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Performance, carcass, organs, haematology and serum biochemical indices of rabbits fed graded levels of mulberry leaf meal in replacement of soybean meal

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Abstract

This study examined the nutritional value of Mulberry leaf meal (MLM) as substitute for soybean meal (SBM) at graded levels. Forty cross-bred young rabbits of mixed sexes used for the study were purchased from a reputable farm in Osogbo, Osun State, Nigeria. The animals were balanced for the initial weight and randomly allocated to five experimental dietary treatments of 8 rabbits per treatment. There were 4 replicates of 2 rabbits per replicate. The rabbits were provided with pelletized experimental diets and clean water ad libitum for 2 weeks pre-experimental period and thereafter for 8 weeks during which data were collected. Five (5) diets containing 0 (0.00% MLM, control), 25 (1.25% MLM), 50 (2.50% MLM), 75 (3.75% MLM) and 100% (5.00% MLM) as replacement for SBM were formulated and contained ME ranging from 2617 – 2661 kcal/kg and crude protein ranging from 15.01 – 16.00%. The average daily weight gain (8.71 g/R/d) obtained in control was similar to 8.03 g/R/d (25.00% MLM), and both significantly (P < 0.05) reduced to 6.75 g/R/d (50.00% MLM), 6.73 g/R/d (75.00% MLM) and 5.98 g/R/d (100.00% MLM). The average daily feed intake (60.08 g/R/d) obtained in animals fed the control diet reduced (P < 0.05) to 53.44 g/R/d (25.00% MLM), 53.44 g/R/d (50.00% MLM), 55.36 g/R/d (75.00% MLM) and 51.52 g/R/d (100.00% MLM) respectively. Cost of feed per kg live weight gain were □471.39 (0.00% MLM), □396.80 (25.00% MLM), □459.52 (50.00% MLM), □454.67 (75.00% MLM), and □473.24 (100.00% MLM). The percentage dressed weight, head, feet, shoulder, loin, thigh and fore legs were significantly (P < 0.05) affected by the dietary treatments. The highest dressed weight (55.12%) was obtained in rabbits fed 0.00% MLM-based diet compared with 45.51, 46.32, 50.28 and 44.88% respectively in animals fed 25.00, 50.00, 75.00 and 100.00% MLM. All the organs (heart, lung, kidney and stomach) except the liver were significantly (P < 0.05) affected by the dietary treatments. All haematological (haemoglobin, packed cell volume, white blood cell and red blood cell); and serum (glucose and total protein) metabolites except albumin investigated were significantly (P < 0.05) influenced by the dietary treatments. It was concluded that MLM can economically replace 75% SBM (5%) in growing rabbits' diets; but 25% (1.25%) level of substitution was the cheapest and most economical level with no deleterious effects on carcass and health status of the animals.

Keywords: Mulberry leaf meal, replacement, soybean meal, health, performance

Introduction

Feed is one of the main problems of intensive livestock production in Nigeria due to competition among the various alternative users of the conventional feed ingredients. It accounts for about 70% of total cost of production. High cost of soybean meal an important protein source for livestock is also a great challenge. This has been the prime stimulant for continuous search for alternative feedstuffs that can meet the nutritional requirements of micro-livestock; and reduce the cost of feed and subsequently the cost of animal production.

Price of most of the non-conventional feed ingredients like leaf meals are relatively low due to their non-competitive nature in terms of human consumption. The low animal protein content of Nigerians' diets could also be attributed to high cost of production. Rabbit is prolific, tolerable to variability in feeds than poultry, fast growing animal, less fat in carcass than pork, beef and chicken. Rabbits are docile animals, and can be raised in backyard producing minimal odour and therefore a good stock option for urban centres. These coupled with the short generation intervals makes it one of the quickest ways of meeting the animal protein of ever increasing populace. Mulberry leaves have quality attributes that makes it a potential replacement for concentrate in rabbit feeds. Manuel, (2000) identified the attractive biomass yield, palatability and exceptionally high nutritive value for ruminant and monogastric animals as reasons behind the great interest in mulberry for animal feeding; and preferred feed for guinea pigs, rabbits and snails. Trigueros and Villalta (1997) and Manuel (2000) reported replacement of a commercial concentrate with 15% mulberry leaf in growing pigs' diets. Mulberry leaves are available all year round and leaves for feeding silkworm and other uses are selected leaving the rejects for livestock feeding. The nutritional potential of mulberry leaf meal as substitute for soybean meal was investigated through its effects on performance, carcass and health status vis-a-vis the blood indices.

