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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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The undersigned certified that they have supervised and recommended to Bindura University of Science Education for acceptance of dissertation entitled **"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"** submitted in partial fulfillment of a Bachelor of Science Degree (Honours) in Animal Health and Production Extension.

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DECLARATION

I hereby declare that the research project entitled **"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"** submitted in partial fulfillment of a Bachelor of Science Degree (Honours) in Animal Health and Production Extension submitted to Bindura University of Science Education, Department of Animal Science is a record of an original work done by me under the guidance and supervision of **Dr P Chatikobo** and this work is submitted in partial fulfilment of the requirements for the award of a Bachelor Science Degree (Honours)in Animal Health and Production Extension. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree or diploma.

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DEDICATION

This work is dedicated to my husband, Peter and kids (Tapiwanashe, Tatendaishe and Tadiwanashe).

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 had significant differences economically ($p<0.05$), diets became cheaper with higher *Piliostigma thonningii* inclusion level. There is however need to do further evaluations at higher inclusion levels so as to establish the most economic inclusion level.

Keywords: *Piliostigma thonningi*, Economics, Feed Conversion Ratio, Feed intake, Weight gains

List of Acronyms and Abbreviations

ABBREVIATION	**MEANING**
WHO	World Health Organisation

FAO	Food and Agriculture Organisation
WOAH	World Organisation for Animal Health
DM	Dry Matter
ME	Metabolizable Energy
ADFI	Average Daily Feed Intake
CP	Crude Protein
ADWG	Average Daily Weight Gains
DCP	Digestible Crude Protein
MJ	Mega joules

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CHAPTER 1

1 Introduction

Livestock and their products are the main sources of proteins for humans (WHO, 2007). This explains livestock farming is globally considered as an important component of people's livelihoods (FAO, 2004). Successful livestock production is basically dependent on genetics and environmental 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). Owing to the high value attached to cattle as they dominate the livestock sector, their role in food and nutrition security in most African societies is quite limited. This leaves small ruminants, especially goats, as a key component of food and nutrition security in the communal areas (Safoura *et al.*, 2021).

Despite their key role in society, sheep are less popular due to perceived high susceptibility to disease and parasites. This is exacerbated by nutritional challenges especially during the dry season when both the quantity and quality of pastures are compromised (Kasale, 2013). During this time the browse component also play a very important role (Ramirez, 1999). By virtue of their feeding habits (75-85% browsers) and (15-25% grazers) goats are less vulnerable to feed challenges during the dry season. Sheep are however opposite as they graze 75-85% and only get 15-25% of their nutritional requirements from browsing. Unlike goats, sheep are largely grazers and do not derive much benefits from the abundant browse during the dry season.

Coupled with internal parasites infestation, feed challenges are a serious hindrance to sheep productivity in the small holder communal areas (Whittier *et al.,* 1995). This calls for intervention strategies to ensure that sheep also benefit from the available browse component during the dry season. Improved utilization of browse will address the problems of low growth rate and mortalities which are frequently recorded during the dry period.

Piliostigma thonningii is one of the commonest pod~~s~~ producing browse species of the Fabaceae family (Mapuranga, 2015). It is widely distributed throughout Zimbabwe and the African continent. 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 shade off to 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 in terms of dry season feeding for sheep. *Piliostigma thonningii* has also been reported to exhibit some anthelmintic benefits to the animals (Safoura *et al.*, 2021). The anthelmintic properties are due to the presents of some 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. Some of the anti-nutritional factors in *Piliostigma thonningii* are therefore beneficial especially saponins though their levels need to be ascertained.

The main anti-nutritional compounds found in *Piliostigma thonningii* include saponins, flavonoids, phenolics, glycosides, anthraquinone and cardiac glycoside (Jimoh and Oladiji., 2005). 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 (Hemen *et al.,* 2012). Sun drying has been mainly adopted as an effective way of dealing with these ant-nutritional factors in *Piliostigma thonningii*. Previous work on it in goats did not however follow any treatment method other than sun drying as this is believed to be detrimental since it can destroy some of these beneficial compounds (Jimoh and Oladijim, 2005). In ruminants, tannins and saponins are reported to have some benefits to the animal. Tannins have some anti-bloat properties for ruminants (Ahlam and El-Shewy, 2018). Ruminants are therefore believed to 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 with anthelmintic properties of the pod being another potential area which can be explored.

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, however did not mention about energy level of the pod meal but Jimoh and Oladiji (2005) affirm 22.76 to 23.24 % Carbohydrates in the seeds. Chawafambira, (2021), mentioned 91.2% Dry Matter, 58.9% Carbohydrates (3404Kcal/kg), 10.2% CP, 3.2% Fat, 8.8% Crude Fibre and 4.3 Ash. The pod can be milled into rough grained pulp and incorporated in the diet as an alternative climate smart energy source.

