



Effect of replacing groundnut cake with dried *Moringa oleifera* leaves on growth and nutrient utilization in crossbred (Hampshire × Ghungroo) grower pigs

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ABSTRACT

The objective of this study was to evaluate the effect of replacement of groundnut cake with dried *Moringa oleifera* leaves on growth and nutrient utilization in crossbred grower pigs. Eighteen crossbred (Hampshire × Ghungroo) grower pigs (about 2 months old, body wt. 12–14 kg) of either sex were divided into three groups of six each in a randomized block design. Three different diets were used for feeding of the animals. These were namely, T₁ (standard grower ration without dried *Moringa* leaves), T₂ (standard grower ration supplemented with 5% dried *Moringa* leaves by replacing groundnut cake) and T₃ (standard grower ration supplemented with 10% dried *Moringa* leaves by replacing groundnut cake). The pigs were fed on the experimental grower rations twice daily in the morning and evening. The crude protein content (% DM) of the grower ration ranged from 18.82±0.08 to 20.36±0.06 while that of *Moringa* leaves was 15.11±0.73. The average dry matter intake was (kg/d) 0.62, 0.62 and 0.60 respectively in T₁, T₂ and T₃ groups which were found similar across all the groups. Digestibility coefficients (%) of dry matter, organic matter, ether extract, crude fibre and nitrogen free extracts increased in *Moringa* supplemented groups. While crude protein digestibility was higher in T₂ group in comparison to other two groups. Nitrogen balance (g/d) was positive across all the groups and values were 16.10, 16.79 and 15.38 in groups T₁, T₂ and T₃ respectively. The absorbed N (g/d) was significantly higher in T₁ group (19.23) in comparison to the other two groups. However, there was no significant difference in absorbed N (g/d) in group T₁ and T₂. The absorbed N as percent intake, net protein utilization and biological value were similar across all the groups. The average body weight gain (g/day) was higher in *Moringa* leaves supplemented groups. The cost (₹/kg gain) was reduced in T₂ and T₃ groups in comparison to T₁. The feed conversion ratio (FCR) was higher in group T₃ and lower in T₂ group. From this study, it is concluded that dried *Moringa* leaves can be supplemented @ 5% level by replacing groundnut cake in grower crossbred pigs for better growth, nutrient utilization, feed conversion efficiency and also to lessen the feed cost.

Keywords: Crossbred pig, Groundnut cake, *Moringa* leaf, Nutrient utilization, Replacement

Moringa (Moringa oleifera L.) is a multipurpose tropical tree. It is mainly used for food and has numerous industrial, medical and agricultural uses, including animal feeding. It has been called the ‘miracle tree’ or ‘tree of life’ in popular media (FAO 2014, Radovich 2009, Orwa *et al.* 2009, Bosch 2004). India is the largest producer of *Moringa* in the world, with an annual production of 1.1 to 1.3 million tonnes of tender fruits (Drumstick) from plot of 380 km². Average yields of 6 tonnes/ha/year in fresh matter can be achieved. The leaves are nutritious and rich in protein, vitamins (A, B and C) and minerals. Protein of *Moringa* has high biological value (Zarkadas *et al.* 1995). All essential amino acids present in *Moringa* are in a concentration greater than the one recommended by FAO and WHO mentioned in the feed reference that is soybeans (Zarkadas *et al.* 1995).

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In pig farming, feed costs alone represent more than 70–75% of total cost of production. In intensive pig production, pig directly compete with humans for feeding, since conventional fattening is based on feeding cereals like maize, wheat, oats, barley etc along with other protein, mineral and vitamin supplements. Farmers cannot support costly feeding program because of high cost of cereals and oil cakes. As a result, animal nutritionist used to search for new feed especially unconventional feeds in order to produce economical feeding program for swine and other livestock. *Moringa* leaves (*Moringa oleifera*) is one of such unconventional feed for pigs. *Moringa* leaves are a valuable source of protein (23–24% on DM). It increases the growth rate, milk yield as well as birth weight of dairy calves (Reyes *et al.* 2006). The dried leaves of *Moringa* had 19 amino acids. Mukumbo *et al.* (2014) reported that 5% *moringa* leaf meal can be included in the finisher pig ration without any adverse effect on feed conversion ratio, carcass and

meat quality, and it improves the storage life of pork. Research on effect of Moringa leaves supplementation in swine feeding is very scanty. Besides, it is not known how much quantities of leaves have to be used to replace the conventional oil cakes in swine diet. Therefore, in this study, dried Moringa leaves was supplemented at different levels by replacing groundnut cake to see its effect on growth and nutrient utilization in crossbred grower pigs.

