PERFORMANCE OF NON-RUMINANTS WHEN GUAR MEAL (*Cyamopsis tetragonaloba*) IS USED AS THE MAIN PROTEIN SOURCE

HAMUKOMBO MEMORY MOLLY

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PERFORMANCE OF NON-RUMINANTS WHEN GUAR (*Cyamopsis tetragonaloba*) MEAL IS USED AS THE MAIN PROTEIN SOURCE

BY

HAMUKOMBO MEMORY MOLLY

(28007522)

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SUPERVISOR: DR. J SIMBAYA

DEPARTMENT OF ANIMAL SCIENCE

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DECLARATION

This thesis has been compiled by myself and has not been accepted in any previous application for a degree at any university. The work of this is a record that has been done by myself and all sources of information have been acknowledged by means of references.

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HAMUKOMBO MEMORY MOLLY

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DEDICATION

This work is dedicated to the following people: My late mother, grandmother,husband and my siblings.

ACKNOWLEDGEMENTS

This work was as a result of the dedicated efforts of many individuals, several of whom deserve special mention; my supervisorDr.J. Simbaya, the laboratory technician Miss Maliti and the stuff members of the Department of Animal Science.

Special thanks also go to my colleagues for their support and guidance during the same period.

ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
CRD	Completely Randomized Design
LSD	Least Significant differences
FCR	Food Conversion Ratio
AOAC	Association of Official Analytical Chemists
DCP	Dicalcium phosphate
CP	Crude protein
P	Phosphorus

ABSTRACT

A study was conducted to evaluate feed utilization, nutrient digestibility and growth performance of non-ruminants when Guar meal is used as a protein source. Processing methods that were evaluated include roasting, boiling, water soaking, and autoclaving. The processed seed materials were subjected to nutritional evaluations including chemical composition, nutrient digestibility assay and growth feeding trials with rats. The experiment was a completely randomized design (CRD)with six treatments, five replications and 1 rat per experimental unit. The formulation of rations used in the digestibility and growth feeding trials were based on results of chemical composition analysis. Chemical analysis showed that CP was higher in raw guar and low in water soaked treated guar due to leaching of nutrients in the discarded water.

Digestibility assays conductedshowed no significant difference among the guar treated meals($P< 0.05$) . Feeding trial showed that intake was more in soyabean, followed by roasted, soaked and boiled guar.

Final weight change of the rats showed no significant difference among the guar treated meals($P< 0.05$). Feed efficiency also showed no significant differences ($P < 0.05$).

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CHAPTER 1

1.1 INTRODUCTION

The Zambian poultry industry has done relatively well considering that at independence the country was a net importer of poultry products. Since then, the industry took off rapidly such that by 1970, it became the largest enterprise accounting for nearly 30% of the gross marketed agricultural outputs (Lomband and Tweendie, 1972). Production in 1970 was more than double the target set for the First National Development Plan and ten times the value achieved in 1964 (Lomband and Tweendie, 1972). Since then, there has been a decline in poultry production, and most farmers are being forced out of the business due to poor quality of feeds and their limited supply. Like many other developing countries, the main problem with feed quality in Zambia is protein insufficiency. The main energy concentrates like maize and cassava are usually poor in protein content such that people cannot eat in enough amounts to meet their protein needs.

Livestock production in many developing countries is hindered by poor availability of quality feeds. This is because of the high prices for protein rich animal feeds. In order to reduce the cost of productions there is need to look at alternative sources and make use of the locally available plant protein sources. Examples of such crops include Guar (*Cyamopsis tetragonaloba*) among others.

Guar is an annual plant of the Leguminosae family. It is an excellent soil improvement crop and it is produced mainly for the seeds or beans which are enclosed in pods until they are harvested. The seeds contain galactomannon gum, a substance which forms a viscous gel in water and widely used in paper manufacturing, and colour printing of fabrics. This is commonly known as Guar gum.The residual mass leftover after extraction of gum is an excellent high quality protein meal (The wealth of India, 1950) and is also a feed supplement for cattle, much like soyabean meal (Chenault, 2002) .

