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EFFECTS OF FEEDING *Moringa stenopetala* LEAF MEAL ON NUTRIENT INTAKE AND GROWTH PERFORMANCE OF RHODE ISLAND RED CHICKS UNDER TROPICAL CLIMATE

[EFECTO DE LA ALIMENTACIÓN CON HARINA DE HOJA DE *Moringa stenopetala* SOBRE EL CONSUMO DE NUTRIENTES Y COMPORTAMIENTO PRODUCTIVO DE POLLOS RHODE ISLAND RED EN CLIMA TROPICAL]

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SUMMARY

The effects of *Moringa stenopetala* leaf meal (MSLM) on nutrient intake and weight gain (WG) were evaluated. Forty unsexed Rhode Island Red chicks were randomly assigned to 4 treatment groups. The control diet (T1) (MSLM 0%), the experimental diets contained MSML at a rate of 2% (T2), 4% (T3), and 6% (T4) of the diets (as fed basis) to replace 3%, 5.9% and 8.8% of the crude protein (CP) of the control diet. Daily feed, dry matter and CP intake of the chicks fed MSLM diets were higher ($p<0.05$) than those fed the control diet. Average weight gain (AWG) of birds fed MSLM diets were higher ($p<0.05$) than those fed the control diet. Chicks fed T4 showed higher ($p<0.05$) AWG than those on T2 and T3. Feed efficiency ratio (FER, g gain/g feed intake) and protein efficiency ratio (PER, g gain/g CP intake) were higher for chicks fed MSLM. MSLM elicited no deleterious effects in the birds. The results indicated that MSLM is a potential plant protein supplement and could be included to 6% in the diet of grower chicks to substitute expensive conventional protein sources.

Key words: *Moringa stenopetala* leaf meal; Rhode Island Red chicks; nutrient intake; growth performance

RESUMEN

Se evaluó el efecto de la harina de hoja de *Moringa stenopetala* (MSLM) sobre el consumo de nutrientes y ganancia de peso. Cuarenta pollos Rhode Island Red fueron asignados a 4 grupos. Dieta control (T1) (MSLM 0%), y dietas experimentales que contenían MSML al 2% (T2), 4% (T3), y 6% (T4) de la dieta (base fresca) para reemplazar 3%, 5.9% y 8.8% de la proteína cruda de la dieta control. El consumo de materia seca y proteína de los pollos alimentados con MSLM fue mayor ($p<0.05$) en comparación con la dieta control. La ganancia de peso promedio en las aves alimentadas con MSLM fue mayor ($p<0.05$) que las aves del grupo control. Las aves alimentadas con la dieta T4 mostraron una mayor ganancia de peso ($p<0.05$) que las aves en T2 y T3. La eficiencia alimenticia (g ganancia/g consumo alimento) y la eficiencia proteínica (g ganancia/g consumo proteína) fueron mayores en las aves alimentadas con MSLM. MSLM no causó ningún efecto detrimental en las aves. Los resultados indican que MSLM es un suplemento de proteína vegetal que puede ser incluido al 6% en la dieta de pollos de engorda en sustitución de fuentes proteicas convencionales de mayor precio.

Key words: Harina de hoja de *Moringa stenopetala*; pollos Rhode Island Red; consume nutrientes; crecimiento.

INTRODUCTION

Poultry production plays a major role in bridging the protein gap in developing countries where average daily consumption is far below recommended standards (Onyimonyi *et al.,* 2009). However, the productivity of poultry in the tropics has been limited by scarcity and consequent high prices of the conventional protein and energy sources. Protein sources are especially limiting factors in poultry feed production in the tropics (Atawodi *et al.,* 2008). Hence, there is a need to search for locally available alternative sources of protein for use as feed supplement to poultry. One possible source of cheap protein to poultry is the leaf meal of some tropical legume and plants (Iheukwumere *et al.,* 2008).