MATERIALS AND METHODS

Location of study and management of animal welfare:

The study was carried out at Indian Council of Agricultural Research–National Research Centre on Pig Farm located at Rani, Guwahati, Assam, India and it was carried out after the approval by the Institute Animal Ethic Committee. Animals were housed in a well-ventilated sty with proper cleanliness of animals and shed throughout the experimental period. Drinking water was available round the clock and feeding was done twice daily at 9:30 AM and 2: 30 PM.

Preparation of dried Moringa leaves: Moringa (*Moringa oleifera*) leaves were collected fresh from older plants of 5–6 years of age from Rani block of Kamrup district of Assam and sun dried to a dry matter content of 90%. The leaves was crushed manually after drying and then stored in gunny bags till used in the experimental ration. Proximate composition of experimental ration and Moringa leaves were done as per AOAC (1990).

Experimental animals and design of experiment: Eighteen crossbred (Hampshire × Ghungroo) grower pigs (about 2 months old, body wt. ranged from 12–14 kg) of either sex were divided into three groups of six each (n=6, per treatment) in a randomized block design. Three different diets were used for feeding of the experimental animals. The diets were T₁ (standard grower ration without dried Moringa leaves and named as control diet); T₂ (standard grower ration supplemented with 5% dried Moringa leaves by replacing groundnut cake) and T₃ (standard grower ration supplemented with 10% dried Moringa leaves by replacing 42.9% groundnut cake). The ingredient composition of diets are shown in Table 1. Dried Moringa leaves was added on w/w basis to the experimental diets. Lysine and methionine were balanced in all the rations according to the requirement. The pigs were fed on the experimental grower rations twice daily in the morning and evening. The nutrient requirement of pigs was made according to Bureau of Indian Standard (BIS 1986). The experiment was conducted for three months. Fortnightly body weight of the experimental animals was recorded using digital balance. A metabolic trial for 5 days duration was conducted at the middle of the feeding experiment.

Digestion trial: Experimental pigs were shifted from grower sty to metabolic cages during conduction of digestion trial. Individual weight of the pigs was recorded before and after the initiation of digestion trial. Net protein utilization (NPU) was calculated from the percent ratio of N balance and N intake. Biological value (BV) was calculated from the percent ratio of N balance and N-absorbed.

Table 1. Ingredient composition (w/w) of experimental diet

Ingredient	T ₁ (%)	T ₂ (%)	T ₃ (%)
Maize crush	61.0	61.0	61.0
Wheat bran	4.0	3.0	0.5
Soybean meal	16.0	17.0	17.0
Groundnut cake	17.5	12.5	10.0
Dried Moringa leaves	0.0	5.0	10.0
Mineral mixture	1.0	1.0	1.0
Salt	0.5	0.5	0.5
Total	100.0	100.0	100.0
Lysine (g/100 kg)	40.0	40.0	40.0
Phytase enzyme (g/100 kg)	20.0	20.0	20.0

T₁, 0% dried Moringa leaves in the diet; T₂, 5% dried Moringa leaves in the diet; T₃, 10% dried Moringa leaves in the diet.

Statistical analysis: The proximate composition, dry matter intake, nutrient digestibility and nitrogen utilization were statistically analyzed using a two-tailed general linear model (GLM) (PROC GLM) in SAS 9.4 (SAS institute Inc. 2014, USA) with pig as experimental unit. The model included the effects of three diets on response variables. Least squares means were calculated per experimental diet and statistical differences between least squares means were determined using a post hoc Duncan test. The P<0.05 were considered significant and P values between 0.05 and 0.10 were considered indicative of a trend.

RESULTS AND DISCUSSION

Proximate composition: The crude protein content (% DM) of the experimental rations ranged from 18.82±0.08 to 20.36±0.06 (Table 2). Nitrogen free extract content (% DM) of the experimental rations was 65.11±0.48 in T₁, 65.77±0.25 in T₂ and 66.13±0.07 in T₃ group (Table 3). The protein and NFE content of Moringa (*Moringa oleifera*) leaves was 15.11±0.73 and 55.84±0.08, respectively.