CHAPTER 2

2.1 PROBLEM STATEMENT

Soy beans is the main source of protein that is used in the preparation of diets for broiler chickens and other non-ruminants. The crop is also used for human consumption and in the preparation of many food products that has created an ever increasing demand for soy beans. This has resulted in shortage of the commodity and subsequent price hikes that have had a reflection on the cost of poultry production. The rising cost of production has limited capacity of mainly small scale farmers that depend on poultry production for food protein security and income generation. In order to reduce the cost of production for poultry meat, there is need to look for alternative sources of protein for inclusion in poultry rations. One potential source of protein feeds for poultry rations could be through use of animal processing by-products such as meat, bone and fish meal. However, use of these products is also limited by high importation costs and limited supply. Furthermore, use of products of animal origin in animal feeds has been banned in most countries including the European Union (Department of Agriculture, food and marine, 2012). Thus, the only feasible way to reduce the cost of poultry production is to promote use of locally adapted grain legumes that have a protein profile that is comparable to that of soybeans and do not need expensive inputs such as hybrid seed and chemical fertilizers for successful production.

2.2 JUSTIFICATION

In the production of poultry and other non-ruminants, feeding accounts for about 70% of total cost of management. This means that it plays a major role on whether the enterprise makes profit or not. The cost of production also has a bearing on the affordability of the product by consumers of poultry products. In order to reduce the cost of producing chickens and make animal protein more affordable to consumers, there is need for search of alternative cheaper sources of proteins. Among the cheaper alternatives to soya beans; the main protein ingredients used in poultry diets are the indigenous or locally adapted grain legumes. These legumes have advantage over soya beans in that they are easier to cultivate as they do not need expensive farming inputs for successful cultivation. Their nutritional profile in terms of protein and amino acid content is reasonably similar to that of soya beans(Banerjee, 2007). Unlike soya beans, most of the grain legumes can easily be produced locally on smallholder farms. However, like all other tropical legumes, these crops tend to have anti-nutritional factors that adversely affect nutrient utilization and must be destroyed for optimum utilization by non-ruminants. The purpose of this research was to characterize the nutritional profile in Guar meal and to evaluate its potential toxic effects when it is used to replace different levels of soya beans the main protein source in broiler rations.

CHAPTER 3

3.0 OBJECTIVES

3.1 Main Objective

The objective of this research was to evaluate the chemical composition and feeding quality characteristics of guar meal when used in the preparation of rations for non-ruminants. The rat was used as a model for non-ruminants.

3.2 Specific Objectives

1. To determine the content/composition of nutrients in guar meal.
2. To determine appropriate processing methods for increased utilization of nutrients in guar meal.
3. To determine the digestibility of nutrients found in Guar using selected digestibility assays.
4. To determine the growth performance of rats fed on guar meal semi-purified diets.

3.3 Hypothesis

HO: Processing methods will have no effect on the nutritive value and feeding quality characteristics of guar meal for non-ruminants diets.

HA: Processing methods will have an effect on the nutritive value and feeding quality characteristics of guar meal for non-ruminants diets.

CHAPTER 4

4.1 LITERATURE REVIEW

Guar gum or cluster bean (*Cyamopsis tetragonaloba)* isa drought-tolerant annual legume that is cultivated mostly in arid and semi-arid areas (Universal commodity exchange, 2012). Unlike the seeds of other legumes, the Guar bean has a large endosperm. This spherical-shaped endosperm contains significant amounts of galacto-mannan gum, which makes up between 19 to 43% of the whole seed. Chemically, Guar is a polysaccharide composed of sugarsgalactose and mannose. The backbone of this polysaccharide is a linear chain of β 1, 4-linked mannose residues to which galactose residues are found at 1, 6-linked at every second mannose, forming short side-branches.