Leaf meals of various plants have been incorporated in the diets of poultry as a means of reducing the high cost of conventional protein sources (D'Mello *et al.*, 1987; Udedibie and Opara, 1998; Kakengi *et al.*, 2007; Nworgu and Fasogbon, 2007; Iheukwumere *et al.*

2008). According to D'Mello *et al.* (1987) and Fasuyi *et al*. (2005) leaf meals do not only serve as protein source but also provide some necessary vitamins, minerals and oxycaretenoids which cause yellow colour of broiler skin, shank and egg yolk.

Among various types of Moringa species, *Moringa stenopetala* (*M. stenopetala*) is native to Ethiopia, Northern Kenya and Eastern Somali and is the most economically important species after *M. oleifera* (Olson, 2001). It is widely distributed in the Rift Valley of southern Ethiopia (Bekele, 1993; Edwards *et al.,* 2000) and is used as vegetable food for human consumption and animal feed resources during dry period (Abuye *et al.,* 2003). The edible parts of the Moringa tree are exceptionally nutritious (Rams, 1994; Teketay, 2001). Leaf parts are promising as a food source in the tropics because the tree is full of leaves during the dry season when other foods are typically scarce (Fahey, 2005). Recent studies conducted by Melesse *et al.* (2009) and Negesse *et al.* (2009) indicated that leaves of *M. stenopetala* are rich in protein (28.2-36.2%) and contain considerable amounts of essential amino acids. The leafy part of Moringa could thus be used as a protein supplement for poultry. The present study was thus designed to investigate the effects of feeding different levels of *Moringa stenopetala* leaf meal (MSLM) on nutrient intake and growth performance of dual purpose Rhode Island Red (RIR) chicks.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at Hawassa University, College of Agriculture, which is situated 275 km south of Addis Ababa, Ethiopia, at 7°4′N latitude and 38°31′E longitude at an altitude of 1650 m above sea level. Rainfall is bi-modal and ranges between 674 and 1365 mm. The mean temperature ranges between 12 ^{0}C and 27 ^{0}C.

Preparation of experimental diets

Moringa leaves were collected from Farmers Training Centers (Arbaminch, Southern Ethiopia) and from selected farmers' fields which are located near the center. Branches from matured Moringa trees were cut and twigs and leaflets were removed by hand. The collected leaves were then spread on a *Satara* (made of thinly sliced dried bamboo stalks and woven together like wire mesh) and dried in the open air until the leaves were dried out uniformly. Using locally-made *satara* for drying purpose is advantageous because it efficiently enhances air circulation during the drying process and prevents uneven drying of leaves by retaining the greenish color of the leaves. The dried leaves were hand-crushed and further ground using mortar and pestle at 2 mm size.

Pre-trial test

A pre-trial test was conducted using small number of RIR chicks to check whether or not the diets containing MSLM are palatable to the baby chicks. The pre-trial test started when the chicks were 2 weeks old and lasted 2 weeks which was sufficient to check the palatability of MSLM diets.

Experimental design

Ten unsexed RIR chicks were assigned to each of the four replicates of the four treatment diets. The dietary treatments were the control diet (T1) without MSLM and diets containing MSLM at the rate of 2% (T2), 4% (T3), and 6% (T4) to replace 3%, 5.9% and 8.8% of the CP of the control diet (Table 1). T1 was the control diet with approximately 19.16% CP and 3295 kcal ME/kg DM. The proportion of feed ingredients is presented in Table 2. Both Soybean and noug cake have been reduced in T2 through T4 and replaced proportionally by MSLM.

Table 1. Experimental design of the feeding trial with RIR chicks

Diets	Inclusion rate of MSLM (%)	Replicates	Chicks per replicate	Total chicks per treatment
T1	0	4	10	40
T2	2	4	10	40
T3	4	4	10	40
T4	6	4	10	40
Total (n)			40	160

Table 2. Gross composition (g/100 g) of experimental grower diets (n= 4 replications of 10 birds each)

Feed ingredients (%)	Treatment diets			
	T1	T2	T3	T4
Maize	34.0	34.0	34.3	35.0
Wheat bran	25.3	25.3	24.0	23.0
Soybean, roasted	28.0	27.0	26.0	25.8
Noug cake (*Guizotia abyssinica*)	11.0	10.0	10.0	8.50
M. stenopetala leaf meal	0.00	2.00	4.00	6.00
Lime stone[1]	1.20	1.20	1.20	1.20
Salt	0.50	0.50	0.50	0.50
Total	100	100	100	100

