Global Veterinaria 14 (3): 400-408, 2015
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2015.14.03.9372

Digestible Energy and Protein Utilization Efficiency for Gain of Rabbits Fed Diets Supplemented with Moringa Dry Leaves, Applying Slaughter Technique

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Abstract: Forty one male growing New Zealand White rabbits aged five weeks old weighed 566.5 ±24.1 g were classified according to body weight into four groups. Before starting the feeding experiment five randomly chosen rabbits were slaughtered to determine the initial body composition. The rest nine rabbits in each group were individually housed in separated cages for a feeding period lasted 56 days. Dry moringa leaves (ML) were mixed with rabbits ration at 0, 0.15, 0.30 and 0.45% and pelleted at 0.3 cm diameter die and fed *ad libitum* for G_1, G_2, G_3 and G_4, respectively. Body weight and actual feed intake were weekly recorded. At the end of the experiment four digestibility trials were carried out on experimental rations and three representative rabbits from each group were slaughtered to determine the final body composition. Energy and protein utilization efficiency were calculated as net energy and protein gain relative to dietary digestible energy and protein after deducting the maintenance energy and protein requirements. The results indicate that the highest utilization efficiency of energy (18.49%) and protein (43.92%) were recorded with lowest supplementation level of moringa (0.15%) followed by 15.91% for energy and 34.24% for protein with 0.30% ML ration. Energy utilization for control and 0.45% ML groups showed lower comparable values (12.05% and 12.40%), respectively. Protein utilization showed the lowest value (27.91%) with the highest supplementation level of ML (0.45%). It is advisable to supplement ML in the growing rabbits ration at 0.15% to get the best energy and protein utilization efficiency for gain.

Key words: Moringa · Rabbits · Body Composition · Energy and Protein Utilization Efficiency

INTRODUCTION

Feed additives are defined as feed ingredients which will stimulate growth or other types of performance or improve the efficiency of feed utilization or which may be beneficial in some manner to the health or metabolism of the animal [1]. Feed additives are important materials that can improve the efficiency of feed utilization and animal performance. However, the use of chemical products especially those of antibiotics and hormones may cause unfavorable effects. Using medicinal herbs and plants (MH and P) with humans has been known since the old civilization. Inversely many synthesized chemicals caused many hazards to animals, plants and human [2]. The World Health Organization (WHO) encourages using MH and P to substitute or minimize the use of chemicals through the global trend to go back to nature. Singh *et al*. [3] stated that using medical herbs as feed additives in animal diets is a recent global trend to improve productivity, immunity and health status of farm animals.

Moringa oleifera lam is commonly named as the miracle tree or Horseradish tree; it has an impressive range of medicinal uses with high nutritive value throughout the world [4]. Several biological properties ascribed to different parts of this tree, the leaves have been reported to be a valuable source of β-carotene, vitamins (B-complex, C, D and K) beside some important macro and micro-elements as calcium, potassium, zinc, iron, copper and selenium [5, 6]. In the same time moringa leaves are free from anti-nutritional factors, e.g. phenols, tannins, saponins and has high contents of iron (Up to 58.2 mg/100 g DM), β-carotene (up to 40 mg/100 g DM) and vitamin C (Up to 0.92 g/100 g DM) [7]. Recently, Foidl *et al.* [8] reported that moringa leaves contain some anti-nutritional factors; negligible amounts of tannins (1.4%); total phenols (3.4%); nitrate (0.5 mmol/100g); oxalate (4.1%); saponin (1.2%) and phytase (3.1%). Chinwe and Isitua [9] noted that Moringa leaves have positive effects on hematological parameters of rabbits. On the other hand, moringa leaves effectively prevent morphological

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changes and oxidative damage in human and animals by enhancing the activeity of antioxidant enzymes, reducing the intensity of lipid peroxidation and inhibiting generation of free radicals [10, 11]. And it has been used to promote the immune system against microorganism's infection [12].

The present study aimed to evaluate the effect of feeding Moringa dry leaves as a natural feed additive on digestible energy and protein utilization efficiency for gain of New Zealand White rabbits, applying the slaughter technique.