In this study, the protein content of experimental diet was reduced with increased level of Moringa (*Moringa oleifera*) leaves in the diet (Table 2). The reduction was due to lower protein content of Moringa (*Moringa oleifera*) leaves in comparison to groundnut cake. Other studies have reported a variable protein content of Moringa (*Moringa oleifera*) leaves ranging from 16 to 40% (Gidamis *et al.* 2003, Sarwatt *et al.* 2004, Nouala *et al.* 2006, Reyes *et al.* 2006, Oduro *et al.* 2008, Sanchez-Machado *et al.* 2009, Moyo *et al.* 2011). These variations of protein value of Moringa (*Moringa oleifera*) leaves may be because of differences in agro-climatic conditions, age of the trees and possibly because of different stages of maturity of leaves (Aslam *et al.* 2005, Asante *et al.* 2014).

Dry matter intake, nutrient utilization and economy of feeding: The average dry matter intake was (kg/d) 0.62, 0.62 and 0.60 respectively in T₁, T₂ and T₃ groups and was found similar across all the groups (Table 3). The average daily gain (ADG, g/d) was 207.8, 216.7 and 209.2 respectively, in groups T₁, T₂ and T₃. The feed cost/kg gain was 72.41, 67.88 and 62.09 respectively in groups T₁, T₂

Table 2. Proximate composition (on % DM) of experimental diets

Parameter	T ₁	T ₂	T ₃	Moringa leaves
OM (%)	90.66±0.16	90.62±0.16	90.53±0.18	90.70±0.60
CP (%)	20.36±0.06	19.39±0.07	18.82±0.08	15.11±0.73
CF (%)	4.88±0.09	5.13±0.07	5.27±0.06	12.52±0.47
EE (%)	3.98±0.45	3.93±0.22	3.87±0.04	7.25±0.67
Ash (%)	5.68±0.06	5.79±0.03	5.92±0.01	9.30±0.60
NFE (%)	65.11±0.48	65.77±0.25	66.13±0.07	55.84±0.08
Gross energy, Kcal/kg DM*	4662.0±27.6	4643.0±9.9	4635.9±2.2	4788.7±24.6

T₁, 0% dried Moringa leaves in the diet; T₂, 5% dried Moringa leaves in the diet; T₃, 10% dried Moringa leaves in the diet. OM, Organic matter; CP, Crude protein; CF, Crude fibre; EE, Ether extract; NFE, Nitrogen free extract; *Calculated.

and T₃ respectively. The feed conversion ratio (FCR) was higher ($P>0.05$) in T₃ group while lower in T₂ group (Table 3).

Dry matter intake reduced at higher inclusion of Moringa leaves (T₃) which might be because of decrease in palatability of diet (Table 3). It is reported that tannins reduced the feed intake by decreasing the palatability of diet (Barman and Rai 2008a,b; Khan *et al.* 2014). From earlier work by other researcher (Makkar and Becker 1996, 1997, Teixeira *et al.* 2014, Leone *et al.* 2015) it was found that Moringa leaves contained 1.2–1.4% tannins. The cost (₹/kg gain) was reduced ($P>0.05$) by ₹ 10.32 and ₹ 4.53 respectively at 5 and 10% inclusion of dried Moringa leaves in the diet in comparison to T₁ group (Table 3). The average body weight gain (g/day) was higher ($P>0.05$) in Moringa leaves supplemented groups because of apparently higher ($P>0.05$) NPU and BV of protein of Moringa leaves in pigs.

Nutrient digestibility: The digestibility coefficients (%) of dry matter, organic matter, ether extract, crude fibre and nitrogen free extracts increased ($P>0.05$) by 7.17, 7.21, 9.09, 18.54 and 4.79% respectively in T₂ group while same was

Table 3. Effect of Moringa leaves on nutrient utilization in grower crossbred pigs

Parameter	T ₁	T ₂	T ₃	SEM	P value
DMI (kg/d)	0.62	0.62	0.60	0.03	0.456
Initial body weight (kg)	12.40	12.20	12.40	0.75	0.983
Final body weight (kg)	31.10	31.70	31.20	0.78	0.906
ADG (g/d)	207.78	216.67	209.22	3.33	0.324
FCR (Feed : Gain)	2.88	2.65	3.07	0.15	0.319
Feed cost/kg gain	72.41	62.09	67.88	3.50	0.305

T₁, 0% dried Moringa leaves in the diet; T₂, 5% dried Moringa leaves in the diet; T₃, 10% dried Moringa leaves in the diet; ADG, Average daily gain; FCR, Feed conversion ratio.

increased ($P>0.05$) by 8.70, 7.84, 9.50, 32.24 and 9.71% in T₃ group in comparison to T₁ group. The digestibility of crude protein was increased ($P<0.05$) by 13.34 and 6.99% respectively in T₂ and T₃ group in comparison to T₁ group. The crude protein digestibility was significantly ($P<0.05$) higher in T₂ group in comparison to other two groups (Table 4).

