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Full Length Research Paper

Effect of millet offal-based diets on performance, carcass cuts and haematological profile of growing rabbits

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The carcass evaluation and haematological parameters of growing rabbits fed millet offal-based diets were examined in a completely randomized design (CRD) experiment that lasted for eight weeks. Millet offal replaced maize at 0, 25, 50, 75 and 100% inclusion levels for diets 1, 2, 3, 4 and 5, respectively. Feeds and water were supplied *ad libitum* throughout the duration of the experiment. Results showed no significant difference (P > 0.05) on the live weight, slaughter weight, fasting loss, carcass weight, dressing percentage, thigh, shoulder, ribs, loin, limbs, eviscerated weight, neck and carcass length of rabbits fed the various experimental diets. In the same vein, only the lung showed significant difference (P < 0.05) among all the organs measured. On blood parameters, the White blood cells (WBC), mean corpuscular hemoglobin (MCH) and mean corpuscular volume (MCV) were significantly higher (P < 0.05) at 50% and above-based millet offal diets. Other blood variables were not significantly influenced (P > 0.05) by the test diets. Serum metabolites result showed increase in serum protein and blood glucose, with corresponding decrease in total cholesterol at 50% and above millet offal inclusion. Feed cost (₦/kg) and feed cost (₦/kg) weight gain decreased with increase in millet offal inclusion with corresponding improvement in savings as evidenced in the cost differential analysis. Millet offal could therefore replace maize grain up to 100% in rabbit diet, and by extension help in better animal protein consumption of average income resource earner.

Key words: Serum metabolites, carcass evaluation, haematology, millet offal, rabbit.

INTRODUCTION

Protein malnutrition, particularly that of animal origin is ravaging the third world countries (Nigeria inclusive), where it is estimated that, on average, only 10 g of animal protein is consumed per day per head compared to the required daily 35 g recommendation (FAO 1986; Adegbola, 1991; Ahamefule et al., 2000). Small- or micro-livestock production has been identified as the possible means to bridge the protein shortage of the undernourished average African people (Sarikhan et al., 2010; Njidda and Isidahomen, 2011). The advocacy for expanding micro-livestock production, particularly rabbit, stems from the potential of rabbit as animal with short generation interval, high prolificacy (Cheeke et al., 1987; Fielding, 1991; Bassey et al., 2008), good mothering ability, easy management strategy, ability to utilize waste and other unconventional feed sources for maximum meat gain (Bassey et al., 2008; Njidda and Isidahomen, 2011), and the ability to thrive on forage (Fielding, 1991), with little concentrate. Rabbit meat are also known to contain high quality and quantity protein, less fat with higher proportion of polyunsaturated linoleic and linolenic fatty acids (Njidda and Isidahomen, 2011). All these attributes in addition to less fed cost of production, make rabbit a desirable livestock that can help increase and improve protein intake of an average income earning

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Nigerian.

Maize, a conventional feedstuff, has remained the chief energy source in compounding ration for non-ruminants. The various uses to which maize is being committed, such as staple food for man, brewing, confectionaries (Ojewola et al., 2006) and now bio-diesel, has further put pressure on its demand, and thus placed additional cost constraints on its use in livestock diets.

Millet offal, a by-product from millet grain after processing, had been observed to contain appreciable quantity of protein and energy that can be exploited in rabbit diet. Millet offal contains about 14.60 to 20.65% crude protein and metabolizable energy ranging between 2148.00 and 2506.00 kcal/kg (Ezieshi and Olomu, 2008). The metabolizable energy place millet offal in the category of medium energy feed sources. The fat content of about 11% (Bassey et al., 2008) attested to the potential of millet offal as good energy supplier in livestock feeds. Igwebuike et al. (2010) and Bassey et al. (2008) reported good rabbit performance when fed on millet offal in place of wheat offal. Broiler chickens performance was also satisfactory at 50% replacement value for maize (Ezieshi and Olomu, 2008). In view of the nutrient density of millet offal, this study was carried out to evaluate the effect of millet offal on the performance, carcass cuts, organ weights, blood parameters of rabbits, and to examine the cost effectiveness of raising rabbits on millet offal in place of maize grain.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the rabbitry unit of the Teaching and Research farm, Adeyemi College of Education, Ondo, Ondo State, Nigeria (07° 05' N, 04° 55' E).