Guar beans was introduced into the United States from India in 1903. However, commercial production of Guar in the United States only began in the early 1950s and has been concentrated in northern Texas and Southwestern Oklahoma (Jafri, 1966). The major world suppliers are India, Pakistan and the United States, with smaller acreages being found in Australia and some parts of Africa. World demand for Guar has increased in recent years, leading to introductionsof the crop in several countries including Zambia.

In Asia, Guar beans are used as a vegetable for human consumption, and the crop is also grown for cattle feeding and as a green manure crop. In the United States, highly refined Guar is used as a stiffener in soft ice cream, a stabilizer for cheeses, instant puddings and whipped cream substitutes, and as a meat binder. Most of the crop in the United States is grown for lower grade guar gum, which is used in cloth and paper manufacturing, oil well drilling muds, explosives, ore flotation, and a host of other industrial applications. In humans, the guar is mostly used as a source of soluble dietary fibre that is used to reduce food intake and nutrient digestibility to reduce on incidences of obesity (Kawatraetal, 1969).

Guar meal is widely used in poultry feeds and fish meal. It is a by-product obtained after processing of guar seeds for prime guar products. Guar meal is generally obtained in husk or powder form and is rich source of proteins and carbohydrates. It is often used as substitute for soya bean meal and corn gluten meal as it is more affordable than the two. Being an excellent source for digesti n this is widely used in animal feed and poultry feed industries (Altrafine Gum, 2012).

According to the 13th Report of the Joint FAO/WHO Expert committee on the toxicological evaluation of som e food additives including anticaking agents, antimicrobials, antioxidants, emulsifiers and th ickenings agents, feeding chicks for four weeks on a diet containing 3% cholesterol and 0.3% Guar reduce the serum cholesterol levels.

In 1975, Brahma and Siddiqui carried out a preliminary study of replacing expensive peanut cake with toasted Guar Meal up to 75% in poultry feed. The results revealed no significant difference in weight gain an indication that toasted guar meal is also rich with proteins.

Typical broiler rations will contain from 22 to 24 percent protein. The common source of protein in the poultry ration has been the Soya Beans. Some studies have shown the following proximate composition of ingredients in Soya and Guar as shown below.

Table 1: Nutrient Comparison between Soya Bean and Guar Meal (Banerjee, 2007).

Feed Ingredient	*Me kcal/kg*	*DM %*	*CP %*	*CF %*	*EE %*	*NFE %*	*ASH %*	*CA %*	*P%*	*LYS %*	*METH %*	*TRYP %*
Soya bean meal	--	*89.9*	*41.7*	*6.3*	*21.2*	*26.o*	*4.8*	*0.36*	*0.9*	*2.31*	*0.51*	*0.72*
Guar meal	--	*91.0*	*42.6*	*10.9*	*6.2*	*35.1*	*5.8*	*0.54*	*0.70*	*2.94*	--	*0.72*

Like other legumes, guar is an excellent soil-building crop with respect to available nitrogen. Root nodules contain nitrogen-fixing bacteria, and crop residues, when plowed under, improves yields of succeeding crops.

Guar tolerates high temperatures and dry conditions and is adapted to arid and semi-arid climates. Optimum temperature for root development is 25 to 35°C. When moisture is limited, the plant stops growing but does not die. While intermittent growth helps the plant survive drought, it also delays maturity. Growing season ranges from 60-90 days (determinate varieties) to 120-150 days (indeterminate varieties). Guar responds to irrigation during dry periods. It is grown without irrigation in areas with 254 to 1016 mm of annual rainfall. Excessive rain or humidity after maturity causes the beans to turn black and shrivel, reducing their quality and marketability. While profitable seed production in southern U.S. areas of high rainfall and humidity is likely to be limited, guar can be successfully grown as a green manure crop under similar conditions (Undersander et al. 2012).

Seeds at the rate of 30 kilograms/ha are planted at a spacing of 45-60 x 20–30 cm in February–March and June–July. During rainy season, the seeds are sown 2–3 cm deep on ridges and in furrows during summer months. Fertilizer application for N, P_2O_5 and K_2O for the crop is 20:60:80 kg/ha respectively. Under ideal conditions, the average yield of guar beans is 5 to 6 tonnes/ha.