MATERIALS AND METHODS

Moringa Dry Leaves Preparation and Experimental Diets: *Moringa oleifera* shrubs implanted in a sandy soil were harvested at 90 days of age and the leaves without twigs were hand collected, washed and air dried in a shaded place until the moisture reached 10-12%. Dry moringa leaves (ML) were milled, sieved and the powder was thoroughly hand mixed with other feed ingredients at levels 0, 0.15, 0.30 and 0.45% for R_1, R_2, R_3 and R_4, respectively. Experimental diets were pelleted at 0.3 cm diameter and 100 kg of each were processed and poked in polyethylene bags until feeding.

The experimental rations were formulated to cover nutrient requirements for growing rabbits as recommended by NRC [13].

Animals and Their Management: Thirty six growing male New Zealand White rabbits aged five weeks old with an average body weight of 566.5 ±24.1 g were blocked by weight into four equal G_1, G_2, G_3 and G_4, where they were individually housed in galvanized metal wire cages equipped with feeding and water troughs. Experimental diets were offered *ad libtum* at 8.30 a.m. and refused amount of diets were individually collected and daily recorded to detect the actual feed intake. At the end of the feeding period four digestibility trials were conducted on three rabbits from each group, where rabbits were confined in individual stainless steel wire cages for five days collection period to detect dietary nutrient value of TDN and DCP.

Slaughter Technique: Initial slaughter was applied on five representative rabbits and the mean chemical composition of different traits was individually adjusted according to initial live weight of experimental rabbits to estimate the initial body composition. At the end of the feeding experiment, three representative rabbits from each group were slaughtered to determine the final body composition. Mean final body composition was adjusted according to individual live weight of rabbits of each group. Weight gain composition was calculated as the difference between final and initial weight composition.

During initial or final slaughter, rabbits were fasted for 12 hrs. before being slaughter, weighed and handly slaughtered. After complete bleeding, the drained blood was collected and weighed. Slaughtered rabbits were de-skinned, dressed out and the hot carcass including head was weighed and recorded. Edible offals (Giblet i.e.; liver, heart, kidneys and spleen), non edible offals (Lungs and trachea, empty clean G.I.T. and testicles) and trimmings (Fur, four legs and blood) were separately weighed and recorded. The whole carcass of each rabbit was de-bonded and the resultant meat and bone were separately weighed and recorded. Different body traits (Carcass, edible and non-edible offals and trimmings) were separately collected for all slaughtered rabbits. From each group, mixed and minced using Butcher body meat mincer A56H. Fur in particular was sliced before being mixed wit other trimmings. All traits were oven dried at 60 °C for 72 hrs. To determine the moisture content and the dry mixture of each trait was ground and representative sample of each was kept in glass container until further analysis.

Calculations: Dietary gross energy, was calculated according to Blaxter [14], where g CP = 5.65 Kcal, EE = 9.40 Kcal and NFE and CF = 4.15 Kcal.

Total digestible nutrients (TDN) were calculated according to Cheeke *et al.* [15] as:

$$TDN\% = DCP\% + DCF\% + DNFE\% + DEE\% \times 2.25$$

Where, DCP = digestible crude protein, DCF = digestible crude fiber, DNFE = digestible nitrogen free extract and DEE = digestible ether extract.

Digestible energy (DE) were calculated according to NRC [13] and Gaafar *et al.* [16] using the following equation: DE = TDN x 4.409.

The maintenance requirement of digestible energy (DE) for experimental rabbits was calculated according to Partridge *et al.* [17] and Xiangmei [18] using the following equation:

Maintenance equivalent of digestible energy (DE) = 413 KJ DE/ $Kg^{0.75}$ to 98.71 kcal DE/ $Kg^{0.75}$.

While, the maintenance equivalent of digestible crude protein (DCP) was calculated according to Harris *et al*. [19] using the following equation:

Maintenance equivalent of digestible crude protein (DCP) = 442 mg N/ $kg^{0.75}$ equivalent to 2.76 g DCP/ $kg^{0.75}$.

The whole maintenance requirements of digestible energy and protein were calculated as the mean body weight during the feeding period as $kg^{0.75}$ x 56 days x 98.71 kcal for DE or 2.76g DCP for protein.

Analytical Methods: Chemical composition of tested rations and slaughtered rabbits were analyzed according to standard methods described by AOAC [20] includes; moisture, organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash. While, the nitrogen free extract (NFE) was calculated by difference.

Amino acids composition of moringa dry leaves was determined according to the method described by Millipore Cooperative [21] using HPLC and the modification of PICO-TAG methods.