Materials and methods

Source and preparation of mulberry leaf meal

Mulberry leaves were harvested from Sericulture farm site, Ado Ekiti, Ekiti State, Nigeria. The leaves were collected and air-dried for some days until they were completely dried. The leaves became crispy and still retained the greenish colour after been air dried. They were then milled to form Mulberry leaf meal (MLM) before being incorporated into the rabbit diets.

Experimental diets

Five (5) diets containing 0 (0.00% MLM, control), 25 (1.25% MLM), 50 (2.50% MLM), 75 (3.75% MLM) and 100 (5.00% MLM) mulberry leaf meal (MLM) as replacement for soybean meal were formulated. The formulated feeds also contained maize, palm kernel cake, brewer dry grain, bone meal, methionine and salt; and was pelletized into size 4mm. The five diets (Table 1) were formulated to contain metabolizable energy ranging from 2617 – 2661 kcal/kg and crude protein ranging from 15.01 – 16.00%.

Experimental animals, plan and their management

Forty cross-bred young rabbits of mixed sexes used for this study were purchased from a reputable farm in Osogbo, Osun State, Nigeria. The animals were balanced for the initial weight and randomly allocated to five experimental dietary treatments of 8 rabbits per treatment. There were 4 replicates of 2 rabbits per replicate. The experimental rabbits were housed in wooden cages netted with wire mesh measuring 40 x 60 x 54cm in dimension. Adequate ventilation was provided for the rabbits by placing the cages in a building having 1m dwarf walls. The hutches were raised approximately 80cm from the concrete floor and aluminium drinkers and clay pot feeders were adopted. The rabbits were provided with the pelletized experimental diets and clean water *ad libitum*, twice daily at 8.00 and 14.00 hour, respectively for 2 weeks pre-experimental period; and then for 8 weeks experimental period. The experimental animals were weighed at the beginning of the feeding trial and thereafter on weekly basis. Routine medication was administered and welfare of the animals strictly monitored. Feed consumption and weight gain were recorded, from which feed conversion ratio was computed. Cost per kg feed and cost of feed per kg weight gain of the experimental animals were computed from the prevailing prices of the feed ingredients.

Serological and haematological indices determination

At the end of the feeding trial, blood samples were collected from four animals per treatment for serum biochemical and haematological analysis. Blood (5 mL) was collected through venipuncture of the left ear from each animal into labelled sterile universal bottle containing anti-coagulant ethylene diamine tetra acetic acid (EDTA) for the haematological component determination. For the serum biochemical component determination, another 5 mL of blood was collected into labelled sterile bottle which does not contain EDTA. All samples were taken to the laboratory for analysis. The non-coagulated blood samples were used for the determination of packed cell volume (PCV) using the micro-haematocrit technique, the red blood cells (RBC) and the white blood cells (WBC) counts using the improved Neubauer haematocytometer method, and haemoglobin (Hb) using the cynomethemoglobin method (Kelly, 1979). Serum from the coagulated blood samples was used for the measurement of total protein, albumin and glucose.

Carcass and organ evaluation

At the end of the feeding trial, four rabbits were selected from each treatment based on the group average weight for carcass and organ evaluation. The selected experimental animals were starved over night to minimise the contents of the gut. The fasted live weights were recorded. Thereafter, the rabbits were stunned, sacrificed and dissected into various parts. The experimental rabbits were sacrificed by severing the jugular vein with a sharp knife. The tail close to the base, the head, feet and the pelt were removed in this order. The carcass was eviscerated with the internal organs and the gut contents carefully removed. Each of these was separated, weighed and their corresponding weights expressed in gramme per killogramme live weight. The dressed weight was expressed as percentage of live weight while the primal parts were expressed as percentage of carcass weight.

Chemical analysis

The proximate composition of the mulberry (*Morus indica*) leaf meal was determined according to method of AOAC (2005). The metabolizable energy was calculated according to the procedure of Pauzenga (1985) as:

ME (kcal/kg DM) = 37 x % Protein + 81.8 x % Fat + 35.5 x NFE.