Production practices and rainfall during the growing season causes seed yields to vary from about 55 to 370 kg/ha. Experimental plantings of guar at Rosemont and Minnesota have resulted in plants that bloomed but produced very little seed (Undersander*et al.* 2012).

CHAPTER 5

5.0 MATERIALS AND METHODS

5.1 Study Area

The study was conducted at the University of Zambia, School of Agricultural Sciences in the Department of Animal Science. The chemical composition analysis was done in the food chemistry and Animal Nutrition Laboratory, whiledigestibility assays were done in thePhysiology laboratory.

5.2 Sources of Materials

Seeds of guar and soya beans were collected from KasisiAgriculturalTraining Centre in Chongwe. Cassava meal and other ingredients such as DCP, Methionine, Broiler premix, Salt, Limestone and others were procured from Livestock Services Cooperative Society, Lusaka.The rats for digestibility were obtained from the Biological Sciences in the school of Natural Sciences.

5.3 Processing of GuarBeans

Seeds of guar beans were subjected to various processing methods which included roasting, boiling for 60 minutes, soaking in water for 2 days at 60^0C, and autoclaving for 30 minutes at 120^0C. The processed beans were then ground to pass through a 3mm sieve using a Hilley and Willy laboratory mill. After processing, a sample of each processed meal was collected for proximate analysis.

5.4 Proximate Analysis of Processed Guar Meals

Samples of processed guar meals were subjected to chemical composition analysis for Dry Matter (DM), Crude Protein (Kjeldahl N x 6.25), Ether Extract, Ash, Calcium and Phosphorus using established methods of analysis (AOAC, 1990). Based on the chemical composition, semi-purified diets were formulated for digestibility assays using mature winstar rats.

5.5Digestibility Assays

For digestibility assays, five diets contained different treatments of guar beansas shown in Table 2.The diets contained 19% crude proteinand were made up of 45% guar beans and 55% basal ingredients. The ingredients in the basal ration contained cassava meal, limestone, DCP, salt, broiler premix, methionine and lysine. The control diethad 45% soya beans and 55% basal diet.

For the trial,30 Wister rats were randomly allocated to 6 dietary treatments with 5 replications per treatment in a completely randomised design (CRD) were each rat was treated as an individual experimental unit on which data was collected as part of treatment replication.

The feed and water were offered *adlibitum*. The rats were subjected to standard management procedures and the trial lasted for a period of 7days during which feed intake, change in body weight and faecal matter was recorded.

During the trial, feed intake was recorded daily and this was determined by subtracting the left over feed on the following day from the quantity given to the rats on the previous day.Faecal samples were collected during the last four days of the trial. The collected feacal samples were dried at 60^0C for 48 hours after which samples from each treatment were pooled together, ground and subjected to chemical composition analysis as described for the processed guar meals. Digestibility of nutrients was calculated as apparent digestibility using equations described by McDonald *et.al*., (1987).

The initial body weight of the experimental rats was taken prior to the commencement of the experiment, and the final body weight gain was determined at the end of the experiment. Body weight change was determined by subtracting initial body weight from final body weight.

Food conversion ratios (FCR) among treatments were also calculated by dividing the feed intake by weight change.

Table 2: Dietary composition (%) of semi-purified diets used for rat growth digestibility trials

Ingredients(g)	**Treatment Diets (%)**					
	Raw	**Roasted**	**Boiled**	**Soaked**	**Autoclaved**	**Soya beans**
Guar meal	45.00	45.00	45.00	45.00	45.00	00.00
Soya bean meal	00.00	00.00	00.00	00.00	00.00	45.00
Cassava meal	42.08	42.08	42.08	42.08	42.08	42.08
Fish meal	5.00	5.00	5.00	5.00	5.00	5.00
Soya oil	5.00	5.00	5.00	5.00	5.00	5.00
Limestone	0.58	0.58	0.58	0.58	0.58	0.58
DCP	1.83	1.83	1.83	1.83	1.83	1.83
Salt	0.17	0.17	0.17	0.17	0.17	0.17
Broiler premix	0.17	0.17	0.17	0.17	0.17	0.17
Methionine	0.083	0.083	0.083	0.083	0.083	0.083
Lysine	0.083	0.083	0.083	0.083	0.083	0.083
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

5.6 Statistical analysis

All collected data was subjected to analysis of variance (ANOVA). Significantly different means were separated using least square difference (LSD) and Duncan's multiple range test.