Experimental diets

Millet offal was collected fresh from the processing factory, sun-dried for about five days to reduce the moisture content to about 10%. The experimental diets were formulated in which maize was gradually replaced with millet offal at levels 0, 25, 50, 75 and 100% for diets 1, 2, 3, 4 and 5, respectively. All diets and the test ingredient were analyzed for their proximate composition (AOAC 1990). The diets (Table 1) were formulated with crude protein and metabolizable energy ranging between 18.19 to 18.32% and 2896.53 to 3185.70 kcal/kg, respectively. All diets were iso-caloric and iso-nitrogenous.

Management of experimental animals

50 growing rabbits of cross-breeds and mixed sexes were used for the study. The initial weight of the rabbits ranged between 710 to 810 g. The animals were managed according to the provisions of International Guideline Principles of Biomedical Research involving animals (CIOMS 1985). Prior to the experiment, the rabbits were treated against internal and external parasites by subcutaneous injection of Ivomec (0.2 ml/rabbit). A broad spectrum antibiotics (Oxytetracycline L.A) was also administered at the rate of 0.2 ml/rabbit. The rabbits were subjected to one week acclimation period, during which commercial growers mash (Guinea feed) and water were supplied ad libitum. At post acclimation, the rabbits were weighed and randomly allotted in groups of ten to their respective experimental diets. The rabbits in each treatment were housed in hutches measuring 185 × 160 × 50 cm. The hutches were raised 90 cm above the floor in a house with 1.5 m wall height to permit good ventilation. The stands were immersed in insecticidal solution to prevent crawling insects from getting to the animals. The rabbits were fed their respective experimental diets with clean water supplied *ad libitum* for the eight weeks experimental duration.

Data collection

Daily feed intake were collected by subtracting the leftover plus orts from the feed given to each rabbit, while live weight changes were calculated as the difference between initial weight and the final weight for each week. Feed conversion ratio (FCR) was calculated as the ratio of the feed intake to the weight gain. It is mathematically expressed as:

$$FCR = \frac{\text{Total feed intake (g)}}{\text{Total weight gain (g)}}$$

The cost of the feed ingredients and feed cost were evaluated based on the prevailing market cost at Ondo (1US Dollar = ₦158:00) as at the time of the study.

At the end of the 8 week experimental period, three rabbits per treatment were chosen at random and weighed. Blood samples with ethylene diamine tetra acetic acid (EDTA) as an anti-coagulant, and the other without anti-coagulant were collected from the marginal ear vein before slaughter using sterile lancets. The blood with EDTA were used for the determination of the packed cell volume (PCV), red blood counts (RBC), white blood cell (WBC) counts and haemoglobin concentration (Hb). The PCV were determined using the Wintrobe's microhaematocrit technique while the RBC, WBC and Hb values were determined using the improved Neubauer haemocytometer and cyanomethae-moglobin method (Coles, 1986). The mean corpuscular haemoglobin concentration (MCHC) and mean corpuscular volume (MCV) were calculated according to Jain (1986). Blood samples without anti-coagulant were used for the measurement of the various biochemical components. Serum glucose and blood urea were calculated according to WHO (1980) while total cholesterol, total serum protein, albumin and globulin concentration were by Biuret method (Bush, 1975).

After blood collection, six rabbits per treatment were selected, weighed, slaughtered and skinned for carcass evaluation after fasting for about 12 h. After evisceration and removal of intestine, the carcass weight was recorded. The carcass cuts viz: head, neck, shoulder, ribs, loin, thigh, limbs and tail, and the organs viz: heart, liver, kidney, lung and pancreas were expressed as percentage of slaughter weight.

Chemical and data analyses

The proximate composition of the ingredients used before the feed formulation and the test diet samples were analyzed by the methods of AOAC (1990).

Data collected were subjected to statistical analysis using analysis of variance (ANOVA) of SPSS 15 (2006) package. The significant treatment means were compared using the Duncan option of the same software.

Table 1. Gross composition and chemical analyses of experimental diets (g/100g) and test ingredient.