Statistical Analysis: Collected data were statistically analyzed one way analysis of variance according to Snedecor and Cochran [22] applying the general linear model of SPSS [23] program. The mathematical model used was as follow: $Y_{ij} = \mu + T_i + e_{ij}$

Where Y_{ij}: Individual observation, μ: overall mean, T_i: effect of treatment and e_{ij} : experimental error.

The significant differences between means were separated applying Duncan's Multiple Range Test [24].

RESULTS AND DISCUSSION

Results of chemical composition, gross energy and amino acids pattern of dry moringa leaves (ML) presented in Table (1) illustrate that ML had high crude protein (31.68%), crude fat (8.78) and ash (14.88) content. Calculated gross energy of ML was 4.468 kcal/ g. In similar studies carried out on unextracted or dry moringa leaves, values between 23.63-30.29%, 2.23-6.50 and 7.13-13.34% were reported for crude protein, crude fat and ash, respectively [4, 25-29]. Comparable gross energy value 4.469 kcal/ g were noted by Fuglie [26] for unextracted moringa leaves. However, much lower value being 3.097 kcal/ g was mentioned by Oduro *et al.* [27] Discrepancies among studies could be regarded to genotype, agro-climatic conditions, age of plant, way of leaves collection, drying procedure and preparation.

Amino acids pattern in the present study was of 16 detectable amino acid where leucine recorded the highest essential amino acid followed by phenylalanine, lysine and tyrosine, while, the most limiting essential amino acid was methionine (0.12%). In agreement with the present results, Sainchez-Machado *et al.* [30] found that leucine had the highest amino acid content in *moringa olifera* leaves, while Moyo *et al.* [4] reported that alanine had the highest concentration (3.03%) of 19 amino acids. Meanwhile, methionine deficiency in moringa leaves was noted in most previous studies [4, 8, 28, 30]. It's worth noting that, glutamic and aspartic as energetic amino acids comprised more than 25% of that amino acids content in moringa leaves. In the same time, moringa leaves seemed high in its non-protein nitrogen content (22.52 amino acids of 31.68 crude protein per 100g DM). Similar conclusion was noted by Foidl *et al.* [8] who stated that the true protein in the non-extracted and extracted moringa leaves was 20.4 and 40.8% in dry matter, respectively.

Chemical composition of experimental diets shown in Table (2) showed that diets were almost iso-caloric-iso-nitrogenous. In all experimental diets contained 0, 0.15, 0.30 and 0.45% moringa dry leaves (ML) were similar where crude protein(CP) was between 19.11-19.25%, crude fiber (CF) 8.29-8.31%, ether extract (EE) 2.76-2.80%,

Table 1: Chemical composition and amino acids pattern of moringa dry leaves

Item	Moringa dry leaves	Amino acids pattern, g/ 100g dry leaves			
Moisture	8.89	Amino acid		Amino acid	
DM composition, %		Aspartic	2.32	Iso leucine	0.65
OM	85.12	Threonine	0.80	Leucine	1.97
CP	31.68	Serine	1.05	Tyrosine	1.32
CF	6.41	Glutamic	3.80	Phyenyl alanine	1.78
EE	8.78	Glycine	0.55	Histidine	1.11
NFE	38.25	Alanine	1.88	Lysine	1.40
Ash	14.88	Valine	0.81	Arginine	1.76
Calculated gross energy, kcal/ g	4.468	Methionine	0.12	Proline	1.20

[1]Gross energy was calculated according to Blaxter [14] where g CP = 5.65 kcal, EE = 9.40 kcal and NFE and CF = 4.15 kcal.

Table 2: Chemical composition of experimental rations

	Experimental rations			
	R_1	R_2	R_3	R_4
Item	0% ML	0.15% ML	0.30% ML	0.45% ML
Moisture	10.00	10.00	10.01	10.00
DM composition, %				
OM	84.18	84.30	84.41	84.56
CP	19.11	19.16	19.20	19.25
CF	8.29	8.29	8.30	8.31
EE	2.76	2.77	2.80	2.80
NFE	54.02	54.08	54.11	54.20
Ash	15.82	15.70	15.59	15.44
Calculated gross energy, kcal/ g	3.925	3.931	3.938	3.945

R_1: Control ration was formulated to contain; 30% alfalfa hay, 25% ground yellow corn, 25% wheat bran, 14% soybean meal (44%), 3% cane-molasses, 1.5% lime stone, 1% sodium chloride and 0.5% vitamin and mineral premix.