CHAPTER 6

6.0 RESULTS AND DISCUSSION

6.1 Chemical Composition Analysis

The results of chemical composition of guar meal samples subjected to various processing methods were presented in Table 3. Calcium and ME showed no significance difference ($P > 0.05$). However, the results for the other nutrients (moisture, ash, protein, phosphorus, fibre,NFE and ether extract) showed significant differences ($P < 0.05$). The data was further subjected to least square difference (LSD) for multiple comparisons and Duncan Multiple range for separation of means.

Table 3: Results obtained from nutrient analysis (means).

Parameters	Treatments				
	Raw	Roast	Boiled	Soaked	Autoclaved
DM (%)	9 .85^{b}	95.69^{a}	93.66^{a}	92.39^{b}	92.59^{b}
CP (%)	4 .06^{c}	41.00^{bc}	39.31^{bc}	33.07^{a}	36.13^{ab}
EE (%)	2 56^{a}	4.09^{b}	4.28^{bc}	5.27^{c}	5.20^{c}
CF (%)	8 50^{a}	12.02^{c}	9.51^{ab}	11.35^{bc}	9.38^{ab}
NFE (%)	3 .77^{a}	32.80^{a}	35.79^{ab}	39.69^{b}	35.81^{ab}
ME(kcal/kg)	3 21^{a}	3.36^{b}	3.35^{ab}	3.32^{ab}	3.31^{a}
Ash (%)	[illegible] 86^{b}	6.85^{bc}	4.76^{b}	3.01^{a}	6.06^{c}
Ca (%)	0 56	0.45	0.49	0.51	0.44
P (%)	0 65^{a}	0.65^{a}	0.63^{a}	0.75^{b}	0.64^{a}

Means with different superscripts letters within each row were significantly different from each other at P<0.05% level.

6.2 Digestibility Assay

After the study, diets as well as feacal samples were analyzed in the lab in order to come up with the percentage of digestibility of dry matter and crude protein as shown in Figures 1 and 2. It was shown that there were no significant differences (P<0.05) among the treatments.