	Levels of millet offal (%)					
	0	25	50	75	100	MO
	Diets					
	1	2	3	4	5	
Maize	57.95	43.46	28.98	14.49	-	
Millet offal	-	11.94	24.60	32.62	47.46	
GNC	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	
Salt	0.30	0.30	0.30	0.30	0.30	
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	
Total	100	100	100	100	100	
	Calculated composition (%)					
Crude fibre	12.38	12.97	13.41	13.69	13.75	
Crude protein	18.16	18.09	18.16	18.13	18.08	
	Analyzed composition (%)					
Dry matter	92.50	92.70	93.10	90.30	91.80	92.12
Crude protein	18.21	18.19	18.27	18.32	18.23	12.08
Crude fibre	12.51	13.13	12.43	12.40	12.31	15.94
Ether extract	4.32	4.11	3.71	3.52	3.41	8.69
Ash	6.30	6.54	6.71	6.79	6.85	6.36
NFE	58.66	58.03	58.88	58.97	59.20	56.93
ME (kcal/kg)	3185.70	3004.41	2974.94	2908.67	2896.53	2531.30

GNC: Ground nut cake, NFE: Nitrogen free extract, ME: Metabolizable energy, MO: Millet offal.

RESULTS AND DISCUSSION

The results of the chemical composition of millet offal used in this study and those of the experimental diets are presented in Table 1. The chemical composition values obtained for millet offal in this study: 12.08% crude protein and 6.36% ash were lower than 15.31 to 15.70% crude protein and 7.25 to 9.18% ash reported by Olupona and Balogun (2005) and Muir and Massaete (1996). The crude fibre value of 15.94% observed in this study is higher than the 6.25 to 12.50% earlier reported (Igwebuike et al., 2010).

The average weight gain as shown (Table 2) revealed no significant (P > 0.5) difference between rabbits fed the control diet and the reference diets. This thus confirms the nutritive adequacy of the millet offal vis-à-vis the test diets (Table 1); and by implication, any of the diets could be used for rabbit production in areas where shortage of maize abounds. The non significant (P > 0.05) influence of the dietary treatments on weight gain confirms the earlier reports by Bassey et al. (2008) that millet bran could replace wheat bran in rabbit diet. The average feed consumed (59.09 to 71.70 g/day) in this study falls within the values of 40.3 to 71.19g/day (Taiwo et al., 2005; Amaefule et al., 2005), but higher than the values (30 to 32 g) reported by Denli et al. (1991) for rabbits of the same age. The result of the feed conversion ratio (FCR) shows that though the effect of dietary treatment was not statistically different (P > 0.05), rabbits fed on the test diets better utilized their diets than those fed the control diet.

Carcass evaluation

The dressing percentage (47.69 to 50.98%) (Table 3) recorded in this study was similar to the 45.30 to 50.18% reported by Njidda and Isidahomen (2011), that fed rabbits up to 8% sesame seed meal, and close to the values 51.3 to 53.4% for rabbits fed soybean milk

Table 2. Performance characteristics of growing rabbits fed millet offal-based diets (g/100 g).

	Levels of inclusion (%)					
Parameters	**0**	**25**	**50**	**75**	**100**	**SEM**
Diets						
	1	2	3	4	5	
Initial body weight	810.00	750.00	810.00	710.00	720.00	38.59 [NS]
Final live weight	1814.50	1787.68	1800.50	1725.00	1723.10	52.74 [NS]
Total weight gain/rabbit	1004.50	1037.68	990.50	1015.00	1003.10	26.39 [NS]
Average weight gain/rabbit/day	17.94	18.53	17.69	18.13	17.91	0.69 [NS]
Total feed consumed	4015.35[a]	3701.91[ab]	3460.68[b]	3308.89[b]	3702.08[ab]	74.23*
Average feed consumed/rabbit/day	71.70[a]	66.11[ab]	61.80[b]	59.09[b]	66.11[ab]	5.82*
Feed conversion ratio	3.99	3.57	3.49	3.29	3.26	0.24 [NS]
Feed cost (₦/kg)	63.33	55.68	48.23	40.52	32.85	
Feed cost (₦/kg) weight gain	254.59	198.09	168.56	131.49	121.55	
Cost differential	-	56.50	86.03	123.10	133.04	

[ab] means in the same row with different superscripts differ significantly (P < 0.05); NS = Not significant; *= Significant; SEM: Standard error of the mean.

residue, cowpea testa and corn starch residue up to 20.5% (Odeyinka et al., 2007), and maize gluten (Sobayo et al., 2008) for the same experimental duration. The dressing percentage in this study was lower than the value (67.6 to 67.7%) reported for rabbits fed millet offal (Uko et al., 1999). The low dressing percentage could be attributed to the age, weight and content in the digestive tract at killing (Fielding, 1991).

