International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 11, Issue: 01 "January-February 2025"

AN ASSESSMENT OF THE NUTRITIVE VALUE OF *PILIOSTIGMA THONNINGII* (MONKEY BREAD) AND ITS POTENTIAL AS ENERGY SOURCE IN POST-WEANING DRY SEASON SUPPLEMENT SABI SHEEP DIETS

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DOI: https://doi.org/10.51193/IJAER.2025.11108

Received: 10 Jan. 2025 / Accepted: 18 Jan. 2025 / Published: 08 Feb. 2025

ABSTRACT

The experiment aimed at exploring the nutritional value of *Piliostigma thonningii* as a locally available energy source for sheep supplementation. This study also sought to determine acceptability of *Piliostigma thonningii* by Sabi weaner sheep, its effects on feed conversion ratio (FCR), daily weight gains and subsequently the economics behind its inclusion in the Sabi sheep weaners' diets. Thirty Sabi weaner sheep were divided into five groups of six sheep. Each group comprised of three male and three female sheep. The five groups were balanced for weight. These groups were randomly allocated to five treatment diets, Grass diet (negative control treatment), 0% *Piliostigma thonningii* diet, 15% *Piliostigma thonningii* diet, 30% *Piliostigma thonningii* diet and Lamb Meal as the control diet. Results showed that *Piliostigma thonningii* is a potential energy source. Results indicated that there were no significant differences in feed intake, feed conversion ratio and weight gains ($p>0.05$). Some differences were noted in terms of growth performance between the negative control diet against each of the other diets ($p<0.05$). All the three compounded diets and Lamb Meal showed significant differences in terms of cost of the diets ($p<0.05$), diets became cheaper with higher *Piliostigma thonningii* inclusion level. There is however need to do further evaluations at higher inclusion levels to establish the optimal and economic inclusion level.

Keywords: *Piliostigma thonningii*, Feed intake, Feed Conversion Ratio, Growth Performance, Economic Performance.

INTRODUCTION

Livestock and their products are the main sources of proteins for humans, WHO (2007). This explains why livestock farming is globally considered as an important component of people's livelihoods, FAO (2004). Successful livestock production is dependent on gene-environment interaction. Nutritional management largely constitutes the key environmental factor and thus it takes up the greatest proportion of production costs in many livestock production enterprises, Maertens and Gidenne (2016). Although cattle dominate the livestock sector, their role in food and nutrition security in most African societies is quite limited owing to the high value attached to them, Safoura *et al* (2021). This leaves small ruminants as a key component of food and nutrition security. Goats take the lead especially in the communal production systems whilst sheep are considered to be a second thought probably due to disease and parasite susceptibility, Safoura *et al* (2021). This does not however imply that sheep are less important in the rural livelihoods. Infect, sheep are an equally potential enterprise with dual benefits of economic and social attachment apart from food and nutrition security, just like cattle. Their choice for production is also affected by feeding challenges especially during the dry season where much of the bulk feed is provided by the browse component. As opposed to their feeding habits, sheep as grazers do not derive much benefits from the browse species. This is typical characteristic of most extensive livestock production systems in communal areas of low rainfall potential. Coupled with internal parasites infestation, Whittier *et al* (1995), feed challenges particularly proteins, the bulk and energy sources are a serious hindrance to sheep productivity in the small holder communal set up. This calls for intervention strategies so that the available browse component benefits sheep in order to addressed low growth rate and deaths that arise during this period.