1.1 Problem statement

Protein and energy sources for livestock nutrition are a global concern (Richard and Nigel, 2018). The challenge is mostly experienced during the dry season when quantity and quality of veld pasture would have declined at national level. This coupled with the high demand and competition between livestock and humans exacerbate the already dire livestock feed situation. In livestock feed, the energy constitutes the greatest portion of around 55-60% of the total diet composition (Richard and Nigel, 2018). This makes its availability a big concern after protein especially during the dry season period. Due to shortages in energy in sheep diets, sheep are affected by negative energy imbalance which eventually leads to health problems, reproduction challenges and mortalities and less profits for the farmer. Intervention strategies should thus focus on least cost existing environmental outputs especially those that are climate smart and readily available during such periods.

1.2 Justification

Piliostigma thonningii contains 3404Kcal/kg of energy (Chawafambira, 2021) and maize has 3840Kcal/kg (CIRAD, 2017). It is also found in most part of Zimbabwe and mostly the dry parts of the country (Mapuranga, 2015). There is competition on maize as an energy source for both humans and animals, especially in Zimbabwe where maize is a staple food. Anti-nutritional factors in *Piliostigma thonningi* such as saponins have anthelmintic properties (Jimor and Oladiji, 2005) and exhibit beneficial attributes to sheep. This in turn reduce internal parasites as well as reduction in use of man-made dosing remedies. Preservation of such trees is a climate smart approach as it protects the environment and also binds the soil preventing soil erosion as only pods can be harvested without cutting down the tree.

1.3 Main objective

The main objective of the project is to assess the feasibility of using *Piliostigma thonningii* as readily available dry season energy supplement in extensive sheep production systems.

1.4 Specific objective

1.4.1 To determine the nutritional value of *Piliostigma thonningii.*

1.4.2 To determine feed intake feed, conversion ratio and subsequent growth performance of Sabi sheep weaners fed Piliostigma thonningii based diets.

1.4.3 To determine the economics (gross margin per dollar variable cost) of the different Piliostigma thonningii based diets.

1.5 Hypothesis

H_0: *Piliostigma thonningii* is a better energy source than maize.

H_1: *Piliostigma thonningii* is not a better energy source than maize.

H_0: Inclusion of *Piliostigma thonningii* in Sabi weaner sheep diets will improve feed intake, feed conversion ratio and growth performance.

H_1: Inclusion of *Piliostigma thonningii* in Sabi weaner sheep diets will not improve feed intake, feed conversion ratio and growth performance.

H_0: *Piliostigma thonningii* pod-based meal has better economic returns than maize.

H_1: *Piliostigma thonningii* pod-based meal has less economic returns than maize.

1.6 Limitations of the study

The study concentrated on the nutritional attributes of *Piliostigma thonningi*, anthelmintic properties is also an area of interest regarding the pod. The study fell short of digestibility properties of Piliostigma thonningi as this has an effect on its performance. Carcass characteristics and taste are also other interesting areas. All these are potential areas which any further research should consider.

1.7 Ethical consideration

The lambs were subjected to research under good and friendly conditions. Environmental parameters such as ventilation and space were considered. The animals were given adaptation period to avoid a sudden change of diet. For the animals which were given feed, the feed was a balanced diet to cater for their nutritional requirements. Water was provided *adlibitum* with clean and well-ventilated housing. The lambs were only subjected to minimum stress on weighing, no any other form of pain, fear and distress in accordance with WOAH- Terrestrial Animal Health Code, (2022). Good animal husbandry practices such as feeding, hygiene and water provision were practiced to maintain the health and welfare of the sheep weaners.

CHAPTER 2

2 Literature Review

2.1 Distribution of Piliostigma thonningii

Piliostigma thonningii is one of the commonest pods producing browse species of the Fabaceae family (Mapuranga, 2015). It is widely distributed throughout Zimbabwe and the African continent. Its pods are part of wildlife and cattle diet under extensive production systems (Mapuranga, 2015). According to Chawafambira (2021), Piliostigma thonningii is one of the native to tropical Africa, it is also well adapted to Miombo woodlands. The fruit grows well in semi-dry and dry areas of Zimbabwe's forests. The pods ripen from March to October (Orwal *et al.*, 2009), coinciding with the dry season. The pods are green and become rusty brownish as they mature (Bombardelli *et al.,* 1994). In English *Piliostigma thonningii* is known as monkey bread and musekesa or muchekecha in Shona (Chawafambira, 2021).