Dietary treatments have no influence on the slaughter weight, fasting loss, eviscerated weight, carcass weight, thigh, shoulder, ribs, loin, limbs, neck and carcass length as observed in this study. The lower relative weight of the shoulder compared to the thigh might be attributed to the late maturing characteristics of the shoulder, especially the scapular region (Ijaiya and Fasanya, 2004). The findings from this study agree with the works of previous researchers on the use of various agro-industrial by-products and wastes in place of maize grain in rabbit's diets (Odeyinka et al., 2007; Adeyemi et al., 2010; Olorunsanya et al., 2007; Njidda and Isidahomen, 2011; Amata, 2010). The non-significant difference (P > 0.05) obtained in these parameters suggest that millet offal had no dire consequence on the rabbit's carcass cuts.

The no discernable pattern (P < 0.05) observed in the weights of the tail, pelt (skin) and head (Table 3) could be attributed to the age, sex, hereditary, breed or type of rabbit (Bill et al., 2007), rather than the test diets.

Organ weights

The values obtained for the internal offal such as the liver, kidney, heart, intestine and pancreas (P > 0.05) were very low, indicating that there were no abnormalities or pathological lesions in these organs, thus confirming no toxicity in the treatment diets (Bone, 1979; Njidda and Isidahomen, 2011). The values reported for the various organs in this study conforms with those reported by Olorunsanya et al. (2007) on rabbits fed sun-dried cassava waste, Uko et al. (1999) that fed rabbits on cereal by-products, Adeyemi et al. (2010) on rabbits placed graded levels of pineapple waste meal, and Amaefule et al. (2005) in their works on rabbits fed boiled pigeon pea seed meal.

Haematology

The haematological responses of rabbits fed the dietary treatments are presented in Table 4. The PCV, RBC, MCHC, Hb, neutrophils, eosinophils, lymphocytes, basophils and monocytes across the dietary treatments were not significant (P > 0.05). The PCV (36.50 to 38.70%) observed in this study was within the range value of 31 to 38% reported by Shah et al. (2007), and Njidda and Isidahomen (2011) on rabbits fed sesame seed meal. The values reported for these blood parameters were within the normal physiological range for rabbits (Amata, 2010; Hewitt et al., 1989; Marco et al., 2003; Omoikhoje et al., 2006; RAR 2007; Njidda and Isidahomen, 2011). Adejumo (2004) reported that haematological traits, especially PCV and Hb were positively correlated with the nutritional status of animal. Hence, the values for PCV and Hb in this study suggest that the various experimental diets had no toxicity effect on the health status of the experimental animals. The values of WBC and MCV increased with increasing level of millet offal (P < 0.05), particularly at 75%-based millet offal and above. The implication therefore is that inclusion of millet offal at higher levels in rabbit diet showed no indication of allergic condition, presence of parasites or invasion of pathogen or foreign substance in the circulatory system of the animal (Ahamefule et al., 2008).

The values obtained for MCH in diets 3 and 5, and

Table 3. Carcass evaluation and organ weights (% body weight) of rabbits fed millet offal-based diets.