[1]Gross energy was calculated according to Blaxter [14] where g CP = 5.65 kcal, EE = 9.40 kcal and NFE and CF = 4.15 kcal.

Table 3: Digestion coefficients and nutritive value of experimental rations

	Experimental rations						
	R_1	R_2	R_3	R_4			
Item	0% ML	0.15% ML	0.30% ML	0.45% ML	SEM	P. level	Sign.
Digestion coefficients, %							
Organic matter (OM)	72.17^{b}	72.12^{b}	75.55^{a}	70.19^{c}	0.61	0.000	**
Crude protein (CP)	59.61^{c}	66.50^{b}	71.63^{b}	67.42^{ab}	1.42	0.002	**
Crude fiber (CF)	44.51^{b}	54.55^{a}	57.11^{a}	46.28^{b}	1.79	0.053	*
Ether extract (EE)	92.91	93.86	92.26	94.11	0.63	0.771	NS
Nitrogen free extract (NFE)	79.84^{a}	75.70^{b}	78.89^{a}	73.61^{c}	0.76	0.000	**
Nutritive value, %							
Total digestible nutrients (TDN)	63.95^{b}	64.05^{b}	66.99^{a}	62.64^{c}	0.43	0.001	**
Digestible crude protein (DCP)	11.39^{c}	12.74^{b}	13.75^{a}	12.98^{b}	0.26	0.002	**

a, b and c: Means in the same row having different superscripts are significantly different at (P<0.05).

SEM: standard error of means. *: Significant at level (P<0.05). **: Significant at level (P<0.01). NS: Not significant.

Table 4: Adjusted initial weight of different traits for rabbits (n = 9/ group)

	Initial slaughtered rabbits							
	G_10	G_2	G_3	G_4				
Item	% ML	0.15% ML	0.30% ML	0.45% ML	Overall mean	SEM	P. level	Sign.
Live body weight, kg	0.474	0.587	0.522	0.726	0.577	0.038	0.108	NS
Empty body weight, kg	0.418	0.519	0.488	0.641	0.516	0.034	0.106	NS
Carcass weight, kg	0.251	0.311	0.292	0.385	0.310	0.020	0.106	NS
Lean + fat, kg	0.195	0.242	0.227	0.299	0.241	0.016	0.108	NS
Bone	0.056	0.069	0.065	0.086	0.069	0.005	0.111	NS
Edible offals (giblet), kg	0.020	0.025	0.023	0.030	0.024	0.002	0.135	NS
Non-edible offals, kg	0.046	0.057	0.054	0.071	0.057	0.004	0.096	NS
Trimmings, kg	0.101	0.126	0.119	0.155	0.125	0.004	0.118	NS

SEM: standard error of means NS: Not significant.

Table 5: Adjusted final weight of different traits for rabbits (n = 9/ group)

	Final slaughtered rabbits						
	G_1	G_2	G_3	G_4			
Item	0 % ML	0.15% ML	0.30% ML	0.45% ML	SEM	P. level	Sign.
Live body weight, kg	1.809[b]	2.281[a]	2.210[a]	1.889[b]	0.007	0.003	**
Empty body weight, kg	1.620[b]	2.107[a]	2.038[a]	1.736[b]	0.007	0.003	**
Carcass weight, kg	1.020[b]	1.368[a]	1.336[a]	1.106[b]	0.005	0.001	**
Lean + fat, kg	0.769[d]	1.114[a]	1.082[b]	0.872[c]	0.005	0.001	**
Bone, kg	0.251[a]	0.254[a]	0.254[a]	0.234 [b]	0.003	0.036	*
Edible offals (giblet), kg	0.080	0.091	0.091	0.084	0.002	0.052	NS
Non-edible offals, kg	0.168[b]	0.186 [a]	0.185 [a]	0.161[b]	0.004	0.024	*
Trimmings, kg	0.352	0.462	0.426	0.385	0.002	0.108	NS

a, b, c and d: means in the same row having different superscripts are significantly different at (P<0.05).

SEM: standard error of means

*: Significant at level (P<0.05). **: Significant at level (P<0.01). NS: Not significant.