Piliostigma thonningii is one of the commonest pods producing browse species of the Fabaceae family, Mapuranga (2015). It is widely distributed throughout Africa, it is therefore abundant in most regions of Zimbabwe. Its pods are part of wildlife and cattle diet under extensive production systems, Mapuranga (2015). Goats always eat the various browse species whilst sheep occasionally eat those that fall onto the ground. *Piliostigma thonningii* is rarely used by small stock owing to the huge size of the pod, even the goats as browsers. Studies on *Piliostigma thonningii* pods as energy source in goats by Safoura *et al* (2021) gave some interesting prospects on growth performance and parasitic status of the animals. *Piliostigma thonningii* also exhibit some anthelmintic benefits to the animals. The anthelmintic properties are due to the effect of some of its chemical compounds present in the pod. These compounds are also reported to have inhibitory effects on some gram-negative bacteria such as *Escherichia coli* and *Bacillus subtilis*, Jimoh and Oladiji (2005), hence reduction in intestinal infections which are a common problem in sheep.

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Some of the anti-nutritional factors in *Piliostigma thonningii* are therefore beneficial especially saponins though their levels need to be ascertained.

The anti-nutritional compounds found in *Piliostigma thonningii are* tannins, saponins, flavonoids, phenolics, glycosides, athraquinone and cardiac glycoside, Jimoh and Oladiji (2005). Although most authors are silent about levels of these anti-nutritional factors in *Piliostigma thonningii* pods, tannins and saponins are cited as the main anti-nutritional factors. According to Haruna et al (2015), *Piliostigma reticulatum* raw seed contains 0.07mg/100g saponins and 0.26ml/100g tannins. Just like the case with most browse and legumes species, the effects of anti-nutritional factors in *Piliostigma thonningii* can be reduced through various treatment methods (heating on direct sunshine, boiling and fermenting), Hemen e*t al* (2012). Its use in goats did not follow any treatment method. Treatment could be detrimental if over done since it can destroy some of these beneficial compounds, Jimoh and Oladiji (2005). In ruminants, tannins and saponins have some benefits to the animals. Tannins have some anti-bloat properties for ruminants, Ahlam and El-Shewy (2018). Ruminant animals exhibit some ability to deal with anti-nutritional factors through their ruminal activity. Raw pods of *Piliostigma thonningii* may also bring about similar benefits besides being a potential energy source for sheep. This study however focuses on the potential of the pods as energy source although anthelmintic attributes of the pod is another area for possible studies. In this study, the effects of ant-nutritional factors in *Piliostigma thonningii* addressed through the natural ripening and drying process then further sun drying before processing.

In terms of nutritional value, *Piliostigma thonningii* pods contain 94.49% dry matter, 8.69% crude protein, 91.5% Organic matter and 8.5% ash Safoura *et al* (2021). The author is however silent about energy level of the pod meal but Jimoh and Oladiji (2005) cited 22.76 to 23.24 % Carbohydrates in the seeds. Chawafambira (2021) cites 91.2% Dry Matter, 58.9% Carbohydrates (3404Kcal/kg), 10.2% CP, 3.2% Fat, 8.8% Crude Fibre and 4.3 Ash. The pods can be milled into rough grained pulp then incorporated into the diet as energy source.

MATERIALS AND METHODS

Animal Housing

The sheep were allowed two-week stabilisation post weaning at six months. Prior to weaning pulp kidney vaccine was administered. The animals were then housed in individual diamond mesh fence pens of dimensions 1.5m*2m. Roof was of iron sheets roof with rough concrete floor where grass bedding material was put.

Feed Ingredients Treatment

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(i) Hay; Katambora Rhodes grass hay was milled in a hummer mill for easy of incorporation for diet formulation. The hummer mill sieve was removed to avoid fine hay particles.

(ii) Maize; the grain was run through a hummer mill into mesh before incorporation into the diet.

(iii) Soya Beans; whole soya beans were roasted to a uniform standard for 10 minutes then cooled to room temperature before running them through a hummer mill into mesh.

(iv) *Piliostigma thonningii* pods; these were harvested at 10% pod shading then further shade dried for a 30 days period. The whole pods were run fast through a hummer mill without the sieve just to reduce them in size. The milled pods were rerun slowly through the hummer mill, now with the sieve fixed to come up with the desired mesh size.