Diets	1	2	3	4	5	SEM
			Levels of millet offal (%)			
Parameters	**0**	**25**	**50**	**75**	**100**	
Initial weight (g)	810.00	750.00	810.00	710.00	720.00	38.59^{NS}
Final live weight (g)	1814.50	1787.67	1800.80	1725.00	1723.10	52.74^{NS}
Slaughter weight (g)	1775.05	1748.81	1761.54	1688.47	1685.08	37.05^{NS}
Fasting loss (%)	2.19	2.18	2.16	2.15	2.22	0.35^{NS}
Carcass weight (g)	854.65	874.41	825.81	798.95	845.30	12.97^{NS}
Dressing %	48.15	50.00	47.69	48.00	50.98	5.38^{NS}
Thigh	18.31	18.24	18.18	18.11	18.02	4.63^{NS}
Shoulder	11.91	11.13	10.86	10.76	10.60	4.05^{NS}
Ribs	4.09	4.10	4.00	3.90	3.89	0.25^{NS}
Tail	0.50^{b}	0.59^{c}	0.58^{c}	0.55^{bc}	0.48^{b}	0.13*
Pelt	9.08^{c}	8.07^{b}	9.30^{c}	6.32^{a}	7.88^{b}	1.75*
Head	8.65^{b}	8.57^{b}	9.06^{c}	8.14^{a}	8.33^{b}	0.52*
Loin	9.64	9.70	10.05	9.88	9.57	1.59^{NS}
Limbs	2.69	2.70	2.64	2.59	2.61	0.21^{NS}
Eviscerated weight (g)	545.31	540.08	551.23	532.00	537.82	13.61^{NS}
Neck	2.15	2.14	2.21	2.16	2.17	0.08^{NS}
Carcass length (cm)	28.55	28.00	28.50	25.00	26.00	2.17^{NS}
Organs weights						
Liver	3.07	3.06	2.95	2.97	2.94	0.05^{NS}
Lung	0.82^{b}	0.81^{b}	0.73^{a}	0.78^{b}	0.75^{a}	0.07*
Kidney	0.77	0.79	0.75	0.71	0.75	0.05^{NS}
Heart	0.22	0.20	0.23	0.19	0.21	0.06^{NS}
Intestine	23.81	24.03	23.74	23.92	23.79	0.58^{NS}
Pancreas	0.14	0.15	0.15	0.14	0.15	0.03^{NS}

[abc]means in the same row with different superscripts differ significantly (P < 0.05); SEM = Standard error of the mean; NS = Not significant; * = Significant.

Table 4. Haematology of growing rabbits fed millet offal-based diets.

Diets	1	2	3	4	5	SEM
			Levels of millet offal (%)			
Parameters	**0**	**25**	**50**	**75**	**100**	
PCV (%)	38.70	36.50	39.50	37.30	38.06	2.48^{NS}
RBC (10^9/ml)	5.98	6.12	6.24	5.89	6.18	0.86^{NS}
WBC (10^9/ml)	5.96^{a}	6.57^{a}	7.36^{b}	7.39^{b}	7.42^{b}	0.73*
MCH (pg)	19.36^{a}	20.00^{a}	25.61^{b}	21.10^{a}	26.23^{b}	2.59*
MCHC (%)	30.40	30.60	30.55	31.00	30.70	1.16^{NS}
MCV (fl)	55.28^{a}	54.71^{a}	55.39^{a}	68.34^{b}	66.93^{b}	5.17*
Hb (g/dL)	11.38	11.56	11.62	11.68	11.69	1.36^{NS}
Neutrophils (%)	35.46	36.34	35.75	36.10	35.98	1.74^{NS}
Eosinophils (%)	2.06	1.97	2.00	1.89	2.10	0.75^{NS}
Lymphocytes (%)	40.84	41.28	41.31	40.99	41.28	3.05^{NS}
Basophils (%)	3.42	3.33	3.40	3.38	3.35	0.68^{NS}
Monocytes (%)	8.10	7.90	7.78	7.75	7.72	1.13^{NS}

[ab]means in the same row with different superscripts differ significantly (P < 0.05); SEM = Standard error of the mean; NS = Not significant; * = Significant.

Table 5. Serum metabolites of growing rabbits fed millet offal-based diets.