2.2 Nutritional value of Piliostigma thonningii

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, however did not mention about energy level of the pod meal but Jimoh and Oladiji (2005) state that 22.76 to 23.24 % Carbohydrates in the seeds. Chawafambira (2021), mentioned 91.2% Dry Matter, 58.9% Carbohydrates (3404Kcal/kg), 10.2% CP, 3.2% Fat, 8.8% Crude Fibre and 4.3 Ash. The pod can be milled into rough grained pulp and incorporated in the diet as high-quality energy source. Mandibaya and Chihora (1999), mentioned that pod meal contains 78.4 CP, 230 Crude fibre, 919 dry matter, 32.3 ether extract, 47.9 crude ash per kg.

2.3 Nutritional Requirements of weaner lambs

At post weaning phase lambs require dietary ME of 10.4 MJ/kg and DCP of 10.44% in order to attain average daily gain of 112grams, Tripathi *et al.*, (2011). According to Machen (2013), sheep should be provided with a dry season supplement of 250-500g dry matter feed per and this is in line with the feed consumption level. 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 of *Piliostigma thonningii* has an inviting aroma and taste such that it positively affects feed intake by animals and health benefits as reported by Chawafambira (2021) and Ahlam and El-Shewy (2018).

2.4 Feed intake of weaner lambs

Weaner lambs consume 74.68 grams DCP, 886 grams feed dry matter. Dry matter intake has poor relationship with average daily gain. Lambs consume 7.26 grams dry matter with its daily feed intake of 885.9grams for an average daily gain of 125.3 grams, which has an average of 86 to 172 grams per day, Tripathi *et al* (2011). According to the Department of Primary Industries and Regional Development's Agriculture and Food Division (2022), weaner lambs meant for slaughter in the future need to grow at a rate of 150 grams per day although some producers may want the weaners to reach 250 grams per day to reach slaughter targets early,

2.5 Feed conversion ratio of weaner lambs and weight gains

Feed conversation ratio can be calculated using mathematical equation. Lambs have a dietary requirement of 9.5MJ and 9.04% DCP. According to Tripathi *et al*., (2011), a conversion ratio of 6.92 is estimated for average daily gain of 124 grams. Karim and Verma (2001), noted an average daily gain of 150g with a feed conversion efficiency of 15-18% under intensive feeding with locally available protein, energy and roughage. According to AGRI farming (2023), typical feed conversion ratio for sheep should be in the range of 6 to 8. Rani *et al.,* (2016) produced a feed conversion ratio of 4.386 to 12.449. Safoura *et al.*, (2021), noted that goats had an average daily gain of 13.20 to 22.06 grams/day.

2.6 Economics of feeding various feed ingredients

According to Geoffrey (2012)'s findings own farm feed production reduces feed costs and subsequent cost of production. Non-conventional feeding, according to Saiyed *et al* (2003), reduces cost of feeding due to reduction in cost of ingredients.

CHAPTER 3

3 Materials and Methods

3.1 Description of Study Area

The experiment was carried 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, the Institute is in natural farming region IIa in Mazowe District of Mashonaland Central Province of Zimbabwe. Henderson Research Institute stretches from the 28^{th} km peg to the 35^{th} km peg north of capital Harare, along the Harare – Bindura highway. The institute is located at an altitude of 1,300 meters above sea level, in fact the place is in a valley. Total annual rainfall ranges between 750 mm to 1,000 mm. The rainfall 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 resemble those of low rainfall potential with wide temperature range. In such areas major farming activities include, production of drought resistant crops and livestock. Average temperatures range from 15^0C to 22^0C with lowest winter temperatures going as low as 0^0C in July whilst highest temperatures can go up to 35^0C in October.

3.2 Animal Housing

The sheep were allowed two weeks of stabilisation post weaning at six months. Prior to weaning pulp kidney vaccine was administered. They 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.

3.3 Feed Ingredients

(i) Hay; Katambora Rhodes grass hay was milled in a hummer mill for easy of incorporation for diet formulation. The sieve of the hummer mill 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, it was 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 period of 30 days. The whole pods were run fast through a hummer mill without the sieve just to reduce them in size. The milled pods were then rerun slowly through the hummer mill, now with the sieve fixed on so as to come up with the desired mesh size.

3.4 Feed Formulation

Three (3) iso-nitrogenous and iso-energetic lamb meal diets were formulated and compounded with standard lamb meal from Gain Cash and Carry as the positive control diet. The diets re formulated in line with the Agriculture Victoria (2018) which stipulates that growing lambs 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 Coarse salt. The diets were as follows; 0% Monkey Bread, 15% Monkey Bread and 30% Monkey Bread for treatments 1, 2 and 3 respectively. The other group of the weaners was fed lamb meal as the positive control diet, that is, treatment 5 and treatment 6, Katambora Rhodes grass as 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	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread
Crude Protein (CP)	15.51	15.50	15.50
Metabolizable Energy (ME-MJ/Kg)	14.74	15.12	15.17
Crude Fibre	10.72	11.11	12.87
Cost/t (USD)	316.95	291.87	260.43

3.5 Feeding, Measurements and Data Collection

After weaning, the lambs were dosed using Systamex Plus Fluke 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. Feeding was done at 0800hrs and 1500hrs respectively. The 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. Katambora Rhodes grass hay was also supplied *adlibitum* as the basal diet. The increases were at the same rate across all the treatments. Refusals were weighed and recorded each morning before introducing feed for the next day. Feed intake were 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 feed conversion ratio 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.