Feed Formulation

Three (3) iso-nitrogenous and iso-energetic lamp meal diets were formulated and compounded. Standard lamp meal from the local feed manufacturing company (Gain Cash and Carry) was the positive control diet. The formulated diets and control diet were formulated in line with the Agriculture Victoria (2018) which stipulates that growing lamps require 12-15% crude protein for growth and 7-8% crude protein for maintenance. The diets composition were formulated using Mpofu (2015)'s Dlpd software and comprised of maize (standard energy source), graded levels of *Piliostigma thonningii*, Soya Bean Meal, Milled Katambora grass hay, Mineral Mix, Limestone Flour and Rock Salt. The diets were as follows; 0% Monkey Bread, 15% Monkey Bread and 30% Monkey Bread. The other group of the weaners was solely fed grass and this was the negative control diet. By composition, the Monkey Bread based diets were as indicated in table 1 below.

Table 1: Nutritional Composition and Cost per Tonne of Formulated Diets

Parameter	Lamb Meal	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread
Crude Protein (CP)	13.00	15.51	15.50	15.50
Metabolizable Energy (ME-MJ/Kg)	12.40	14.74	15.12	15.17
Crude Fibre	5.00	10.72	11.11	12.87
Cost/t (USD)	385.00	316.95	291.87	260.43

Feeding, Measurements and Data Collection

The sheep weaners were administered with pulp kidney vaccine prior to weaning. After weaning they were then dosed using Systamex plus just before the start of the experiment. Routine management was just like under the normal production system. Hay and water were available every time whilst supplementary feed was fed in two equal parts for those that were supplemented.

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Feeding was done at 0800hrs and 1500hrs respectively. Feed quantity was gradually increased as the animals got conditioned with an initial quantity of 200g per day per animal and a maximum quantity of 400g per day per animal. Rhodes grass hay was also supplied *adlibitum* as the basal diet. The increase was at the same rate across all the treatments. Refusals were weighed and recorded each morning before introducing feed for the next day. Feed intake was thus calculated from the difference between feed administered less refusals. The trial ran for seven weeks with individual sheep weights recorded on a weekly basis. Using these two measurements FCR was then calculated as ratio of total feed intake to total weight gains. Feed production costs were also computed from calculations done and these were used to come up with feed cost.

Description of Study Area

The study was done out at Henderson Research Institute. It is located south of the Equator in the Southern hemisphere of Africa. The Institute lies at $17^0$35' latitude and $30^0$58' longitude. The Institute receives a Savannah type of climate. According to agro-potential zonation system of the country, the Institute is in natural farming region IIa in Mazowe District of Mashonaland Central Province of Zimbabwe. The institute is located at an altitude of 1 300 meters above sea level, infect the place is in a valley. Total annual rainfall ranges between 750 mm to 1 000 mm. This is usually received from mid-November to mid-April with mid-season droughts experienced in January. Although the place receives high rainfall amount, temperature patterns resample those of low rainfall potential with wide temperature range. In such areas major farming activities include extensive production of drought resistant crops and livestock production. Under such production systems, supplementation of critical livestock category is key for efficient livestock production.

Research Design

Thirty Sabi weaner sheep, fifteen males and fifteen females were randomly allocated to five treatments in a Complete Randomized Block Design. The treatment weights were then balanced with each treatment comprising of three females and three male weaners with sex as the blocking factor. The five treatment groups were then randomly allocated to five treatment diets comprising of 0%, 15%, and 30% *Piliostigma thonningii*. The fourth and fifth diets included standard lamb meal which was the positive control diet and grass which was negative control diet. The experimental design model therefore was, $Y_{ij} = \mu + T_i + B_j + E_{ij}$, where

Y_{ij} was the total response of each measured parameter,

μ was the overall mean of each and every measured parameter,

T_i was dietary effect on each measured parameter,

B_j was sex effect on each response variable, Eij was the random error term on each response variable.