Statistical analysis

All data collected were subjected to analysis of variance (ANOVA) using the procedure of SAS (1999) and mean values compared using Duncan Multiple Range Test of the same package.

Results

The gross composition of the experimental diets is shown in Table 1. The metabolisable energy increased from 2617 to 2661 kcal/kg and the crude protein decreased from 16.00 to 15.01% as mulberry leaf meal (MLM) inclusion level increased. Results of the analysed proximate composition of mulberry leaf meal is presented in Table 2. The MLM contained 28.56% crude protein, 5.34% ether extract, 4.31% crude fibre, 2.87% ash, 58.40% nitrogen free extract and 99.48% dry matter.

Table 1: Gross composition of experimental diets

Ingredients	Treatments				
	T1 (0% MLM)	T2 (25% MLM)	T3 (50% MLM)	T4 (75% MLM)	T5 (100%MLM)
Maize	40.00	40.00	40.00	40.00	40.00
SBM	5.00	3.75	2.50	1.25	0.00
MLM	0.00	1.25	2.50	3.75	5.00
BDG	25.00	25.00	25.00	25.00	25.00
PKC	28.20	28.20	28.20	28.20	28.20
Bone meal	1.30	1.30	1.30	1.30	1.30
Methionine	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
DM (%)	87.00	91.20	91.30	91.30	91.50
Crude P (%)	16.00	15.52	15.34	15.20	15.01
ME (kcal/kg)	2617.00	2628.00	2639.00	2650.00	2661.00
Crude F (%)	13.21	13.30	13.31	13.40	13.40

SBM = soybean meal, MLM = mulberry leaf meal; BDG = brewer dried grain, PKC = palm kernel cake; DM = dry matter; P = protein; F = fibre.

Table 2: Proximate analysis of mulberry (*Morus indica*) leaf meal

Constituents	**Composition**
Dry matter (%)	99.48
Crude protein (%)	28.56
Ether extract (%)	5.34
Crude fibre (%)	4.31
Ash (%)	2.87
Nitrogen free extract (%)	58.40

Performance of rabbits fed the experimental diets is presented in Table 3. The animals were balanced for the initial weight. The average weight gain, average daily weight gain, average daily feed intake and cost per kg feed differed significantly (*P < 0.05*) among the dietary treatments. The highest (*P < 0.05*) of all these parameters were obtained in the experimental animals fed the control diet. The highest average weight gain value (487.50 g/R) obtained at 0.00% MLM which was similar to 450.00 g/R (25.00% MLM) were significantly (*P < 0.05*) higher than 443.33 g/R (50.00% MLM), 376.67 g/R (75.00%MLM) and 335.00 g/R (100.00% MLM). The average daily weight gain (8.71 g/R/d) obtained in 0.00% MLM was similar to 8.03 g/R/d (25.00% MLM) and was significantly (P < 0.05) reduced to 6.75 g/R/d (50.00% MLM), 6.73 g/R/d (75.00% MLM) and 5.98 g/R/d (100.00% MLM). The highest average daily feed intake (60.08 g/R/d) obtained in animals fed 0.00% MLM significantly (*P < 0.05*) reduced to 53.44 g/R/d (25.00% MLM), 53.44 g/R/d (50.00% MLM), 55.36 g/R/d (75.00% MLM) and 51.52 g/R/d (100.00% MLM). Cost (□61.14) per kg feed of the 0.00% MLM significantly (*P < 0.05*) reduced to □59.58 (25.00% MLM), □58.02 (50.00% MLM), □56.46 (75.00% MLM), and □54.90 (100.00% MLM). The average initial body weight (already balanced for weight), average final body weight, feed conversion ratio, and cost per kg live weight gain were not significantly (*P>0.05*) affected by dietary treatments.

