg) of sorghum offal.

The average weight gain (21.14 to 25.36g/d) for Diets 1 to 3 in this study was similar to the 22.37 to 25.72g/d on rabbits fed malted and unmalted sorghum [3, 6], 17.17 to 23.73 g/d on broiler-chicks fed processed pigeon pea meal [16], but surpassed the 8.40 to 11.67 g/d reported for rabbits placed on varying levels of *Centrosema pubescens* or *Calapogonium mucunoides* [17]), 12.60 to 16.9 g/d reported by Uko *et*

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al. [4] for rabbits fed cereal by-products. The progressive linear decrease in feed intake was similar to rabbits fed malted and unmalted sorghum [6] and rabbits placed on varying levels of *Centrosema pubescens* or *Calapogonium mucunoides* leaf meal [17]. The numerical decrease in feed intake along the test diets could be attributed to the possible higher tannin levels in sorghum than maize [18]. High tannin has been reported to reduce the nutritive value of sorghum due to the formation of tannin-protein complexes, which cannot be readily hydrolyzed by the digestive system, and could reduce the performance of monogastrics [7, 18]. The feed conversion ratio (FCR) in this study was similar to the 3.40 to 3.70 for rabbits fed cereal by-products [4], and better than the 3.33 to 5.27 for rabbits placed on varying levels of *Centrosema pubescens* leaf meal [19]. The FCR values in this study are a true reflection of how the diets were utilized for growth as evidenced in their decreased weight gain at higher sorghum offal inclusion.

The mean value for the carcass yield (47.17 to 51.77%) in this study was similar to the 46.86 to 51.55% reported for rabbits fed cassava root meal by Eshiet *et al.* [20]. The progressive linear decrease observed in the carcass yield could be attributed to the rich-fibre diet, which had been reported to lower slaughter yield [21]. The similar head and skin weights conform to the earlier study on rabbits fed plantain peel-based diets [5]. The non dietary influence on limbs weight supports the findings by Adama and Haruna [22] on rabbits fed dietary sources of fibre. The lower significant values observed for the carcass weight, thigh, shoulder, loin and ribs weights at 75 to 100% sorghum offal-based diets might be attributed to the higher fibre levels in these diets (Diets 4 and 5) while, the lack of a definite pattern in the tail weights across the dietary treatments could be traced to factors such as age, sex or genetic [23]. The increase in fasting loss with concomitant increase in sorghum offal inclusion could be attributed to the high fibre in the experimental diets compared to the reference diet.
The higher organ weights at higher sorghum offal inclusion could be as a result of the activity of those organs to detoxify the possible anti-nutrients in those diets [24]. The significant differences ($P<0.05$) reported in these organs conform to the findings from previous researchers that dietary treatments exert some influences on certain organ weights [5, 25].

The value (33.27 to 39.43%) obtained for PCV, though significantly lower with increased sorghum offal inclusion was still within the normal physiological range for rabbits [26]. The RBC values indicate that rabbits have normocytic and normochromic red cells [3]. Thus, explaining that feeding sorghum with diets containing up to 50% inclusion does not affect the utilization of iron. The lower levels of WBC at 75 and 100% sorghum offal-based diets could be due to the possible presence of anti-nutritional factor in the diet that may have activated the immune system [27]. The low value of eosinophil showed that the animal had no respiratory problem as high level of eosinophil could cause pulmonary dysfunction [28]. The low value of monocyte, which is responsible for breaking down foreign materials, suggests that the animals were not affected by disease [28]. The values observed for all the blood indices measured showed that dietary sorghum offal, particularly at 50% replacement for maize grain was able to support normal rabbit growth. Albumin, globulin, creatine and urea are indicators or otherwise of protein in terms of quality and quantity in diet. Tannin, an anti-nutrient present in sorghum may affect the pattern of protein utilization in animals. However, the evidence of tannin was not so pronounced because the values obtained in this study were within the range for rabbits [29]. The normal metabolites recorded, particularly, for Diets 1 to 3 (0 to 50%-based sorghum offal diets, respectively) indicate the efficiency of utilization of metabolizable energy in the diets [30].