[1]Limestone contains 35% Calcium (Boushy and Van der Poel, 2000)

Management of experimental chicks

Unsexed dual purpose RIR chickens were bought from Poultry Multiplication and Distribution Center, Awassa, Ethiopia. The center multiplies chickens of this breed and distributes to private investors, Research Institutes and smallholder farmers. Experimental pens, watering and feeding troughs were cleaned and disinfected with appropriate disinfectants prior to the commencement of the experiment. Chicks were vaccinated against Newcastle and Infectious Bursal Diseases (*Gumboro*) on the 7th and 12th days, respectively. The chicks were fed a starter ration for the first two weeks. They were then leg-tagged and 10 chicks were randomly assigned to each of the four replicates of the four treatment diets.

They were kept in a deep litter housing system with concrete floors. Wood shavings were used as litter at a depth of 5 cm. Each day, a measured amount of feed was offered to birds. Daily offer of each group was 10% more than intake of the previous day and fresh clean water was available at all times. Daily feed refusals in each pen was collected, weighed and recorded at 8:00 AM before feed was offered.

Mortality and any abnormality were recorded throughout the entire experimental period. Body weight was taken at the beginning of the experiment and subsequently on a weekly basis. Weighing of the chicks was carried out in the morning between 7:00 and 9:00 AM before the feed was offered. Weight gain, nutrient intake, nutrient conversion and nutrient efficiency ratios were calculated.

Nutrient analysis

Dry matter, crude fiber (CF) and ash were determined according to AOAC (1990). Dry matter content of feed offered and refused was determined by drying the samples at 105^{o}C overnight. Ash was determined by combusting the sample at 550^{o}C for 5 hrs. Total nitrogen was determined using the micro-Kjeldahl method. Crude protein (CP) was calculated as N x 6.25. The ME values were calculated indirectly from the ether extract, crude fiber and ash adopting the equation proposed by Wiseman (1987). The concentration of calcium was analyzed using an atomic absorption spectrophotometer. Phosphorus was determined by continuous flow auto-analyzer (Chemlab, 1978). All samples were analyzed in duplicates at the National Veterinary Institute (NVI) Laboratory, Ethiopia.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) for completely randomized designs consisting of four treatments by 4 replications using the General Linear Models (GLM) Procedure of Statistical Analysis System (SAS, 2001). Where significant differences were observed treatment means were compared with Tukey's studentized range (HSD) test. All statements of statistical differences were based on $p<0.05$ unless noted otherwise.

RESULTS

Nutrient composition

Nutrient and energy contents of the MSLM and experimental diets are presented in Table 3. The diets were very close in their CP (from 18.8 to 19.9% CP) and energy (from 3235 to 3296 kcal/kg DM) contents. The fat content of T1 was slightly higher than those of the other treatment diets because of higher amount of soybean in T1. This is apparently reflected in the ME content of diets.

Nutrient intakes

Table 4 shows the daily mean nutrient intakes of chicks fed different levels of MSLM. Dry matter and CP intake were significantly ($p<0.05$) higher in all chicks fed MSLM diets than those on the control diet. When the MSLM level increased from 2 % (T2) to 6% (T4), DM intake remained similar throughout the experimental period (Table 4). No significant differences were observed in the ME, CF, Ca and P intake of chicks fed the MSLM diets and the control. Within treatment groups, the CP intake of T4 was significantly ($p<0.05$) higher than those of T2 and T3 whereas it was higher in T3 than those of T2 and T1. The CP intake showed linear increase with increasing levels of MSLM supplementation.

Body weight gain and efficiency ratios

The average body weight, body weight gain and feed efficiency ratios of RIR chicks fed the different levels of MSLM diets are presented in Table 5. The average body weight gain of chicks fed the MSLM diet was significantly ($p<0.05$) higher than those fed on T1. Average body weight and weight gain of chicks fed on T4 were significantly ($p<0.05$) higher than those on T2 and T3 indicating improved performance with increased levels of MSLM supplementation.