3.6 Research Design

Thirty Sabi weaner sheep, fifteen males and fifteen females were randomly allocated to five treatments following 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,

E_{ij} was the random error term on each response variable.

3.7 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.

CHAPTER 4

4 Results

4.1 Laboratory analysis results

Maize, Monkey Bread and Soya beans were subjected to a laboratory analysis to determine their nutritional values in order 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
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

4.2 Feed Intake

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 weights, as covariate also showed no significant differences $P>0.05$) on feed intake. The table below shows the average daily feed intake trend of all the diets.

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

The grand mean was 309.9 and there was no significant difference amongst the treatment diets ($P>0.05$) and the mean range was from 308.5-315.1. as in the table below according to the Analysis of variance. Overall mean feed intake for the compounded diets and lamb meal was 315.1g per day as illustrated in Table 4 below.

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).

4.3 Weight Gains and Feed conversion Ratio

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 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 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. Feed conversion ratio ranged from 2.12 to 2.97 with a grand mean of 2.34.

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 ($p>0.05$).

Fig 1.0 below shows the average weekly weight trends, with the average initial weight ranging from 11366.67 to 11833.3 grams up to the 6th week. Animals on grass diet performing less than the other four diets.

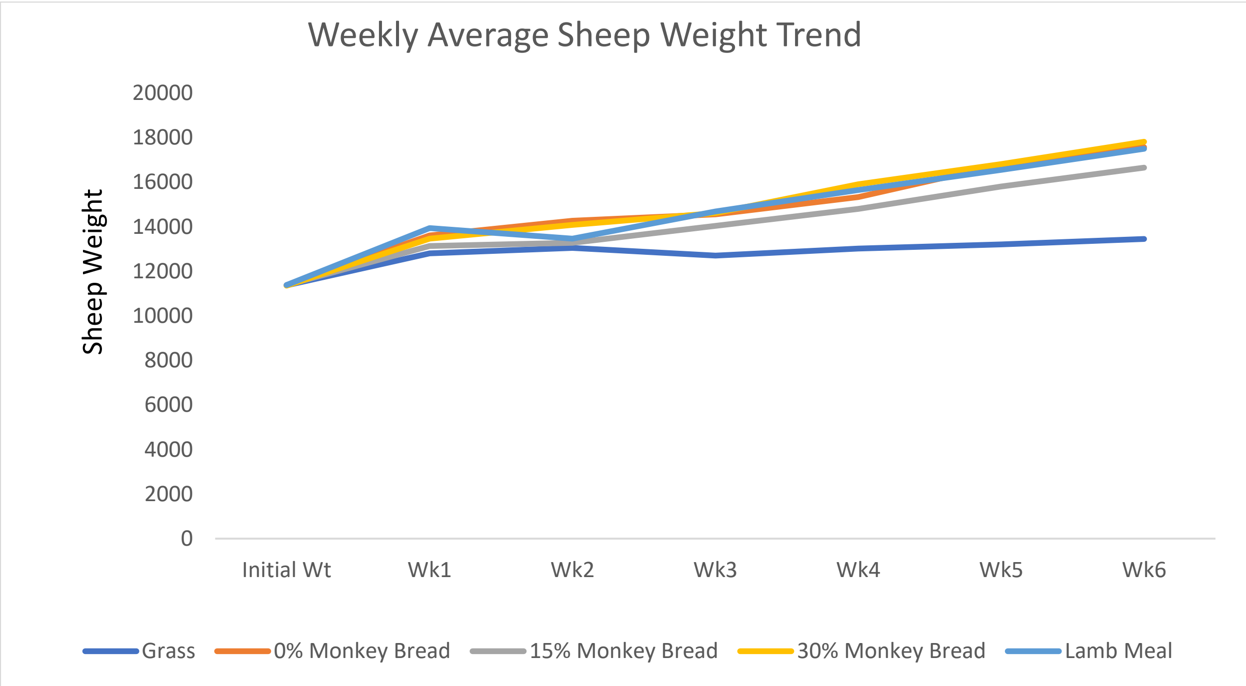

Fig 1.0 Average Weekly Weights

4.4 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 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.

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 ($p>0.05$).