In this study, nutrients digestibility was higher in the Moringa leaves supplemented groups in comparison to control group (Table 4). The higher digestibility of Moringa leaves might be because of low concentration of acid detergent fibres and neutral detergent fibres as reported by Rubanza *et al.* (2005).

Nitrogen balance: Nitrogen intake (g/d) was 20.12, 19.35 and 17.91 respectively in groups T₁, T₂ and T₃ (Table 5). Nitrogen intake was reduced significantly ($P<0.01$) with increased Moringa leaves in the diet. Faecal excretion of N decreased ($P>0.05$) with increased Moringa leaves in the diets. However, excretion of N (g/d) through urine was higher ($P<0.05$) in group T₁ (3.13) in comparison to groups

Table 4. Effect of Moringa leaves supplementation on digestibility coefficient (%) of nutrients and nitrogen balances and its utilization in crossbred grower pigs

Parameter	T ₁	T ₂	T ₃	SEM	P value
DM %	68.03	72.91	73.95	2.31	0.402
OM %	69.77	74.80	75.24	2.18	0.393
CP %	79.01 ^a	89.55 ^b	84.53 ^a	1.32	0.043*
EE %	58.87	64.22	64.46	3.10	0.566
CF %	43.33	51.36	57.30	3.10	0.169
NFE %	70.62	74.00	77.48	1.64	0.197
Nitrogen intake (g/d)	20.12 ^a	19.35 ^b	17.91 ^c	0.05	0.0003**
Faecal nitrogen (g/d)	0.89	0.83	0.78	0.09	0.805
Urinary nitrogen (g/d)	3.13 ^a	1.73 ^b	1.76 ^b	0.05	0.014
Total nitrogen excretion (g/d)	4.02	2.56	2.54	0.58	0.364
Nitrogen balance (g/d)	16.10	16.79	15.38	0.56	0.447
Nitrogen absorbed (g/d)	19.23 ^a	18.52 ^{ab}	17.13 ^{bc}	0.12	0.0041**
Nitrogen absorbed as % intake	95.58	95.71	95.64	0.49	0.988
Net protein utilization (%)	80.03	86.76	85.85	2.93	0.455
Biological value (%)	83.70	90.63	89.79	2.90	0.429

T₁, 0% dried Moringa leaves in the diet; T₂, 5% dried Moringa leaves in the diet; T₃, 10% dried Moringa leaves in the diet. a,b,c Values within a row with different superscripts differ significantly at * $P<0.05$ and ** $P<0.01$.

T₂ (1.73) and T₃ (1.76) which might be due to high intake of N in that group. Nitrogen balance (g/d) was positive across all the groups and values were 16.10, 16.79 and 15.38 in groups T₁, T₂ and T₃ respectively. The absorbed N (g/d) was significantly higher ($P<0.01$) in T₁ group (19.23) in comparison to the other two groups. However, there was no significant difference in absorbed N (g/d) in groups T₁ and T₂. Similarly, there was no significant difference in absorbed nitrogen as percent intake, net protein utilization and biological values across all the treatments (Table 5).

Nitrogen intake was reduced ($P < 0.01$) with increased level of Moringa leaves in the diet because of decreased in protein content of the diet with increasing Moringa leaves (Table 4). This is because the crude protein content (%) of Moringa leaves in this study was 15.11 ± 0.73 which is lower than the groundnut cake (40%). The absorbed N as percent intake, net protein utilization and biological value were higher ($P > 0.05$) in T_2 and T_3 groups. Zarkadas *et al.* (1995) also reported that proteins of Moringa have high biological value. This showed that inclusion of Moringa leaves up to 5% have positive affect on N utilization which was reflected through increased ($P > 0.05$) growth of pigs in T_2 group. Nitrogen intake was lower in groups T_2 and T_3 compared with group T_1 and it was because of low protein content of the experimental diet in those groups (Table 4). Similarly, Sultana *et al.* (2015) also reported higher nitrogen retention in goat fed with moderate level of Moringa leaves by replacement of conventional concentrate.

From this study, it is concluded that supplementation of dried Moringa leaves at 5% by replacing groundnut cake is both nutritionally and economically viable in crossbred grower pigs.

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