The FER and PER of chicks fed the MSLM diets were not significantly different among each other but were significantly higher ($p<0.05$) than those on the control diet. Mortalities were observed only in chicks fed on the control diet.

Table 3. Nutrient and metabolizable energy contents of *Moringa stenopetala* leaf meal and the experimental diets

Diets	Nutrients (% DM)							ME
	Ash	CP	EE	CF	NFE	Ca	P	(kcal/kg DM)
T1	7.88	19.2	9.17	9.39	47.1	0.65	0.75	3295
T2	7.74	18.8	8.45	9.35	49.0	0.71	0.73	3266
T3	7.83	19.4	8.52	9.18	48.8	0.74	0.68	3235
T4	7.97	19.9	8.74	9.19	48.7	0.82	0.63	3236
MSLM	11.8	30.6	4.73	8.30	40.2	2.09	0.37	2992

CP=Crude protein; EE=Crude fat; CF=Crude fiber; NFE=Nitrogen-free extract; Ca=Calcium; P=Phosphorous; ME=Metabolizable Energy

Table 4. Mean daily nutrient and ME intake of RIR chicks fed diets with different levels of *M. stenopetala* leaf meal

Nutrient intakes	Treatment diets				S.E.M	p
	T1	T2	T3	T4		
DMI (g/chick/d)	61.3^{b}	61.9^{a}	62.3^{a}	62.6^{a}	1.130	<0.05
CPI (g/chick/d)	12.6^{c}	12.6^{c}	13.0^{b}	13.4^{a}	0.232	<0.05
CFI (g/chick/d)	5.80	5.79	5.77	5.76	0.127	0.56
MEI (g/chick/d)	218	217	216	219	0.057	0.34
CaI (g/chick/d)	0.55	0.54	0.56	0.56	0.003	0.49
PI (g/chick/d)	0.46	0.47	0.46	0.46	0.001	0.73

Means between treatment diets in the same row with different superscript letters are significantly ($p< 0.05$) different; DMI=Dry matter intake; CPI=Crude protein intake; CFI=Crude fiber intake; MEI=Metabolizable Energy intake; CaI=Calcium intake; PI=Phosphorus intake; S.E.M=Standard error of means

Table 5. Average body weight, body weight gain, feed and protein efficiency ratios of RIR chicks fed different levels of *M. stenopetala* leaf meal

Parameters	T1	T2	T3	T4	S.E.M	p
Average body weight (g)	293^{c}	318^{b}	320^{b}	333^{a}	1.743	<0.01
Body weight gain (g/bird/d)	6.03^{c}	7.43^{b}	7.98^{b}	8.55^{a}	0.097	<0.01
FER (g gain/g feed)	0.10^{b}	0.12^{a}	0.12^{a}	0.13^{a}	0.003	<0.01
PER (g gain/g CP)	0.50^{b}	0.61^{a}	0.65^{a}	0.65^{a}	0.162	<0.01

Means between treatment diets in the same row with different superscript letters are significantly ($p<0.05$) different; S.E.M= Standard error of means

DISCUSSION

The CP content of *M. stenopetala* leaf obtained in the present study was slightly higher than reported by Oduro *et al.,* 2008 (27.5%) and Melesse *et al.,* 2009 (28.2%) but lower than CP values found by Negesse *et al.*, 2009 (36.0%). Soliva *et al.* (2005) reported 32.1% of CP for *M. olifera* leaves, which is slightly higher than found in the present study. The CP contents of the diets varied between 18.8 to 19.9%. Eekeren *et al.* (1997) suggested the minimum CP requirement for growing chicks as 18% on air dried basis. Similarly, Scanes *et al.* (2004) recommended 20% and 18.5% CP for grower and finisher broilers, respectively.

The fat content of the control diet showed a slight increase than the other treatments. This resulted in slightly higher ME content in the respective treatments than the recommended 3200 kcal ME/kg DM for broilers by Scanes *et al.* (2004) although maximum ME requirement is not stated and information on RIR chickens in the tropics is scanty.