CHAPTER 5

5 Discussion

5.1 Nutritional value of *Piliostigma thonningi*

The results showed that *Piliostigma thonningii* used in this study contains almost same amount of energy compared to the observations by Chawafambira (2021) who cited that it contains 10.2% crude protein and 1424KJ/100g energy. There were however notable differences for other nutrients compared with this same author. Safoura *et al.,* (2021) established that the pods contain 8.69% crude protein. The observations by these two authors in terms of protein content differ 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 fruit at early fruit formation, fruit development stage, fruit ripening and fruit falling stage is likely to differ owing to nutrient translocation dynamics. There is thus need for further studies to establish the stage at which the highest amount of proteins and energy can be harnessed.

Results also showed that *Piliostigma thonningii* contains comparable energy level (1472.76KJ/100g) to that of maize (1648.46KJ/100g), thus it can easily be incorporated into diet formulations in place of maize without challenges since balancing for energy can be easily achieved. Nutritional composition results of maize from this study are in agreement with the results obtained by the Agriculture Victoria (2018), which cited 8-13% and 1200-1400KJ/100g.

5.2 Feed intake

Feed intake started low but gradually 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 This has been reported by other scientists 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 a period of a week with almost no left overs recorded across all treatments. According to Machen (2013), sheep should be provided with a dry season supplement of 250-500g dry matter feed per day and this is in line with the feed consumption level observed in this study. 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 and taste such that it positively affects feed intake by animals.

5.3 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. 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 are very favorable 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 favorable to those of Rani *et al.,* (2016). This is 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 then was channeled 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 way down compared to the findings from this study and this can be attributed 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.

5.4 Weight gains

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 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 lamb meal respectively. The grand mean weight gain was 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 favorable 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 (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 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 from 118.25 to 158.62g per day.

5.5 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 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 subsequent costs.

CHAPTER 6

6 Conclusion and recommendations

6.1 Conclusion

Piliostigma thonningii pods contains sufficiently high levels of energy, quite comparable to that of the conventional energy source (maize). *Piliostigma thonningii* inclusion level does not affect feed intake of 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 some cost reduction if incorporated in feed. Being a locally available and low-cost feed ingredient, higher inclusion levels have a further cost reduction effect.

6.2 Recommendations

Piliostigma thonningii is a climate smart cheaper energy source available for use by sheep farmers to reduce weight losses and deaths associated with the dry season. There is however need to test its performance at higher inclusion levels so that the optimal inclusion level can be established. There is also need for further laboratory analysis to isolate the chemical compounds responsible for anthelminthic properties.

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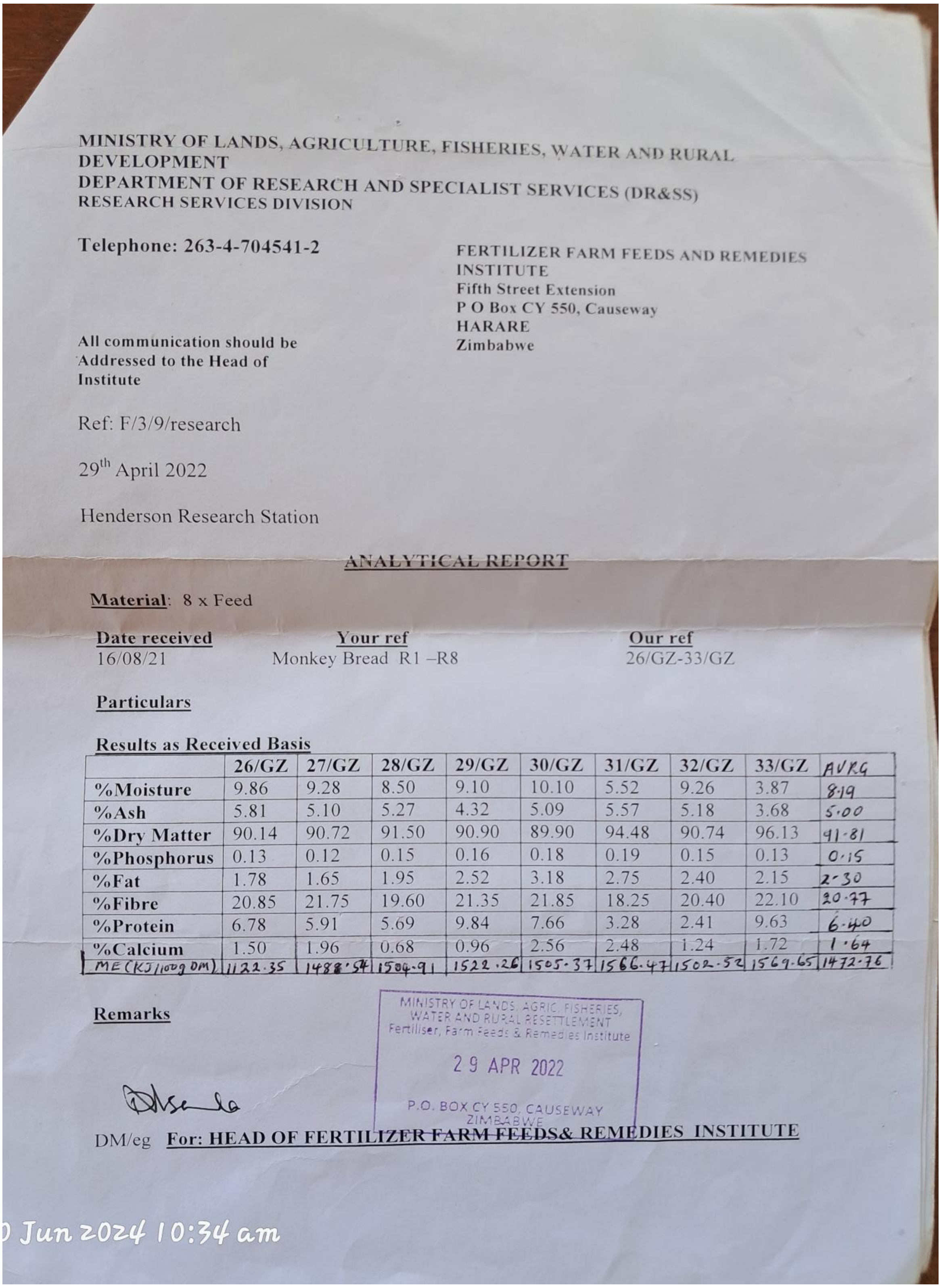
Appendices