Data Analysis

The variates on sheep weaners' parameters were subjected to a one-way ANOVA in randomized blocks using GenStat version 14 with sex as the blocking factor. Initial weights of the weaners constituted the co-variate. Mean separation for treatment effects was performed using Fisher's protected Least Significant Difference (LSD) test. All the tests were conducted at 95% confidence interval.

RESULTS AND DISCUSSION

Laboratory analysis results

Maize, Monkey Bread and Soya beans were subjected to a laboratory analysis to determine their nutritional values to balance proteins and energy in diet formulation, below are the results obtained from the analysis

Table 2: Laboratory Analysis Results for Feed Ingredients.

Parameter	Soya beans	Maize grain	Monkey Bread Pod
Dry Matter	94.92	94.20	91.81
ME (KJ/100g)	1938.13	1648.46	1472.76
% Protein	38.28	10.94	6.40
% Fat	20.63	2.98	2.30
% Fibre	5.97	2.38	20.77
% Calcium	0.37	0.25	1.64
% Phosphorous	0.60	0.28	0.15

Laboratory analysis results presented in table 2 above showed that energy level of 1648.46KJ/100g of maize used in the experiment was higher than that of 1472.76KJ/100g of *Piliostigma thonningii* also used in the study. The energy level of *Piliostigma thonningii* was however comparable to the average of 1200-1400KJ/100g in maize grain reported by Agriculture Victoria (2018). In terms of crude protein content of *Piliostigma thonningii*, the same article cited an average of 8-13% CP in *Piliostigma thonningii*. Based on these laboratory analysis results, *Piliostigma thonningii* has great potential for inclusion in diet formulations in place of maize without compromising the energy level of the diet. Results also showed that *Piliostigma thonningii* used in this study contains almost same amount of energy compared to the observations by Chawafambira (2021). The author cited that the pod contains 1424KJ/100g energy. Crude protein (CP) level of *Piliostigma thonningii* used in this study was 6.4% whilst Chawafambira (2021) observed 10.2%. This also applied to the other nutrients from the pod when compared to those of this same author. Safoura *et al* (2021) established that the pod contains 8.69% crude protein. The observations by other authors in terms of protein content differed from the laboratory analysis results of *Piliostigma thonningii* used in this study. The differences might have been due to climatic and edaphic variations of the trees from where the pods were harvested. This is well supported by Adino *et al* (2018) who noted similar differences in field crops and attributed the differences to variety, climatic and edaphic conditions. Stage of fruit development at harvesting might have also played a role in the variations observed. Nutritional composition of the pods at early fruit formation, pod development stage, pod ripening and pod falling stage is likely to differ owing nutrient translocation dynamics, Almaz *et al* (2019). This observation strongly supports the idea that time of harvesting might have an influence in the nutrient composition of the pod. In this study, the pods were harvested once at 10% natural pod shading stage to reduce losses due to browsing animals. The natural pod shading stage is reported to be the stage where there is maximum dry matter accumulation and with most of the ant-nutritional factors lost through natural drying, Almaz *et al* (2019). Almaz *et al* (2019) observed different nutritional composition of the *Piliostigma thonningii* twig and leaf leave meal with stage of growth and suggested that changes in the chemical composition also influence nutritional composing. There is therefore need for further studies to establish the stage at which the highest amount of proteins and energy can be harnessed.

Feed Intake

Feed intake trend showed a low start, which improved with time. Despite the low amounts of feed offered to the weaners during the first week, the animals had left overs during this period. This observation holds true for all the diets and can be associated with feed adaptation issues. Other scientists have reported this as a normal phenomenon with livestock when they get introduced to a new diet. Madzimure *et al* (2008) made similar observations with Guernsey dairy cattle fed on Baobab seed meal. Average feed intake steadily increased as the feed was increased to tally with the animal requirements. All the diets were readily accepted after the first week with almost no left overs recorded across all treatments.