Table 3: Performance of rabbits fed graded levels of mulberry (*Morus indica*) leaf meal based -diets

Parameters	Treatments					SEM
	T1 (0% MLM)	T2 (25% MLM)	T3 (50% MLM)	T4 (75% MLM)	T5 (100%MLM)	
Average initial body weight (g/R)	450.00	450.00	450.00	450.00	450.00	3.57
Average final body weight (g/R)	937.50	900.00	893.33	826.67	785.00	28.73
Average weight gain (g/R)	487.50^{a}	450.00^{a}	443.33^{ab}	376.67^{ab}	335.00^{b}	29.57
Average daily weight gain (g/R/d)	8.71^{a}	8.03^{a}	6.75^{ab}	6.73^{ab}	5.98^{b}	0.65
Average daily feed intake (g/R/d)	60.08^{a}	53.44^{ab}	53.44^{ab}	55.36^{ab}	51.52^{b}	1.22
FCR	7.71	6.66	7.92	8.23	8.62	0.64
Cost (□/kg feed)	61.14^{a}	59.58^{b}	58.02^{c}	56.46^{d}	54.90^{e}	0.51
Cost (□/kg live weight gain)	471.39	396.80	459.52	464.67	473.24	35.29

R = rabbit, FCR = Feed conversion ratio,
^{a,b,c,d,e} Means in the same row bearing different superscripts are significantly different (P<0.05).

Carcass and organ characteristics of experimental rabbits fed graded levels of mulberry (*Morus indica*) leaf meal-based diets are presented in Table 4. The percentage dressed weight, head, feet, shoulder, loin, and thigh and fore legs were significantly (*P < 0.05*) affected by the dietary treatments. The live weight, carcass weight, skin, tail, hind legs and ribs were not significantly (*P >0.05*) affected by the dietary treatments. All the organs (heart, lung, kidney and stomach) except the liver were significantly (*P < 0.05*) affected by the dietary treatments. The highest dressed weight (55.12%) was obtained in rabbits fed 0.00% MLM-based diet compared with 45.51, 46.32, 50.28 and 44.88%, respectively for animals fed 25.00, 50.00, 75.00 and 100.00% MLM. The corresponding values for the head were 8.69, 12.06, 11.77, 11.75 and 11.90%; while the feet were 1.43, 3.03, 2.40, 2.58 and 3.11%, respectively for the rabbits fed 0.00, 25.00, 50.00, 75.00 and 100.00% MLM-based diets. The highest (7.34%) shoulder obtained for the animals fed 0.00% MLM significantly (*P < 0.05*) reduced to 5.49, 5.78, 5.89 and 5.58% in animals fed 25.00, 50.00, 75.00 and 100.00 MLM-based diets, respectively. In the same order, the loins were 7.72, 7.10, 8.59, 8.19 and 6.36%; and the thighs were 6.81, 8.47, 11.31, 13.70 and 10.48%. The highest (*P < 0.05*) forelegs (1.84%) obtained for animals fed T1 (0.00% MLM) compared with 0.74, 1.02, 1.27 and 0.98%, respectively for animals fed 25.00, 50.00, 75.00 and 100.00% MLM-based diets. The highest values (g/kg live weight) of the heart, lung and kidney were obtained in rabbits fed the control (0.00% MLM- based diet). The highest (1.27g/kg live weight) kidney of the rabbits fed the control diet (0.00% MLM) compared with 0.66, 0.79, 0.79 and 0.85g/kg live weight obtained for the animals fed 25.00, 50.00, 75.00 and 100.00% MLM-based diets, respectively. The least stomach value (17.00g/kg live weight) was obtained in the control diet (0.00% MLM) compared with 19.38, 25.90, 30.74 and 29.63g/kg live weight, respectively for rabbits fed 25.00, 50.00, 75.00 and 100.00% MLM-based diets. The percentage liver increased (*P> 0.05*) with increasing MLM inclusion levels.

Table 5 shows the haematological and serum metabolites of the experimental animals. All haematological (haemoglobin, packed cell volume, white blood cell and red blood cell); and serum (glucose and total protein) metabolites except albumin investigated were significantly (P < 0.05) influenced by the dietary treatments. Animals fed with 75.00% MLM – based diets had the highest values (P < 0.05) for haemoglobin (7.50g/dL), PCV (22.50%), WBC (x10^3/dL), glucose (71.50g/dL) and total protein (5.75g/dL). The lowest (P <

Table 4: Carcass and organ characteristics of rabbits fed graded levels of mulberry (*Morus indica*) leaf meal based-diets