The decrease in nutrients digestibility with increased sorghum offal inclusion could be ascribed to the tannin that is likely to be more at higher sorghum offal inclusion. Tannin as observed by some researchers has the ability to lock up or lower nutrients availability and digestibility [7, 25]. Poor digestibility of crude fibre has been attributed to the masking effect of bacteria in animal gut [19]. The inferior digestibility of nutrients in Diets 4 and 5 (75 and 100% sorghum offal-based diets, respectively) over Diets 1 to 3 (0 to 50% sorghum offal-based diets) suggests poor availability, digestion, absorption and utilization of nutrients in feeds high in sorghum offal.

The economics of production showed that sorghum offal inclusion is possible up to 50% (24.60 g/kg in gross feed composition). Above this level, respective higher cost of ₦23.17 and ₦13.16 will be incurred when using sorghum offal at 75 and 100% inclusion levels to substitute for maize in rabbit feed.

CONCLUSION

The results of this study revealed that dietary sorghum offal can be substituted for maize grains at an optimum inclusion of 50% level (representing 24.60 g/kg in the feed composition). Above this level, there appears to be a decrease in rabbit performance, carcass evaluation characteristics and nutrients digestibility in rabbits. Economics of production showed that rabbits can profitably, be raised at 50% inclusion level of sorghum offal in place of maize grains, above which a great loss will be incurred as evidenced in the cost differential and benefit cost analysis.

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Table 1: Gross composition of experimental diets (%)

	Levels of sorghum offal inclusion (%)							
Ingredients	**0**	**25**	**50**	**75**	**100**	**SEM**	**Sig**	**SO**
	Diets							
	1	**2**	**3**	**4**	**5**			
Maize	57.95	43.46	28.98	14.49	-			
Sorghum offal	-	11.94	24.60	35.62	47.56			
Groundnut cake	24.50	23.00	22.50	20.50	19.00			
Wheat offal	9.30	13.35	16.17	21.14	25.19			
Rice bran	4.00	4.00	4.00	4.00	4.00			
Bone meal	2.00	2.00	2.00	2.00	2.00			
Blood meal	1.50	1.50	1.50	1.50	1.50			
Premix	0.25	0.25	0.25	0.25	0.25			
Lysine	0.10	0.10	0.10	0.10	0.10			
Methionine	0.10	0.10	0.10	0.10	0.10			
Salt	0.30	0.30	0.30	0.30	0.30			
Calculated composition (%):								
Crude protein	17.31	17.25	17.17	17.10	17.01			
Crude fibre	12.09	12.83	13.74	14.69	15.32			
ME (kcal/kg)	3237.93	3175.28	3095.60	2986.06	2934.51			
Analyzed composition (%):								
Dry matter	89.96	88.53	88.87	85.61	85.39	7.03	NS	88.10
Crude protein	17.43	17.38	17.25	17.18	17.12	0.58	NS	10.25
Crude fibre	11.48^{b}	12.61^{b}	13.37^{b}	14.56^{a}	14.89^{a}	2.33	*	13.50
Ether extract	7.74^{a}	6.90^{ab}	6.32^{b}	5.28^{c}	5.04^{c}	1.45	*	4.85
Ash	6.58^{b}	6.82^{b}	7.19^{b}	8.53^{a}	8.65^{a}	1.74	*	6.17
Nitrogen-free extract	55.19	56.41	55.63	55.01	54.17	2.81	NS	65.23
ME (kcal/kg)	3244.17	3198.79	3169.35	3099.51	3083.47	52.63	NS	2259.70

SO = Sorghum offal
ME = Metabolisable energy
[a,b,c]Means with different superscripts along the same row are significant (P<0.05)

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Table 2: Performance response and cost implications of rabbits fed sorghum offal-based diets