Table 3: Average Daily Feed Intake Trend

Diet	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
0% Monkey Bread	170.5952	226.4286	291.3095	365.3571	398.2143	398.9286
15% Monkey Bread	181.0714	217.381	276.9048	349.881	400	399.5238
30% Monkey Bread	188.0952	224.5238	295.9524	363.5714	400	400
Lamb Meal	190.5952	228.5714	300	371.4286	400	400

No significant differences were noted in feed intake across the four diets (p>0.05) serve for the negative control grass treatment where no supplementary feed was provided. Initial weight, as covariate also showed no significant differences P>0.05) on feed intake. Overall mean feed intake for the compounded diets and lamb meal was 315.1g per day. Machen (2013) cited that sheep

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require a dry season supplement of 250-500g dry matter feed per and this is in line with the feed consumption level observed in this study. Department of Primary Industries and Regional Development (2022) cites a supplementary level of 250g per day as the recommended supplementary level. Department of Animal Production and Health (2012) cites a much higher supplementary feed level of +500g per day of various leaf meal formulations. The high palatability and health benefits of *Piliostigma thonningii* reported by Chawafambira (2021) and Ahlam and El-Shewy (2018) respectively are well supported by the results from this study where inclusion level did not affect feed intake, infect its presence in the diets numerically improved on feed intake. *Piliostigma thonningii* has an inviting aroma resulting in favourable feed intake.

Table 4: Average Daily Feed Intake ANOVA Results

Parameter	Grass	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread	Lamb Meal	Grand Mean	SEM	P-Value	Sign	% CV
Sample Size	6	6	6	6	6	-	-	-	-	-
Initial Average Weight	11366.67	11366.67	113833.3	11350.00	11383.33	835.28	-	-	-	=
Average Daily Feed Intake (g)	-	308.5	304.1	312	315.1	309.9	5.75	0.579	NS	4.5

SEM – Standard Error of Mean, Sign - Significance

* Significantly different, NS - Not Significant

[abc] – Mean values with the same or without superscript in the same row for diet do not differ ($p>0.05$).

Feed Conversion Ratio

The FCR in this study was defined as applied by Houndonougbo *et al* (2012), quantity of feed (g) which is required by the animal to gain weight by a gram (g). Initial weights of the animals and the diets had no significant differences on the feed conversion ratio ($p>0.05$). Feed conversion ratio ranged from 2.12 to 2.97 with a grand mean of 2.34. According to AGRI farming (2023), typical FCR for sheep should be in the range of 6 to 8. Feed conversion ratios obtained in this study were very favourable when compared to the typical conversion ratios by AGRI farming (2023). From their study, Rani *et al* (2016) produced FCR of 4.386 to 12.449. Results from this study compare more favourable to those of Rani *et al* (2016). This could be attributed to the fact that the animals were zero grazed with minimum energy losses, hence high feed conversion ratio and weight gains. This zero grazing concept was also highlighted by Gororo (2015) in his studies on Pen fattening of beef cattle in Zimbabwe. Housing of the sheep, with basal feed (hay) provided adlibitum coupled with restricted animal movement resulted in reduced energy losses, which was

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channelled towards fat deposition. In their study on effects of feeding ration incorporating *Piliostigma thonningii* (schum) pods on growth and gastrointestinal parasites on West African Dwarf goats, Safoura *et al* (2021) established a feed conversion ratio of 10.3 to 18.06. This is low when compared to the findings from this study and this is attributable to the differences in the type of animals used in the two studies. Dwarf goats tend to have low feed conversion efficiency hence the low growth response associated with the animal. This confirms the fact that *Piliostigma thonningii* has highly degradable proteins comparable to maize.

Weight Gains

Generally, the average weights followed an upward trend, however period after week one was marked by a general surge across all the treatments. For the grass treatment this prolonged up to week four. This might have been due to shock induced by change of the environment. Sheep are reported to react to any form of stress exerted on them, Tüfekci and Sejian (2023).