Appendix a. Laboratory Analytical Results for *Piliostigma thonningii*



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DEPARTMENT OF RESEARCH AND SPECIALIST SERVICES (DR&SS)
RESEARCH SERVICES DIVISION

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Fifth Street Extension
P O Box CY 550, Causeway
HARARE
Zimbabwe

All communication should be Addressed to the Head of Institute

Ref: F/3/9/research

29th April 2022

Henderson Research Station

ANALYTICAL REPORT

Material: 8 x Feed

Date received	Your ref	Our ref
16/08/21	Monkey Bread R1 –R8	26/GZ-33/GZ

Particulars

Results as Received Basis

	26/GZ	27/GZ	28/GZ	29/GZ	30/GZ	31/GZ	32/GZ	33/GZ	AVRG
%Moisture	9.86	9.28	8.50	9.10	10.10	5.52	9.26	3.87	8.19
%Ash	5.81	5.10	5.27	4.32	5.09	5.57	5.18	3.68	5.00
%Dry Matter	90.14	90.72	91.50	90.90	89.90	94.48	90.74	96.13	91.81
%Phosphorus	0.13	0.12	0.15	0.16	0.18	0.19	0.15	0.13	0.15
%Fat	1.78	1.65	1.95	2.52	3.18	2.75	2.40	2.15	2.30
%Fibre	20.85	21.75	19.60	21.35	21.85	18.25	20.40	22.10	20.77
%Protein	6.78	5.91	5.69	9.84	7.66	3.28	2.41	9.63	6.40
%Calcium	1.50	1.96	0.68	0.96	2.56	2.48	1.24	1.72	1.64
ME (KJ/100g DM)	1122.35	1488.54	1504.91	1522.26	1505.37	1566.47	1502.52	1569.65	1472.76