Parameters	Levels of sorghum offal inclusion (%) 0	25	50	75	100	SEM	Sig
	Diets 1	2	3	4	5		
Initial weight (g)	850	830	840	820	850	17.18	NS
Final live weight (g)	2270.16[a]	2114.08[ab]	2023.84[b]	1761.92[c]	1728.08[c]	52.73	*
Total weight gain (g)	1420.16[a]	1284.08	1183.84[b]	941.92[c]	878.08[c]	15.08	*
Average weight gain/rabbit/day (g)	25.36[a]	22.93[ab]	21.14[b]	16.82[c]	15.68[c]	5.49	*
Total feed consumed (g)	3537.20	3449.04	3395.84	3375.96	3312.04	59.87	NS
Average feed consumed/rabbit/day (g)	63.16	61.59	60.64	60.29	59.14	5.09	NS
Feed conversion ratio	2.49[a]	2.69[ab]	2.89[b]	3.58[c]	3.77[c]	1.04	*
Cost of feed ₦/kg	76.01	70.86	65.74	60.63	55.49		
Cost of feed ₦/kg weight gain	194.84	190.99	189.42	218.01	208.72		
Cost differential	-	3.01	5.42	23.17(loss)	13.16(loss)		
Relative cost benefit	-	1.98	2.78	11.89(loss)	7.12(loss)		

[a,b,c]Means with different superscripts along the same row are significant ($P<0.05$)
1USD = ₦162 as at the time of the study

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Table 3: Carcass cuts (g/kg body weight) of rabbits fed sorghum offal-based diets

Parameters	Levels of sorghum offal inclusion (%) 0	25	50	75	100	SEM	Sig
	Diets 1	2	3	4	5		
Final live weight (g)	2270.16[a]	2114.08[ab]	2023.84[b]	1761.92[c]	1728.08[c]	52.73	*
Slaughter weight (g)	2218.01	2060.54	1970.83	1710.00	1677.44	57.08	NS
Fasting loss (%)	2.36[c]	2.58[b]	2.64[b]	2.89[a]	2.91[a]	0.62	*
Carcass yield (%)	51.77	50.80	49.62	47.48	47.17	5.34	NS
Carcass weight (g)	1123.09[a]	1033.74[ab]	961.73[b]	852.17[b]	825.49[c]	47.52	*
Eviscerated weight (g)	719.70	721.05	707.93	711.18	690.35	33.74	NS
Thigh	21.31[a]	19.27[a]	17.45[ab]	17.23[b]	16.49[c]	3.51	*
Shoulder	12.56[a]	11.83[a]	11.24[ab]	10.31[b]	9.73[b]	2.64	*
Limbs	2.93	2.90	2.83	2.85	2.88	0.52	NS
Neck	1.87	1.73	1.85	1.79	1.81	0.38	NS
Loin	9.47[a]	9.32[a]	9.08[a]	8.67[b]	8.59[b]	1.03	*
Head	7.69	7.43	7.49	7.61	7.59	1.61	NS
Ribs	3.95[a]	3.47[ab]	3.36[abc]	3.15[c]	3.11[c]	0.73	*
Skin	17.09	17.21	16.83	17.17	16.94	1.16	NS
Tail	0.45[b]	0.36[c]	0.40[b]	0.52[a]	0.38[c]	0.18	*
Carcass length (cm)	31.97	31.07	30.32	29.58	30.98	1.91	NS

[a,b,c]Means with different superscripts along the same row are significant (P<0.05)

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Table 4: Organ weight (g/kg body weight) of growing rabbits fed sorghum offal-based diets

Parameters	Levels of sorghum offal inclusion (%) 0	25	50	75	100	SEM	Sig
	Diets 1	2	3	4	5		
Full intestine	30.02	32.31	29.75	30.84	29.93	2.03	NS
Liver	2.47[a]	2.51[a]	2.63[ab]	2.91[b]	2.97[b]	0.47	*
Kidney	1.11[a]	1.09[a]	1.14[a]	1.24[b]	1.26[b]	0.21	*
Lung + trachea	0.92	0.89	0.94	0.90	0.93	0.09	NS
Heart	0.44[a]	0.45[a]	0.49[ab]	0.55[c]	0.57[c]	0.07	*
Pancreas	0.13[a]	0.14[a]	0.15[a]	0.18[b]	0.19[b]	0.04	*
Kidney fat	0.37	0.39	0.35	0.33	0.36	0.04	NS