Kakengi *et al*. (2007) observed increased feed intake in layer hens fed diets containing 10 and 20% levels of *M. olifera* leaf meal in which inclusion rates were about twofold higher than those of the present study. However, dietary *M. olifera* leaf meal levels up to 5% did not show any significant effect on feed intake (Kakengi *et al*., 2007). Iheukwumere *et al*. (2008) reported similar intake values for groups on 5% dietary levels of *Cassava* leaf meal. Consistent with the present study, Ekenyem and Madubuike (2006) reported improved feed intake for broilers fed diets with 5% and 10% levels of *Ipomoea asarifolia* leaf meal but intake was depressed at 15%. On the other hand, Nworgu and Fasogbon (2007) reported reduced feed intake for Black Nera pullets fed diets containing 2%, 4% and 6% *Centrosema pubescens* leaf meal.

The present findings indicate that MSLM to have lowered anti-nutritional factors (ANFs) and toxic substances reported in other leaf meals (Makkar and Backer 1997). Melesse *et al.* (2009) observed negligible amounts of tannins and total phenols in leaves of *M. stenopetala*. Similarly, unextracted leaves of *M. oleifera* had negligible amounts of tannins (14 g/kg DM) and condensed tannins were not detectable (Makkar and Becker, 1996). Moreover, leaves from *M. stenopetala* did not show any haemolytic activity of saponin (Negesse *et al.*, 2009). According to Makkar and Becker (1997), cyanogenic glycoside and glucosinolates were not detected in leaves of *M. oleifera*. Besides, humans consume Moringa leaves without apparent harm.

Nworgu and Fasogbon (2007) observed lower CP intake in growing pullets fed 2%, 4% and 6% levels of *C. pubescens* leaf meal compared to those on control diet. Reduced CP intake was also reported in broilers fed on cassava leaf meal at levels of 5%, 10% and 15% (Iheukwumere *et al*., 2008), more specifically at higher levels of inclusion rate.

The intakes of both major minerals (Ca and P) in chicks fed on MSLM diet were not different to those of control diet. The Ca content in MSLM (2.09%) was much higher than that of soybean (0.26%; Ensminger, 1992). Phytate is known to reduce bioavailability of minerals (Reddy *et al.,* 1982) which justifies why Ca intake did not change with increasing levels of leaf meal supplementation. Negesse *et al.* (2009) reported high levels of phytate in *M. stenopetala* leaves. Similar high levels of phytate were also reported by Gupta *et al.* (1989) and Makkar and Becker (1996) for unextracted leaves of *M. oleifera*.

Nworgu and Fasogbon (2007) observed enhanced ($p<0.05$) body weight gain in growing pullets fed diets of 2%, 4% and 6% *C. pubescens* leaf meal which is in good agreement with the present findings. Moreover, Omeje *et al*. (1997) reported similar observations in broiler chicks fed on 5-10% *C. pubescens* leaf meal. Broiler chickens fed on 2.5-5% levels of *C. pubescens* leaf meal showed increased growth performance compared to control group (Nworgu, 2004). On the other hand, Du *et al.* (2007) observed no significance difference in growth performance of 3 weeks old broilers (Arbor Acres) that were fed on diets supplemented with 0.5, 1.0, 2.0 and 3.0% levels of *M. oleifera* leaf meal. Reduced growth performance was observed in broilers fed diets containing increased levels of *Ipomoea asarifolia* (Ekenyem and Madubuike**,** 2006). Similarly, D'Mello and Acamovic (1989) reported depression in the growth performance of chicks on high dietary inclusion rates of *Leucaena leucocephala* leaf meal.