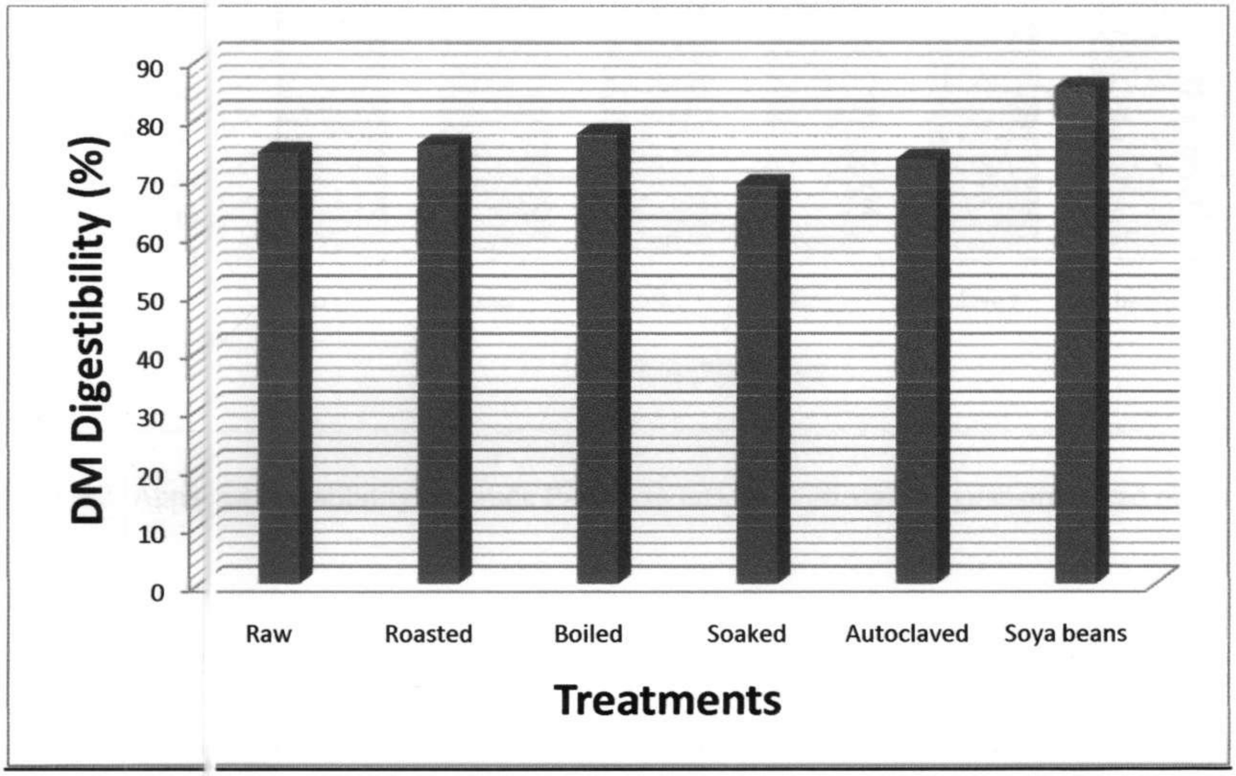

Figure 1: Apparent digestibility of Dry Matter in rats fed with various guar-processed meals