Remarks

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ZIMBABWE

DM/eg **For: HEAD OF FERTILIZER FARM FEEDS& REMEDIES INSTITUTE**

0 Jun 2024 10:34 am

Appendix b. Data Collected for Analysis

Diet	Animal Indentity	Sex	Replication	Intitial wgt	Total Feed Intk	Daily Avera	Wght Gns	Daily Weigl	FCR (gains/	Feed Cost
Grass	22-53	M	1	13300	0	0	3500	83.33333		0
Grass	22-14	M	2	11200	0	0	3300	78.57143		0
Grass	22-21	M	3	10800	0	0	100	2.380952		0
Grass	22-31	F	4	13000	0	0	2500	59.52381		0
Grass	22-36	F	5	9900	0	0	1100	26.19048		0
Grass	22-63	F	6	10000	0	0	2000	47.61905		0
0% Monkey Bread	22-11	M	1	14200	13220	314.7619	6900	164.2857	1.915942	4.190079
0% Monkey Bread	22-16	M	2	11500	12135	288.9286	6100	145.2381	1.989344	3.846188
0% Monkey Bread	22-09	M	3	10200	13300	316.6667	6600	157.1429	2.015152	4.215435
0% Monkey Bread	22-20	F	4	12000	13290	316.4286	5000	119.0476	2.658	4.212266
0% Monkey Bread	22-32	F	5	10300	12490	297.381	5600	133.3333	2.230357	3.958706
0% Monkey Bread	22-46	F	6	10000	13300	316.6667	7000	166.6667	1.9	4.215435
15% Monkey Bread	22-03	M	1	13100	10935	260.3571	1700	40.47619	6.432353	3.191598
15% Monkey Bread	22-27	M	2	11600	13300	316.6667	8400	200	1.583333	3.881871
15% Monkey Bread	22-08	M	3	11000	12690	302.1429	6000	142.8571	2.115	3.70383
15% Monkey Bread	22-02	F	4	13000	13115	312.2619	5600	133.3333	2.341964	3.827875
15% Monkey Bread	22-37	F	5	9600	13300	316.6667	4700	111.9048	2.829787	3.881871
15% Monkey Bread	22-45	F	6	10000	13300	316.6667	5200	123.8095	2.557692	3.881871
30% Monkey Bread	22-12	M	1	13500	13300	316.6667	5500	130.9524	2.418182	3.463719
30% Monkey Bread	22-66	M	2	12200	13300	316.6667	6600	157.1429	2.015152	3.463719
30% Monkey Bread	22-52	M	3	10000	13300	316.6667	7600	180.9524	1.75	3.463719
30% Monkey Bread	22-25	F	4	10800	13180	313.8095	5400	128.5714	2.440741	3.432467
30% Monkey Bread	22-57	F	5	10600	12250	291.6667	5900	140.4762	2.076271	3.190268
30% Monkey Bread	22-28	F	6	11000	13300	316.6667	7800	185.7143	1.705128	3.463719
Lamb Meal	22-05	M	1	13000	12905	307.2619	7000	166.6667	1.843571	6.4525
Lamb Meal	22-10	M	2	12500	13300	316.6667	5700	135.7143	2.333333	6.65
Lamb Meal	22-51	M	3	10400	13300	316.6667	7200	171.4286	1.847222	6.65
Lamb Meal	22-40	F	4	12400	13300	316.6667	6200	147.619	2.145161	6.65
Lamb Meal	22-30	F	5	10000	13300	316.6667	5400	128.5714	2.462963	6.65
Lamb Meal	22-43	F	6	10000	13300	316.6667	5200	123.8095	2.557692	6.65

Appendix c. ANOVA Results for feed Intake

Analysis of variance (adjusted for covariate)

Variate: Daily_Average_Feed_Intake
Covariate: Intitial_wgt

Source of variation	d.f.	s.s.	m.s.	v.r.	cov.ef.	F pr.
Sex stratum						
Covariate	1	140.6	140.6			
Sex.*Units* stratum						
Diet	3	400.6	133.5	0.67	1.00	0.579
Covariate	1	71.1	71.1	0.36		0.557
Residual	18	3565.6	198.1		0.97	
Total	23	4178.7				

Tables of means (adjusted for covariate)

Variate: Daily_Average_Feed_Intake
Covariate: Intitial_wgt

Grand mean 309.9

Diet	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread	Lamb Meal
	308.5	304.1	312.0	315.1

Standard errors of means

Table	Diet
rep.	6
d.f.	18
e.s.e.	5.75

Standard errors of differences of means

Table	Diet
rep.	6
d.f.	18
s.e.d.	8.13

Least significant differences of means (5% level)

Table	Diet

rep.	6	
d.f.	18	U
l.s.d.	17.07	

Stratum standard errors and coefficients of variation (adjusted for covariate)

Variate: Daily_Average_Feed_Intake
Covariate: Intitial_wgt

Stratum	d.f.	s.e.	cv%
Sex	0	*	*
Sex.*Units*	18	14.07	4.5

Appendix d. ANOVA Results for Daily Weight Gains

Analysis of variance (adjusted for covariate)

Variate: Daily_Weight_Gains
Covariate: Intitial_wgt

Source of variation	d.f.	s.s.	m.s.	v.r.	cov.ef.	F pr.
Sex stratum						
Covariate	1	1091.	1091.			
Sex.*Units* stratum						
Diet	4	44757.	11189.	10.79	1.00	<.001
Covariate	1	90.	90.	0.09		0.771
Residual	23	23843.	1037.		0.96	
Total	29	69784.				