These discrepancies observed in the weight gain of chicks maintained on diets containing MSLM and other leaf meal supplements might be explained by the presence of high pepsin soluble nitrogen (82-91%), low acid detergent insoluble protein (1-2%) and low anti-nutritional factors in Moringa leaf meal compared to the other leaf meals (Makkar and Becker, 1997). This suggests that the protein in Moringa leaf is readily available to most animals and more suitable to monogastric animals (Kakengi *et al*., 2003). Moreover, the depressed appetite in chicks fed the control diet could probably be due to the amino acid imbalance in maize, wheat bran and noug cake which demands supplementation of cereal based diets with animal protein (Agbede and Aletor, 1997). Apart from this, methionine is in particular the primary limiting sulfur containing amino acid in soybean meal based poultry diets (NRC, 1994; Cavins *et al.*, 1972). As shown in Table 6, the concentration of most essential amino acids in *M. stenopetala* leaves is higher than those found in soybean meal. The MSLM is notably rich in methionine compared to soybean meal. Thus, the presence of this limiting amino acid as well as other essential amino acids in Moringa leaves might have contributed to the observed better nutrient intake and growth performance of chicks fed the MSLM diet compared to those on the control diet. It might also be due to the influence of other substances such as the vitamins in MSLM diet, which improved the efficiency of feed utilization of RIR chicks in the present study. Thus, these substances need further investigation. Among others, ME concentration in the diet may affect the response of chickens to amino acid levels (Coon, 2002). However, the ME content of soybean meal (Ensminger, 1992) and *M. stenopetala* leaves (Melesse *et al.,* 2009) are similar (10.17 vs. 10.0 MJ/kg DM).

All MSLM fed chicks showed better efficiency in converting feed to body tissues. In agreement with the present findings, Nworgu and Fasogbon (2007) observed increased FER in growing pullets fed diets containing 2%, 4% and 6% *C. pubescens* leaf meal. On the other hand, Fasuyi *et al*. (2008) observed reduced FER in broiler chicks fed the diets containing different levels of *Amaranthus cruentus* leaf meal as an alternative protein supplement. Moreover, low FER was observed in broilers fed diets containing 5%, 10% and 15% cassava (Iheukwumere *et al*., 2008) and *I. asarifolia* leaf meal (Ekenyem and Madubuike, 2006). Similarly, Kakengi *et al*. (2007) observed low feed utilization in layers fed 20% levels of *M. oleifera* leaf meal.

Table 6: Composition of essential amino acids of *Moringa stenopetala* leaves (g/16g N) compared to soybean meal

Amino acids	Soybean meal [a]	*M. stenopetala* leaves [b]
Methionine	1.22	1.71
Cystine	1.70	2.04
Valine	4.59	5.34
Leucine	7.72	8.50
Phenylalanine	4.84	5.27
Threonnine	3.76	4.45
Tryptophan	1.24	1.54
Isolucine	4.62	4.47
Lysine	6.08	5.68
Arginine	7.13	6.4

Source: [a]Hossain and Becker, 2001; [b]Melesse *et al*., 2009

The PER among the Moringa leaf fed groups was comparable whereas those on 6% MSLM were more efficient compared to those on other diets. Nworgu and Fasogbon (2007) observed increased PER in growing pullets fed 2, 4 and 6% *C. pubescens* leaf meal which is in agreement with the current study. However, Fasuyi *et al*. (2008) observed a reduced PER in broiler chicks fed varying levels of *A. cruentus* leaf meal.

Except in the control group, no mortality was observed in chicks fed MSLM diets throughout entire experiment. Consistent with the present findings, Nworgu and Fasogbon (2007) observed no mortality when pullet chicks were fed diets containing different levels of *C. pubescens* leaf meal. Possible explanation for the absence of mortality in chicks fed on the MSLM diet might be due to the presence of antioxidants in Moringa leaves, which enhances the immune system of animals (Yang *et al*., 2006). Moreover, Moringa leaf extracts exhibited anti-microbial activity including inhibition of the growth of *Staphylococcus aureus* strains isolated from food and animal intestines. Du *et al.* (2007) reported that dietary supplementation of *M. oleifera* might have increased immune ability of broilers. Thus, leaf meal from both *M. stenopetala* and *M. oleifera* might be potential feed additives in livestock production.

CONCLUSION

Dry matter and crude protein intake and average weight gain of RIR chicks fed on MSLM diets increased with increasing levels of MSLM. Thus, the supplementation of chicks' diet with MSLM could be an alternative feeding strategy in rural and peri-urban chicken production practices in Moringa growing tropical regions. However, further investigation is needed to establish the optimum level of MSLM inclusion in grower dual purpose chicks such as RIR. Inclusion of MSLM did not cause any health problems in the experimental birds.

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