Table 6: Overall mean body composition (%) ±SD of fresh traits for initial and final slaughtered rabbits

Item	Lean + fat	Bone	Edible offals	Non-edible offals	Trimming
Initial slaughtered rabbits					
Moisture	76.26±0.34	56.54±2.75	73.29±1.12	81.26±1.75	67.42±0.43
Protein	17.89±0.82	20.13±0.71	20.86±0.77	14.33±1.76	25.96±0.28
Fat	4.48±0.83	5.73±0.30	4.60±0.78	3.34±0.97	4.42±0.64
Ash	1.30±0.09	17.50±1.33	1.12±0.06	0.99±0.09	2.18±0.05
G_1 (0 % ML)					
Moisture	75.28±2.80	57.43±2.34	74.49±0.34	80.15±1.75	67.43±0.43
Protein	19.65±0.42	20.85±0.23	20.88±0.06	15.29±1.34	26.03±0.38
Fat	3.32±2.40	6.01±1.78	3.05±0.38	3.50±0.31	4.47±0.04
Ash	1.48±0.04	15.47±0.42	1.52±0.01	1.00±0.09	2.00±0.02
G_2 (0.15 ML)					
Moisture	74.34±3.34	55.19±4.34	73.33±1.88	80.19±1.75	67.23±0.43
Protein	19.37±1.36	21.06±1.59	20.03±0.90	16.11±1.33	26.22±0.38
Fat	4.52±1.87	6.75±1.65	5.04±0.76	2.69±0.31	4.54±0.04
Ash	1.46±0.17	16.80±0.99	1.51±0.21	1.00±0.09	1.98±0.02
G_3 (0.30 ML)					
Moisture	73.02±2.25	52.17±1.51	73.42±1.09	80.01±1.75	67.48±0.43
Protein	18.77±0.13	19.52±0.13	19.94±1.88	15.42±1.34	26.17±0.38
Fat	6.36±1.91	8.76±1.19	5.08±1.14	3.52±0.31	4.51±0.04
Ash	1.54±0.21	19.39±0.20	1.48±0.31	0.98±0.09	1.83±0.02
G_4 (0.45 % ML)					
Moisture	75.42±2.83	55.03±1.38	76.92±2.87	79.81±1.75	68.17±0.43
Protein	18.15±1.15	19.82±0.57	17.66±2.08	15.62±1.34	25.96±0.38
Fat	4.71±1.54	6.83±0.47	4.08±0.65	3.60±0.31	4.81±0.04
Ash	1.44±0.11	18.15±0.35	1.27±0.12	0.97±0.09	1.68±0.02

n = 5 for initial body composition.

n = 3 rabbits/ group for final body composition.

Table 7: Utilization efficiency of digestible energy and protein for gain of rabbits in experimental groups

	Experimental groups						
	G_1	G_2	G_3	G_4			
Item	0% ML	0.15% ML	0.30% ML	0.45 ML	SEM	P. level	Sign.
Initial body weight, kg	0.474	0.587	0.552	0.726	0.04	0.108	NS
Final body weight, kg	1.862[b]	2.343[a]	2.272[a]	1.956[b]	0.07	0.003	**
Mean body weight	1.168[b]	1.465[a]	1.412[a]	1.341[a]	0.04	0.013	*
Mean weight, $Kg^{0.75}$	1.124[b]	1.331[a]	1.295[a]	1.246[a]	0.03	0.012	*
Initial body energy content, kcal	620.76	770.61	724.62	951.85	50.22	0.105	NS
Final body energy content, kcal	2504.93[b]	3428.10[a]	3450.30[a]	2713.73[ab]	168.64	0.071	*
Total energy gain, Mcal	1.888[ab]	2.657[ab]	2.726[a]	1.762[b]	0.176	0.076	*
Initial body protein content, g	82.60	102.55	96.43	126.66	6.68	0.105	NS
Final body protein content, g	334.30[b]	435.97[a]	407.67[a]	341.50[b]	15.90	0.025	*
Total protein gain, g	251.70[b]	333.42[a]	311.24[a]	214.84[b]	17.12	0.021	*
Feed intake, kg / period / head							
Dry matter (DM)	8.288	8.176	8.680	8.064	0.003	0.570	NS
Total digestible nutrients (TDN)	5.300[b]	5.237[b]	5.814[a]	5.051[c]	0.002	0.091	*
Digestible crude protein (DCP)	0.944[b]	1.042[b]	1.193[a]	1.047[b]	0.001	0.003	*
Maintenance requirements for:							
Digestible energy (DE, M cal / period / head)	6.211[b]	7.357[a]	7.160[a]	6.889[a]	0.15	0.012	**
Digestible crude protein (DCP, kg / period / head)	0.174[b]	0.206[a]	0.200[a]	0.193[a]	0.004	0.012	**
Available for gain:							
DE left for gain, Mcal / period / head	15.641[b]	14.355[c]	17.104[a]	14.157[c]	0.36	0.000	**
DCP left for gain, kg / period / head	0.706[c]	0.765[b]	0.917[a]	0.781[b]	0.02	0.000	**
Utilization efficiency for gain, %							
Energy	12.05[c]	18.49[a]	15.91[b]	12.40[c]	1.14	0.025	*
Protein	35.98[b]	43.92[a]	34.24[b]	27.91[c]	2.13	0.030	*