Parameters	Treatments					SEM
	T1 (0% MLM)	T2 (25% MLM)	T3 (50% MLM)	T4 (75% MLM)	T5 (100%MLM)	
Live weight (g)	938.60	910.00	900.00	816.88	786.50	39.95
Carcass wt. (g)	800.00	800.00	820.00	667.50	775.00	37.02
Dressed wt. (%)	55.12^{a}	45.51^{b}	46.32^{b}	50.28^{ab}	44.88^{b}	3.95
Head (%)	8.69^{b}	12.06^{a}	11.77^{a}	11.75^{a}	11.90^{a}	0.48
Skin (%)	4.93	6.42	6.21	6.59	6.62	0.34
Feet (%)	1.43^{b}	3.03^{a}	2.40^{a}	2.58^{a}	3.11^{a}	0.18
Tail (%)	3.37	3.34	3.37	3.30	2.91	0.47
Shoulder (%)	7.34^{a}	5.49^{b}	5.78^{b}	5.89^{b}	5.58^{b}	0.18
Loin (%)	7.72^{ab}	7.10^{ab}	8.59^{a}	8.19^{a}	6.36^{b}	0.28
Thigh (%)	6.81^{b}	8.47^{a}	11.31^{a}	13.70^{a}	10.48^{a}	1.23
Fore legs (%)	1.84^{a}	0.74^{b}	1.02^{ab}	1.27^{ab}	0.98^{ab}	0.14
Hind legs	5.71	3.02	2.70	3.21	2.68	0.43
Ribs (%)	8.84	9.44	8.87	10.01	8.47	0.25
Organs (g/kg live weight)						
Heart	0.51^{a}	0.21^{b}	0.26^{ab}	0.21^{b}	0.26^{ab}	0.04
Lung	2.14^{a}	0.77^{ab}	0.60^{b}	0.90^{ab}	0.55^{b}	0.20
Liver	2.26	2.62	3.13	4.09	4.22	0.27
Kidney	1.27^{a}	0.66^{b}	0.79^{b}	0.79^{b}	0.85^{b}	0.07
Stomach	17.00^{c}	19.38^{bc}	25.90^{ab}	30.74^{a}	29.63^{a}	1.77

^{a,b,c} Means in the same row bearing different superscripts are significantly different (P<0.05).

0.05) values of haemoglobin, 5.60g/dL(25.00% MLM), PCV, 17.00% (25.00% MLM), WBC, 2400.00 x10^{3}/dL(0.00% MLM), glucose, 56.50g/dL (25.00%MLM) and total protein, 3.60g/dL(25.00 MLM) were obtained in the experimental rabbits. The RBC values ranged from 1.90 – 2.40 (x10^{6}/dL). The lowest value of this parameter was obtained for animals fed 25.00% MLM and the highest for the rabbits fed 100.00% MLM. Variations obtained in the albumin were not significant (P > 0.05) across the dietary treatments.

Table 5: Haematological parameters and serum biochemistry of rabbits fed graded levels of mulberry (*Morus indica*) leaf meal based -diets

Parameters	Treatments					SEM
	T1 (0% MLM)	T2 (25% MLM)	T3 (50% MLM)	T4 (75% MLM)	T5 (100%MLM)	
Hb (g/dl)	6.15^{ab}	5.60^{b}	6.65^{ab}	7.50^{a}	7.00^{ab}	0.24
PCV (%)	18.50^{ab}	17.00^{b}	20.00^{ab}	22.50^{a}	21.00^{ab}	0.72
WBC (x10^{3}/dl)	2400.00^{b}	2650.00^{b}	4000.00^{a}	4800.00^{a}	4100.00^{a}	277.93
RBC (x10^{6}/dl)	2.10^{ab}	1.90^{b}	2.28^{ab}	2.25^{ab}	2.40^{a}	0.08
Glucose (g/dl)	56.50^{b}	57.00^{b}	64.50^{ab}	71.50^{a}	68.50^{ab}	2.03
Total protein (g/dl)	4.60^{ab}	3.60^{b}	5.00^{ab}	5.75^{a}	5.30^{a}	0.25
Albumin (g/dl)	2.30	2.47	2.45	3.00	2.65	0.16

^{a,b,} Means in the same row bearing different superscripts are significantly different (P<0.05).
Hb = haemoglobin, PCV = packed cell volume, WBC = white blood cell, RBC = red blood cell