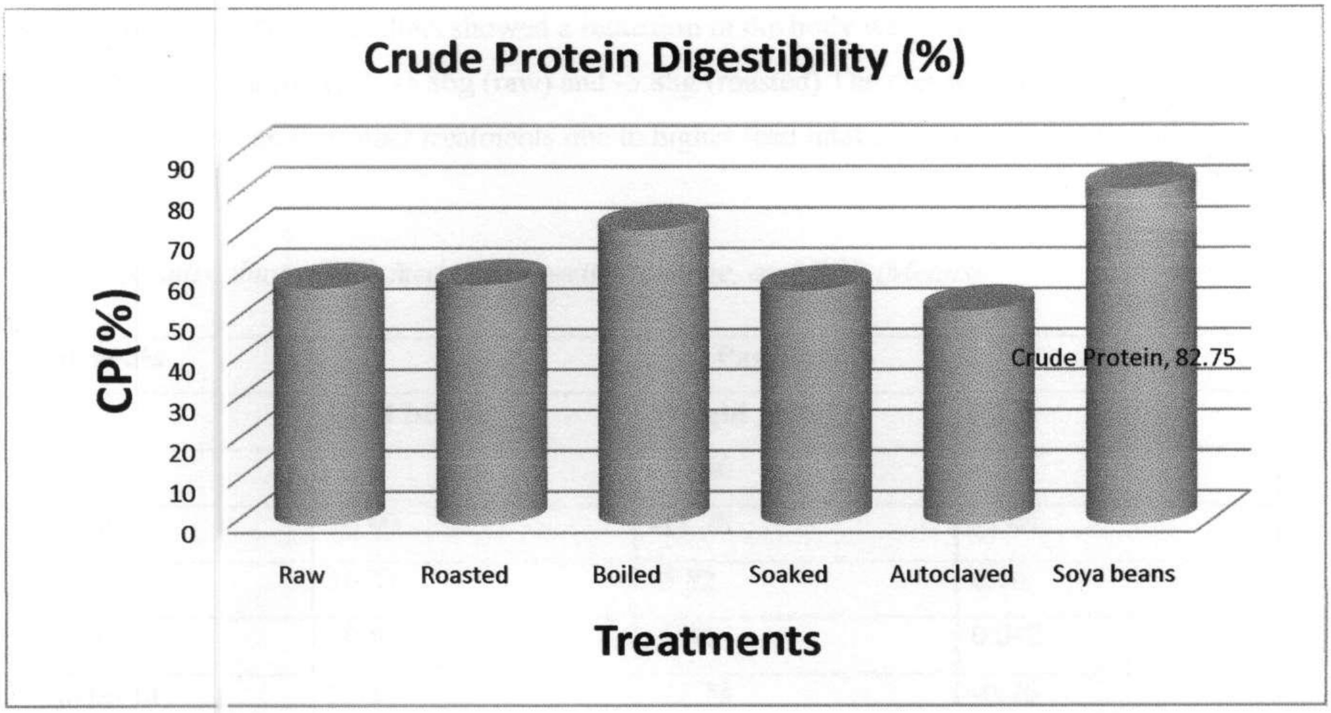

Figure 2: Apparent digestibility of Crude Protein in rats fed with various guar-processed meals

6.3 Growth Performance Trial

As shown in Table 4, there were no significant differences (P > 0.05) in the feed intake among the treatment rats. The diet containing soya beans recorded the highest average feed intake 12.31g/day out of 30g given. Followed by diet containing roasted beans with 10.99g, then diet containing boiled with 10.53g. The last two were raw (9.81g) and autoclaved (9.43g). This difference could be due to difference in palatability levels of the meals.

Feed conversion ratio showed no significant difference (P > 0.05) among the different treatment diets. Although results showed no significant difference, roasted guar beans recorded the lowest average feed conversion ratio while boiled guar beans had the highest feed conversion ratio of 0.76. This shows that roasting was not effective in detoxifying the meals. The difference in FCR may have been as a result of difference in digestibility of nutrients.

The results in weight change did not show a significant difference (P > 0.05) among treatments. Two treatments led to increased body weights in the rats (Soya beans with 6.10g and soaked guar beans with 0.02g). The other diets showed a reduction in the body weights with -1.46g (autoclaved), -2.50g (boiled), -5.86g (raw) and -5.88g (roasted).The diet with soya beans performed better than diet other treatments due to higher feed intake as compared to the other diets

Table 4: Results obtained for feed intake, weight change, and FCR (Means)

Treatments	**Parameters**		
	Feed Intake	**Weight gain(g)**	**FCR**
Raw	9.81	-13.46	0.24
Roasted	10.99	-11.78	-5.44
Boiled	10.53	-5.82	0.76
Soaked	10.67	-5.48	0.042
Autoclaved	9.48	-11.78	-0.76
Soya beans	12.31	3.36	-0.57

CHAPTER 7

7.1 CONCLUSION

The nutrient content results showed that crude protein was high in raw and roasted guar but low in water soaked due to leaching of nutrients in the discarded water. As the beans stayed under water for longer periods, the process of fermentation resulted in increased nutrients particularly ether extract and crude fibre.Hence, roasting might present the best results since there is an increase in CP, CF, EE and DM.

The results from this study showed that digestibility was highest in soya beans, followed by boiled and soaked guar beans. This is because the galacto-mannan gum which binds to nutrients was leached out during boiling and soaking.

During the period of the study, autoclaved was eaten the least and soya bean based diet was consumed the highest followed by roasted, soaked and boiled. This could be due to cases of anti-nutritional factors.

There was weight a minimum increase in rats fed on soya beans and a decline in weight change on all the guar fed rats. The weights reduced due to differences in feed intake.

7.2 RECOMMENDATIONS

The study shows that guar beans cannot be used in feeding non-ruminants. I therefore recommend the use of guar beans in supplementing human diets as it is helpful in weight loss.According to the 13th Report of the Joint FAO/WHO Expert committee on the toxicological evaluation of some food additives including anticaking agents, antimicrobials, antioxidants, emulsifiers and thickenings agents,guar reduces the serum cholesterol levels as it binds to cholesterol during digestion.

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