Tables of means (adjusted for covariate)

Variate: Daily_Weight_Gains
Covariate: Intitial_wgt

Grand mean 124.4

Diet	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread	Grass
	147.6	125.4	153.9	49.6

Diet	Lamb Meal
	145.7

Standard errors of means

Table	Diet
rep.	6
d.f.	23
e.s.e.	13.14

Standard errors of differences of means

Table	Diet
rep.	6
d.f.	23
s.e.d.	18.59

Least significant differences of means (5% level)

Table	Diet

rep.	6
d.f.	23
l.s.d.	38.46

Stratum standard errors and coefficients of variation (adjusted for covariate)

Variate: Daily_Weight_Gains
Covariate: Intitial_wgt

Stratum	d.f.	s.e.	cv%
Sex	0	*	*
Sex.*Units*	23	32.20	25.9

Fisher's protected least significant difference test

Diet

Comparison	Probability	Significant
Grass vs 15% Monkey Bread	0.0005	yes
Grass vs Lamb Meal	0.0000	yes
Grass vs 0% Monkey Bread	0.0000	yes
Grass vs 30% Monkey Bread	0.0000	yes
15% Monkey Bread vs Lamb Meal	0.2876	no
15% Monkey Bread vs 0% Monkey Bread	0.2446	no
15% Monkey Bread vs 30% Monkey Bread	0.1386	no
Lamb Meal vs 0% Monkey Bread	0.9169	no
Lamb Meal vs 30% Monkey Bread	0.6600	no
0% Monkey Bread vs 30% Monkey Bread	0.7367	no

	Mean	
Grass	49.6	a
15% Monkey Bread	125.4	b
Lamb Meal	145.7	b
0% Monkey Bread	147.6	b
30% Monkey Bread	153.9	b

Appendix e. ANOVA Results for Feed Conversion Ratio

Analysis of variance (adjusted for covariate)
Variate: FCR_gains_feed_consumed
Covariate: Intitial_wgt

Source of variation	d.f.	s.s.	m.s.	v.r.	cov.ef.	F pr.
Sex stratum						
Covariate	1	0.0052	0.0052			
Sex.*Units* stratum						
Diet	3	3.2675	1.0892	1.25	1.00	0.320
Covariate	1	0.9535	0.9535	1.10		0.309
Residual	18	15.6532	0.8696		1.01	
Total	23	19.9052				

Tables of means (adjusted for covariate)

Variate: FCR_gains_feed_consumed
Covariate: Intitial_wgt

Grand mean 2.34

Diet	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread	Lamb Meal
	2.12	2.97	2.07	2.20

Standard errors of means

Table	Diet
rep.	6
d.f.	18
e.s.e.	0.381

Standard errors of differences of means

Table	Diet
rep.	6
d.f.	18
s.e.d.	0.538

Least significant differences of means (5% level)

Table	Diet
rep.	6
d.f.	18
l.s.d.	1.131

Stratum standard errors and coefficients of variation (adjusted for covariate)
Variate: FCR_gains_feed_consumed
Covariate: Intitial_wgt

Stratum	d.f.	s.e.	cv%
Sex	0	*	*
Sex.*Units*	18	0.933	39.8

Appendix f. ANOVA Results for Feed Cost

Analysis of variance (adjusted for covariate)

Variate: Feed_Cost
Covariate: Intitial_wgt

Source of variation	d.f.	s.s.	m.s.	v.r.	cov.ef.	F pr.
Sex stratum						
Covariate	1	0.02953	0.02953			
Sex.*Units* stratum						
Diet	3	38.46727	12.82242	419.20	1.00	<.001
Covariate	1	0.01351	0.01351	0.44		0.515
Residual	18	0.55058	0.03059		0.97	
Total	23	39.05283				

Tables of means (adjusted for covariate)

Variate: Feed_Cost
Covariate: Intitial_wgt

Grand mean 4.466

Diet	0% Monkey Bread	15% Monkey Bread	30% Monkey Bread	Lamb Meal
	4.106	3.728	3.413	6.617

Standard errors of means

Table	Diet
rep.	6
d.f.	18
e.s.e.	0.0714

Standard errors of differences of means

Table	Diet
rep.	6
d.f.	18
s.e.d.	0.1010

Least significant differences of means (5% level)

Table	Diet
rep.	6
d.f.	18
l.s.d.	0.2121

Stratum standard errors and coefficients of variation (adjusted for covariate)

Variate: Feed_Cost

Covariate: Intitial_wgt

Stratum	d.f.	s.e.	cv%
Sex	0	*	*
Sex.*Units*	18	0.1749	3.9

Diet

Comparison	Probability	Significant
30% Monkey Bread vs 15% Monkey Bread	0.0058	yes
30% Monkey Bread vs 0% Monkey Bread	0.0000	yes
30% Monkey Bread vs Lamb Meal	0.0000	yes
15% Monkey Bread vs 0% Monkey Bread	0.0015	yes
15% Monkey Bread vs Lamb Meal	0.0000	yes
0% Monkey Bread vs Lamb Meal	0.0000	yes

	Mean	
30% Monkey Bread	3.413	a
15% Monkey Bread	3.728	b
0% Monkey Bread	4.106	c
Lamb Meal	6.617	d