Discussion

The protein levels in the formulated diets compared favourably with 15.84 – 16.85% and 15.34 – 17.50% adopted by Abegunde *et al.* (2014) and Olajide *et al.* (2016), respectively but lower than 17 – 18% reported for rabbits (deBlas and Wiseman, 2003). The protein level reduced with increase in mulberry leaf meal (MLM) inclusion level in the diets. This could be attributed to the lower crude protein content of MLM (28.56%) compared to soybean (44.00%) crude protein level. The crude fibre of the experimental diets was comparable with 13 – 14% reported by Coudert *et al.* (1986) and 14% reported by

Cheeke *et al.* (1987). It also compares with 10.03 – 12.17% and 9.01 -13.76% respectively used for rabbits (Olajide and Adeniyi, 2015; Olajide *et al.,* 2016). The metabolisable energy on the other hand increased as the MLM inclusion level increased; and the values higher than 2520.08 – 2528.90 kcal/kg and 2522 – 2555.31 kcal/kg reported for rabbits (Abegunde *et al.,* 2014; Olajide and Adeniyi, 2015). The values were true reflections of the nutrients and caloric contents of MLM and SBM. Results of chemical composition of mulberry fractions from various authors indicate that crude protein content in leaves varies from 15 to 28% depending on the variety, age of the leaves and growing conditions. Datta (2000) stated that the mulberry leaf composition differs according to variety and maturity; and based on the analysis carried out at CSRTI (Mysore) the author reported 19 – 25% crude protein. Carlos (2000) also reported that the chemical composition of leaves was affected by planting density, cutting height and frequency.

Although the variations among the dietary treatments for the average final body weight were not significant, the values however, numerically decreased with MLM inclusion levels. This eventually translated into significant reductions in the average weight gain and average daily weight gain as the level of substitution of MLM for SBM increased. The decrease in feed intake agreed with the submission that monogastric animals including growing rabbits tends to regulate their feed intake according to energy content. The decrease in weight gain and increasing value of the feed conversion ratio were in line with the results of Bamikole and Ezenwa (1999) where weight losses of rabbits were reported even though adequate level of diets were served. Average daily weight gain obtained in the present study were lower than 9.29 – 12.14 g/d (Abegunde *et al.,* 2014), 12.92 – 13.74 g/d (Olajide and Adeniyi, 2015); and 9.37 – 11.33 g/d (Olajide *et al.,* 2016). The daily feed intake (68.93 – 74.29 g/d (Abegunde *et al.,* 2014) and 65.22 – 78.95g/d (Olajide *et al.,* 2016) were also higher than the present values. The feed conversion ratio 5.97 – 7.99 (Abegunde *et al.,* 2014) and 7.08 – 8.44 (Olajide *et al.,* 2016) were comparable to the present values. The differences in these parameters could be as a result of variations in the diets, age, and breed of the rabbits among others. The decreasing average final body weight, average daily weight gain; decreasing average daily feed intake and numerically higher feed conversion ratio obtained as the levels of MLM in the diets increased could be as a result of quality of diet and possibly contents of anti-nutritional factors' in the MLM. Studies on three varieties of mulberry leaves ($S_{36,}$ S_{54} and K_2) were found to contain phytate, cyanide and tannin (Adeduntan and Oyerinde, 2010). Srivastava *et al.* (2006) reported that six genotypes of mulberry contained 0.04 – 0.08% and 0.13 – 0.36% tannic acid in fresh leaves and dried leaf powder, respectively. These anti-nutritional factors have been reported to reduce feed intake and increase feed conversion ratio (Olajide, 2012). Al-Kirshi *et al.* (2010) reported that amino acid composition in mulberry leaves could have compensated for low feed intake brought about by fibres. The significant reduction in the cost of feed per kg was due to the lower price of MLM than that of SBM. The cost of feed per kg live weight gain at 25.00, 50.00 and 75.00% MLM were also lower than the control (0.00% MLM), but 25.00% MLM level being the cheapest (most economical). Beyond 75.00% MLM there was increase in cost of feed per kg live weight gain which tends to show that replacement of SBM with

MLM at 100.00% was not economical. In rabbits, the reduction of concentrate offered daily from 110 to 17.5g with *ad libitum* fresh mulberry reduced gains from 24 to 18g/day; but decreased to more than half the cost of the meat produced (Lara *et al.,*1998 with Manuel , 2000).