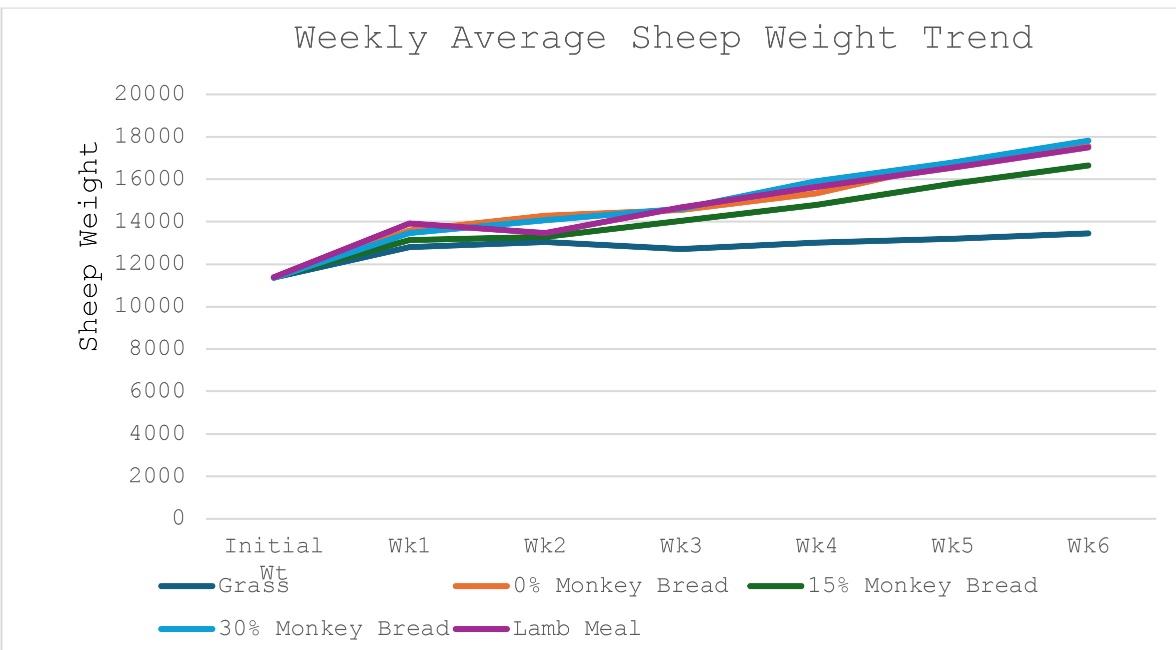

Fig 1: Average Weekly Weights

The initial weights had no effect on the weight gains (p>0.05). Treatment had effects on the growth performance of the sheep only for the negative control diet (p<0.05). Animals in the negative control diet had a significantly lower growth performance than animals in the other four diets. Average weight gains were 49.6[a,] 147.6[b], 125.4[b], 153.9[b], 145.7[b] for grass, 0% Monkey Bread, 15% Monkey Bread, 30% Monkey Bread and lamp meal respectively. The grand mean weight gain was

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124.4grams. The formulated diets performed equally the same as the standard lamb meal and this confirms that diets were iso-nitrogenous and iso-energetic.

The daily weight gains obtained from this study compare very favourable from the gains observed by other researchers. This also corresponds to the feed conversion ratios for the respective studies.

In their comparative study on nutritional evaluation of two leguminous fodder trees (*Prosopis africana* and *Piliostigma thonningii)* pods on growth performance of Djallonke sheep in Burkina Faso, Ouedraogo *et al* (2022) established average daily gains ranging from 56 to 97g. These differences might have arisen from lower crude protein levl (14%) in their diets compared to 15% used in this study. Rani *et al* (2016) observed weight gains between 287-315g per day from their feeding evaluation using Balochi lambs. Breed differences in performance might also have had an impact on the growth performance of the different breeds used in these studies. These differences in breed growth performance are well supported by Momoh *et al* (2013). Kahsu *et al* (2021)'s observations are in agreement with the findings from this study. Growth performance from their study varied from118.25 to 158.62g per day.