a, b and c: means in the same row having different superscripts are significantly different at (P<0.05).

SEM: standard error of means. *: Significant at level (P<0.05). **: Significant at level (P<0.01). NS: Not significant

nitrogen-free extract (NFE) 54.02-54.20% and ash 15.44-15.82% on DM basis, respectively. Calculated gross energy of experimental diets was between 3.925 to 3.945 kcal/ g.

Results of digestibility trials (Table 3) showed significant differences (P<0.05) among groups, where the highest total digestible nutrients (TDN) and digestible crude protein (DCP) were recorded for diet supplemented with (0.30% ML) being 66.99 and 13.75% for TDN and DCP, respectively, followed by 64.05 and 12.74% for (0.15% ML) diet. The lowest TDN value was recorded for (0.45% ML) diet, while, the lowest DCP value (11.39%) for the control diet (0% ML). Many previous studies carried out on rabbits reported positive effects of moringa leaves as a dietary protein source on nutrients digestibility without and adverse effect even when the replacement level reached 15% of total diet [31] or from 20 to 100% of dietary ground nut cake [32]. In this study, the adverse effect of moringa leaves supplementation on nutrient digestibility took place with a very small amount of moringa (0.45%). Concerning the mean daily feed intake of rabbits fed 0.45% ML (Table 7) was 144 g/d provided nearly 650 mg moringa for animals weighed in average 1.250 kg. This particular point might need further study for cumulative effect of phytochemical compounds of moringa dry leaves in different animals and under different feeding conditions.

Adjusted initial and final weights for different traits of rabbits in the experimental groups are given in Tables (4, 5) and the overall mean chemical composition of different traits of slaughtered rabbits is presented in Table (6). Adjusted initial weight of different traits (n=9) showed that there were no significant difference among groups, while, the final slaughter (n=9) showed high significant (P<0.01) differences among groups. Concerning weight of live body, empty body, carcass and lean meat, however,

there was slight significant difference (P<0.05) was recorded among groups concerning weight of bone and non-edible offals. No significant difference was detected for edible offals and trimmings weight. The highest value were recorded for rabbits fed 0.15 and 0.30% ML diet, while lower and comparable weights were recorded for rabbits fed either control (0.0% ML) or 0.45% ML diet.

Overall mean values of composition of different traits for initial and final slaughtered rabbits (Table 6) were used to calculate weight gain composition after adjusted the values according to individual initial and final weight of each group.

Data presented in Table (7) show that there were no significant difference between groups for initial body weight and body energy and protein contents. Mean daily dry matter voluntary intake was similar among groups with values between 144 to 155g/d/head of iso-caloric-iso-nitrogenous diets. Final body energy and protein contents showed significant difference (P<0.05) among groups under the administration of moringa supplementation level. The highest values of final body weight and final body energy and protein contents was recorded on rabbits fed 0.15 and 0.30% ML diets with no significant difference between the two groups. Rabbits fed 0 and 0.45% ML diets showed comparable values being 1.862 and 1.956 kg for final body weight, 2504.93 and 2713.73 kcal for final body energy content and 334.30 and 341.50g for final body protein content, respectively. These values were significantly (P<0.05) lower than those of the other two groups (0.15 and 0.30% ML). Net energy and protein gain calculated as the difference between final and initial body composition confirmed that groups fed 0.15 and 0.30% ML supplemented diets had significantly (P<0.05) higher net energy and protein gain than fed 0% and 0.45% ML diets with no significant difference between each of the two groups. Values of gained energy and protein were respectively, 2.657 and 2.726 Mcal and 333.42 and 311.24g for rabbits fed 0.15 and 0.30% ML diets, while 1.888 and 1.762 Mcal and 251.70 and 214.84g were recorded for rabbits fed control or 0.45% ML diets.