The highest percentage dressed weight obtained in the experimental animals fed with the control diet (0.00% MLM) is a plus for this treatment. Incidentally, this same group of animals had the highest live weight. Virgili *et al.* (2003) reported that the primal cut proportion decreased with increasing body weight and growth rate of the whole body. The percentages of the head, feet and thigh of the experimental animals fed with the control diet (0.00% MLM) were lower than those fed with 25.00 – 100.00% MLM-based diets. On the other hand, the percentages of the shoulder and fore legs of the rabbits fed with the control diet (0.00% MLM) were higher than those fed with 25.00 – 100.00% MLM-based diets. The highest and lowest percentages of the loin were obtained at 50.00% MLM and 100.00% MLM levels of substitution, respectively. The highest values of heart and lung weights obtained in animals fed the control diet may point to variability in these anatomical structures of the animals' body; and not totally reflecting the variability in carcass weight. The numerical increment observed in the liver with increasing MLM inclusion could be linked with the possibility of contents of residual anti-nutritional factors in MLM. The highest kidney weight was however, obtained in animals fed the control diet (0.00% MLM), which tends to negate the generalisation of the observation. The liver and kidney are involved in elimination of toxins and metabolic wastes from animals' body (Onyeyili *et al.,* 1998). Hypertrophy or hypotrophy of these two organs has been linked with the presence of toxins (Voss *et al.,* 1990 with Ewuola *et al.,* 2003). Enlargement of organs like the liver and pancreas has been linked with presence of anti-nutritional factors due to their higher detoxification activity (Aderemi, 2003). The lowest percentage stomach obtained at 0.00% MLM level which increased with the substitution level could point to contents of undigested diets in the stomach as a result of fibres. The fibre levels minimally increased as the contents of MLM in the diets increased. Fibres have been found to lower digestibility of nutrients (Alokan, 2000). The dressed weight and organs (heart, lung, liver, kidney and the stomach) were comparable to values obtained in other studies in the same location with the present study (Abegunde *et al.,* 2014; Olajide and Adeniyi, 2015; Olajide *et al.,* 2016).

The highest values of haemoglobin, PCV, WBC, glucose and total protein obtained in experimental rabbits fed 75.00% MLM is desirable for this diet. The Hb and PCV could enhance the oxygen carrying capacity of blood of the animals in this treatment. The glucose level may point to availability of sufficient energy; although animals fed with the other diets were not found to be deficient in energy as the glucose levels met the recommended range for normal rabbits. It also compared favourably with the range values reported (Olajide *et al.,* 2016). The highest WBC may be as a result of the experimental animals on the diets to increasing challenge by residual anti-nutritional factors in MLM which in turn would have stimulated the production of more WBC or antibodies. These metabolites can fight foreign bodies and diseases when the need arise. Similar observations were made in broilers fed dried hot red pepper (El-Deek *et al.,* 2012; Afolabi *et al.,* 2017). The trend obtained in the WBC may further support the assertion since animals fed the control diet (0.00%

MLM) had the least of this parameter (WBC) which also increased with MLM inclusion level. Yongkang (2000) reported that the dry matter of mulberry leaf contains very high (266mg/100g DM) gamma-aminobutyric acid in average of 119 mulberry varieties investigated. The main function of gamma-aminobutyric acid according to this author is to lower blood pressure and help nerve transmission. It could be that this acid is also capable of challenging and produce immunological response of higher WBC. The increasing total protein contents as MLM increased in the diets coupled with numerical higher albumin in MLM –based diets are also desirable. The haematological values obtained in this study falls within the haemoglobin (1.50 – 17.40g/dl), and PCV (4.40 – 48.60%) reported for normal rabbits (Mitruka and Rawnsley, 1977). Although the total protein (6.0 – 8.30g/dL) recommended for rabbits were higher than the values obtained in the present study, the albumin (2.42 – 4.05g/dL) were within the range recommended by these authors. The PCV (21.00 – 31.00%), RBC (1.78 – 2.60 $x10^6$/L), and total protein (5.30 – 6.75 g/dL) recorded for rabbits (Olajide and Adeniyi, 2015; Olajide *et al.,* 2016); also compared favourably with the results of the present study.

Conclusion

It was concluded that MLM can economically replace 75% of SBM (5%) in growing rabbits' diets; but 25% level of substitution (1.25%) was the cheapest and most economical level with no deleterious effects on carcass and health status of the animals.

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