Diets	1	2	3	4	5	SEM
			Levels of millet offal (%)			
Parameters	**0**	**25**	**50**	**75**	**100**	
Albumin (g/dl)	2.85	2.81	3.05	3.10	2.98	0.21[NS]
Globulin (g/dl)	1.83	2.02	1.85	1.88	2.00	0.14[NS]
Albumin/globulin ratio	1.53	1.38	1.62	1.63	1.50	0.12[NS]
Total serum protein (g/dl)	7.48[a]	7.25[a]	7.93[b]	8.13[c]	8.07[bc]	0.37*
Blood glucose (mol/L)	9.83[ab]	9.58[a]	9.71[ab]	10.53[b]	9.92[ab]	0.25*
Cholesterol (mol/L)	4.25[b]	4.18[b]	3.62[a]	3.58[a]	3.51[a]	0.18*
Urea (mol/L)	10.14[ab]	10.33[b]	10.72[c]	10.83[c]	10.59[bc]	0.54*
Creatine (mol/L)	2.04[a]	2.17[a]	2.42[b]	2.48[b]	2.57[b]	0.15*

[abc]means in the same row with different superscripts differ significantly (P < 0.05); SEM = Standard error of the mean; NS = Not significant; * = Significant.

MCV in diets 4 and 5 may not pose any health problem to the rabbits, since the PCV, RBC and other blood parameters were within the normal physiological range for good rabbit's health status.

Serum metabolites

The albumin, globulin and albumin/globulin ratio (Table 5) syntheses were generally similar across the various test diets. The values for albumin and globulin ranged from 2.85 to 3.10 and 1.83 to 2.02 g/dl, respectively. These values were close to the values of 2.5 to 4.0 g/dl for albumin obtained by Anon (1980), 2.75 to 2.84 g/dl by Amata (2010), 2.2 to 4.2 g/dl by Njidda and Isidahomen (2011); and 1.57 to 2.15 g/dl for globulin (Amata, 2010) and 1.3 to 2.0 g/dl (Njidda and Isidahomen, 2011) for rabbits of similar weight. The values obtained for the albumin and serum globulin, were within the ideal range for rabbit healthy development (Anon, 2004; RAR, 2007). Results as observed in Table 5 showed significant difference (P < 0.05) in the cholesterol, creatine, blood glucose and total serum protein of rabbits fed the experimental diets. Parameters such as blood glucose, serum protein and creatine were significantly higher (P < 0.05), particularly at 50%-based millet offal diet. The total protein and blood glucose were highest (8.13 g/dl) and (10.53 mol/L), respectively on rabbits fed diet 4 as against the lowest value (7.25 g/dl) and (9.58 mol/L) on rabbits fed diet 2. The significant increase (P < 0.05) in these parameters, particularly glucose suggests that rabbits fed on high millet offal are able to derive more energy, which is required for good growth rate in the tropics (Flurharty and Loerch, 1996). Total blood cholesterol values consistently decreased (P < 0.05) with increased inclusion level of millet offal. The highest value (4.25 mol/L) was recorded for rabbits on control diet (diet 1) and lowest (3.51 mol/L) on rabbits placed on 100%-based millet offal diet (diet 5). The explanation for this could be due to the decrease in the fat content of the formulated experimental diets (Table 1). Blood urea concentration, though significantly different (P < 0.05) showed no particular pattern of variation. Since the various serum biochemical characteristics evaluated, either high or low did not pose any serious health challenges to the rabbits, variations observed could be due to environmental factors.

Economic value

The economic implication of replacing maize with millet offal in rabbit production is presented in Table 2. Increasing the inclusion levels of millet offal resulted to decrease in feed cost (₦/kg) from ₦63.33 to 32.82, cost of feed per kilogram weight gain from ₦254.59 to 121.55, and improved savings up to ₦133.04 in rabbits fed total replacement of maize with millet offal, as evidenced in the cost differential analysis.

This finding agrees with the previous reports on the use of plantain peels (Ogunsipe and Agbede, 2010), sweet potato (Ngodigba and Okejim, 1999), cassava peels (Agunbiade et al., 2002), glyricidia leaf protein concentrate (Ogunsipe et al., 2011) and blood-wild sunflower leaf meal mixture (Ajayi et al., 2007) in rabbit's diets.

Conclusion

Based on the results obtained, it could therefore be said that dietary millet offal up to 100% inclusion does not affect the performance, carcass cuts, organ weights and haematological responses of growing rabbits. Thus, the use of millet offal will economically lead to better animal protein production and intake by low income resource earners, especially those in the less-developed and developing countries.

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