[a,b,c]Means with different superscripts along the same row are significant (P<0.05)

Table 5: Haematological profile of rabbits fed sorghum offal-based diets

Parameters	Levels of sorghum offal inclusion (%) 0	25	50	75	100	SEM	Sig
	Diets 1	2	3	4	5		
Packed cell volume (%)	39.43[a]	39.19[a]	38.89[a]	34.61[b]	33.27[b]	5.16	*
Red blood cell (10^9/ml)	6.38[a]	6.24[a]	6.20[ab]	5.97[bc]	5.39[c]	1.02	*
White blood cell (10^9/ml)	7.08[a]	7.11[a]	6.82[ab]	5.38[c]	5.61[bc]	1.72	*
Mean cell haemoglobin (pg)	20.14	19.98	23.72	24.09	22.43	2.88	NS
Mean cell haemoglobin concentration (%)	30.55	31.15	31.38	30.42	31.50	1.23	NS
Mean cell volume (fl)	65.43[a]	66.18[a]	60.33[ab]	56.92[c]	57.31[c]	6.49	*
Haemoglobin concentration (g/dL)	11.41	11.39	11.53	11.65	11.47	0.24	NS
Neutrophils (%)	37.03[a]	36.48[a]	36.18[a]	35.23[b]	35.03[b]	1.18	*
Eosonophils (%)	2.11	2.08	2.10	2.03	2.13	0.31	NS
Lymphocytes (%)	42.43	42.25	41.78	42.34	41.87	0.32	NS
Basophils (%)	3.50[a]	3.54[a]	3.48[a]	3.11[b]	3.09[b]	0.16	*
Monocytes (%)	4.16	4.19	4.19	4.28	4.01	0.12	NS

[a,b,c]Means with different superscripts along the same row are significant (P<0.05)

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Table 6: Serum biochemical of rabbits fed sorghum offal-based diets

Parameters	0	25	50	75	100	SEM	Sig
	Levels of sorghum offal inclusion (%)						
	Diets						
	1	2	3	4	5		
Albumin (g/dL)	3.06^a	2.98^a	2.90^a	2.80^b	2.71^b	0.61	*
Globulin (g/dL)	1.95^a	1.87^a	1.83^a	1.72^b	1.70^b	0.14	*
Albumin/Globulin ratio	1.58	1.60	1.57	1.62	1.59	0.06	NS
Blood glucose (mmol/L)	10.73	10.65	10.70	10.63	10.71	0.08	NS
Cholesterol (mmol/L)	3.69^c	3.73^c	3.99^b	4.24^a	4.26^a	0.73	*
Urea (mmol/L)	10.19^b	10.25^b	10.51^{ab}	10.98^a	11.07^a	0.57	*
Toral serum protein (g/dL)	8.13	8.09	8.21	8.17	8.23	0.10	NS
Creatine (mmol/L)	2.39	2.32	2.41	2.47	2.51	0.23	NS

^{a,b,c}Means with different superscripts along the same row are significant (P<0.05)

Table 7: Apparent nutrients digestibility in rabbits fed sorghum offal-based diets

Parameters (%)	0	25	50	75	100	SEM	Sig
	Levels of sorghum offal inclusion (%)						
	Diets						
	1	2	3	4	5		
Dry matter	74.34^a	71.06^{ab}	69.30^{ab}	64.93^c	60.14^d	10.24	*
Crude protein	76.83^a	73.76^a	69.08^{ab}	64.53^{bc}	58.54^c	12.17	*
Crude fibre	39.31^a	37.49^a	33.16^{ab}	29.42^b	28.14^b	15.32	*
Fat	76.39	74.52	71.09	68.18	66.73	11.93	NS
Ash	58.18^a	56.74^a	50.44^b	48.37^b	46.52^b	10.07	*
Carbohydrate	74.42^a	71.86^a	67.28^b	62.80^c	62.39^c	11.46	*
Gross energy	79.24^a	77.04^a	71.48^b	64.32^c	63.96^c	13.15	*

$^{a-d}$Means with different superscripts along the same row are significant (P<0.05)

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