Due to shortage of information about the maintenance requirements of rabbits in available literature, the dietary energy and protein required for maintenance was calculated as 413 KJ equivalents to 98.71 kcal DE/ kg $w^{0.75}$ [17, 18] and 442 mg digestible nitrogen equivalent to 2.76g DCP/ kg $w^{0.75}$ [19]. Maintenance values of energy and protein were used to calculate by difference the portion of dietary energy and protein left available for gain during the whole feeding period (56 days) of each group. Digestible energy and protein utilization efficiency was the relative value of net energy or protein gain % of DE or CDP intake left available for gain [14].

The highest dietary energy utilization was recorded for rabbits fed 0.15% ML diet (18.49%) with (P<0.05) difference than other groups followed by 15.91% for 0.30% ML, while both of the control (% ML) and 0.45% ML groups recorded lower comparable values being 12.05% and 12.40%, respectively.

Nearly similar trend was also recorded for digestible protein utilization being 43.92% for rabbits fed 0.15% ML diet, while significant (P<0.05) lower, but comparable values were recorded for rabbits fed either control or 0.30 ML diets (35.98 and 34.24%, respectively). The lowest dietary protein utilization was 27.91% for rabbits fed the highest moringa supplementation level (0.45%) with significant (P<0.05) difference from all other groups. The previous results pointed out to that the beneficial effect of moringa leaves supplementation was attained with the levels between 0.15% to a maximum of 0.30% in diets of growing rabbits. Dietary energy and protein utilization efficiency was higher with 0.15% ML diet than control by 50% and 23%, respectively, while corresponding improvement values were decreased with 30% ML diet to 32.5% for energy but nil for protein.

In other words, it seems logic to state that moringa dry leaves (Powder form) to a certain supplementation level can play a role as a natural growth enhancer; however to unknown reason with higher supplementation levels being in this study 0.30 to 0.45% a gradual adverse effect was occurred. In the contrary to our results of recent studies carried out on rabbits, concluded that feeding dried moringa leaves in partial or complete replacement (From 20 to 100%) of traditional oil seed cakes was associated with improvement of weight gain, nutrients digestibility and carcass traits [28-30]. Meanwhile, Adeniji and Lawal [32] found that daily weight gain and feed conversion of growing rabbits were significantly improved with increasing moringa leaves replacement level at 0, 2, 4 and 6%; while significant decreased was mentioned with 8 and 10% replacement of moringa. In the present study, the level of moringa leaves supplementation was too much lower than in the other studies which might imply unconversing results.

When rats was used as models given the water extract of the leaves it showed that 150-200 mg/ kg live weight oral intake is deemed as optimal with greater potency than higher and lower doses [33]. Based on mean daily feed intake and live weight of rabbits in this study, dosages of moringa dry leaves were found to be 0, 150, 329 and 485 mg/ kg weight / animal / day for rabbits in

groups 1, 2, 3 and 4, respectively. In this concern it was noted that despite the plant being referred to as nontoxic this dose not appear to be the case, while supplemental dosages in proper level appear to be save from tested toxicity a relative small increase (3-4 times the recommended dose is known to cause genotoxic damage and may promote cancer formation, whereas doses higher than that causes overt organ damage (mostly liver and kidneys) as cited from Examine. Com [33].

CONCLUSION

It is concluded that supplementation of *moringa oleifera* dry leaves to diets of growing NZW rabbits is highly recommended at 0.15% or at maximum 0.30% of the daily ration (Equivalent to 150 to 330 mg/ kg live weight) to enhance growth performance and improve carcass traits and promote dietary energy and protein utilization efficiency. Indeed there is a need to investigate in future studies the accumulation effect of the bioactive substances of moringa leaves on nutrients absorption and metabolism and the proper oral dosages for different animal species to promote their health status and productivity

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