Table 5: Feed Conversion Ratio and Average Daily Weight Gains ANOVA Results

Parameter	Grass	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread	Lamb Meal	Grand Mean	SEM	P-Value	Sign	%CV
Sample Size	6	6	6	6	6	-	-	-	-	-
Initial Average Weight	11366.67	11366.67	113833.3	11350.00	11383.33	835.28	-	-	-	-
Feed Conversion Ratio (FCR) - per g weight gains	-	2.12	2.97	2.07	2.2	2.34	0.38	0.32	NS	39.8
Average Daily Weight Gains (g)	49.6^{a}	147.6^{b}	125.4^{b}	153.9^{b}	145.7^{b}	124.4	13.1	<0.001	*	25.9

SEM – Standard Error of Mean, Sign - Significance

* Significantly different, NS - Not Significant

^{abc} – Mean values with the same or without superscript in the same row for diet do not differ (p>0.05).

Economic Performance of the Diets

The average cost of feeding each animal from the respective treatments was significantly different for all the compounded diets and the standard lamb meal (p<0.05). The average cost of feeding the

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0% *Piliostigma thonningii* diet was USD$4.11, 15% *Piliostigma thonningii* diet at USD$3.73, 30% *Piliostigma thonningii* diet at USD$3.41 and USD$6.63 for the lamb Meal. Since *Piliostigma thonningii* is locally available and can be collected for a low price, its inclusion level reduces the amount and cost of maize. The higher the *Piliostigma thonningii* inclusion level the less cost the diets become. Lamb Meal had the highest cost, the trend is in agreement with Geoffrey (2012)'s findings that own farm feed production reduces feed costs and subsequently cost of production.

Table 6: Economic Performance Results of the Diets

Parameter	Grass	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread	Lamb Meal	Grand Mean	SEM	P-Value	Sign	CV %
Sample Size	6	6	6	6	6	-	-	-	-	-
Initial Weight	11366.67	11366.67	113833.3	11350.00	113833.3	-	-	-	-	-
Average Feed Cost ($)	-	4.106^{a}	3.728^{b}	3.413^{c}	6.617^{d}	4.466	0.071	<0.001	*	3.9

SEM – Standard Error of Mean, Sign - Significance

* Significantly different, NS - Not Significant

abc – Mean values with the same or without superscript in the same row for diet do not differ (p>0.05).

CONCLUSION

Piliostigma thonningii pods contains sufficiently high levels of energy, quite comparable to that of the conventional energy source (maize). It contains 1472.76KJ/100g of feed against 1648.46KJ/100g of feed. The pods also contain 6.4% crude protein. *Piliostigma thonningii* inclusion level does not affect feed intake by sheep. In terms of Feed conversion ratio and growth performance, *Piliostigma thonningii* performs equally as good as maize with inclusion level having no negative impacts. Piliostigma thonningii has costs reduction effects in terms of feed costs. Being a locally available and low-cost feed ingredient, higher inclusion levels have a further cost reduction effect.

RECOMMENDATIONS

Piliostigma thonningii is a good energy source for use by sheep producers in compounding their post weaning winter supplementary rations. Farmers can take advantage of it being a locally available wide spread feed resource to reduce their cost of production. They can also make use of it as a taste and palatability enhancer for use with other less palatable feed stuffs. There is however need to test its performance at higher inclusion levels to establish the optimal inclusion level to reduce cost of production since intake, feed conversion ratio and growth performance were still on an upward trajectory up to 30% inclusion level. There is need to for further laboratory analysis to determine the stage of harvesting where crude proteins and energy are most harnessed. There is also need to conduct further studies to isolate the chemical compounds responsible for anthelminthic properties and their levels. As of now farmers can use it up to 30% inclusion level.

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