



**THE UNIVERSITY OF ZAMBIA
SCHOOL OF AGRICULTURAL SCIENCES
DEPARTMENT OF ANIMAL SCIENCES**

**NUTRITIONAL EVALUATION OF SWEET POTATO (*Ipomea batatas*)
CHIPS AS AN ENERGY SUPPLEMENT IN STARTER DIETS OF
BROILER CHICKENS.**

**A DISSERTATION
SUBMITTED TO THE SCHOOL OF AGRICULTURAL SCIENCES
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DEGREE OF BACHELOR OF AGRICULTURAL SCIENCES**

BY

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DECLARATION

I, Liswaniso Simushi, hereby declare that this Bachelor of Science in Agriculture Science (BSc. AG) thesis report represents my own work and that it has not previously been submitted for a degree at this or any other university. All sources of information have been acknowledged by citations and references.

SIGN:.....


DEDICATION

To my father Shadreck Maswabi Liswaniso, Mum Christine Maumbu, Mate Martin junior, Milika Mate, Nosiku Mate and Mutinta Bubala.

DEDICATION

To my father Shadreck Maswabi Liswaniso, Mum Christine Maumbu, Mate Martin junior, Milika Mate, Nosiku Mate and Mutinta Bubala.

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LIST OF ABBREVIATIONS AND ACRONYMS

FCR: Feed conversion ratio

ANOVA: Analysis of variance

RCD: Randomized Block Design

SPM: Sweet Potato Meal

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Table 1: Ration formulation

Table 2: Chemical/nutrition composition of sweet potato in comparison to that of maize

Table 3: Feed intake per week

Table 4: weight gain of broilers per week

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ABSTRACT

The major problem that farmers face in production of chickens is the cost of production of which much of it is the cost of feed. Maize which is the major source of energy in most broiler rations is expensive to produce because it requires many inputs such as fertilizers, chemicals and other labor requirements. It is a crop that has many alternative uses and its competition by man and livestock has also led to the crop being expensive hence the need to identify alternative sources of energy such as tubers. Proving alternatives energy sources like sweet potato will not only lower the cost of producing broilers but will help realise the full utility of the crop that has been neglected. The study was conducted at the University of Zambia field station and the animal nutrition laboratory for more 21 days. The sweet potatoes were purchased from Lusaka's Soweto market. These were washed in running water to remove the soils and other foreign materials after which they were chopped in to pieces of 1 cm cubes that were then sun dried until the moisture content was about 10%. The dried sweet potatoes chips were then ground through 3mm. Part of the milled meal was then used to formulate broiler starter rations and some taken for proximate analysis according to AOAC (1990). A feeding trial was conducted to evaluate performance of broiler birds fed Starter rations with sweet potato meal (SPM) levels of 0%, 5%, 15%, and 25%, compared to a commercial feed. 150 Cobb 500 birds were used in a Completely Randomized Design with each treatment replicated 5 times. Analysis of variance (ANOVA) was done using Minitab 16 statistical package. It was observed that maize had more crude protein than sweet potatoes though sweet potatoes had more ash and calcium than maize. In terms of energy the difference was low. There were no significant differences in means of feed intake and feed conversion ratios ($P > 0.05$) but there were significant differences in terms of weight gain among the treatment ($p < 0.05$) however among rations that contained sweet potatoes, there was no significant differences in weight gain ($P > 0.05$). There was observed reduction in weight gain, yet increased FCR with increasing sweet potato levels in the starter rations. Increasing sweet potato inclusion levels increased the cost of feed. It is concluded that sweet potato can be included at 5% and 15% inclusion level in rations of broiler starter ration for 21 days.

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CHAPTER ONE

1.1 INTRODUCTION

One of the major problems faced by poultry farmers in the rearing of chickens is the cost of production, much of which is feed. Inadequate knowledge and unavailability of alternative cheaper feed sources and competition between man and animals for much of our traditional feedstuff has been identified as the root cause (Afolayan, 2012). There is also limited supply for energy sources of feed in Zambia and as such this has also led to high feed prices. This is particularly true for maize which is a major energy source ingredient in broiler feeds. Maize is used in various industries including brewing, starch production and other products for human and livestock consumption. Apart from the increased demand, the production of maize requires many purchased inputs. These include hybrid seeds, chemicals, fertilizers, and its labour requirements as well as the costs of harvesting, weeding and others, which makes it expensive. This translates into high cost of feeds thereby pushing up the cost of poultry production and prices for consumers. Resorting to other energy sources like Sweet Potato is a way out of this problem. With the adverse effects caused by the global warming and climate change that have affected the world, there is need to identify and switch to locally adapted crops such as sweet potato (*Ipomea batatas*) which has apparently been underutilised world over. Sweet potato unlike maize can not only be grown on marginal soils with minimal inputs but in drought areas as well.

There is high production of sweet potato in Zambia but much of it goes to waste due to their limited use and most of it has been known to be limited to human consumption in times of hunger. There is therefore, need to promote sweet potato usage beyond this by identifying other alternative uses. By doing so, market shall be created thereby increase income in people of our rural communities and other producers of sweet potato. One such alternative is in livestock. Therefore the aim of this research was to evaluate the use of sweet potato in broiler starter diets as a partial substitute for maize.

1.2 PROBLEM STATEMENT

Maize as earlier stated is the main energy ingredient in broiler rations. The thing that makes maize not to be the best energy supplement in terms of sustainability, accessibility and availability is that it is too expensive to produce. For maize to grow, it requires purchased inputs like, hybrid seed, chemicals, fertilisers, pesticides, and is also labour intensive. Maize also has a lot alternative uses. Because of the high cost of producing maize and its competing alternatives uses the price of maize available for stock feeds is high thereby increasing animal feed costs.

Maize is a crop that requires a good climate to grow in form of high rainfall, moderate temperatures, and fertile soils. But with the climate change that the planet is facing, the future of maize is not certain. As such, despite the bumper harvests being recorded in Zambia, it is expected that the prices of maize will go high because there will be a limited supply of maize due to the low yields that are expected as a result of climate change.

On the other hand, sweet potatoes are a potential good energy supplement due to the potential advantages it presents on maize despite their challenges of storage due to high moisture content. Sweet potatoes have a very limited usage base. Usually they are associated to feeding by humans in times of droughts. It is important to find alternative uses to it. Sweet potato is a very cheap crop to produce. It can grow in marginal or "poor" soils without application of fertilizers. It is a drought tolerant crop meaning that it is well adapted to our country and region. Sweet potatoes are also supplied in large quantities but with no use. Most of our small scale farmers produce a lot of sweet potato and because of lack of industrial application most of it goes to waste.

Proving alternatives energy sources like sweet potato will not only lower the cost of producing broilers but will help realise the full utility of the crop that has been neglected.

1.3 JUSTIFICATION

There is need to find alternative uses of sweet potato so that farmers can find a market and make money from sweet potato. One potential application is in livestock feeds. This will also reduce the pressure on maize as a feed crop. This will make it more available for other industrial uses. The experiment was intended to bring out the effect of feeding broilers with different levels of sweet potato as an energy substitute of maize in broiler starter feeds. It is only through scientific research that we can establish to what extent or level we can include sweet potato meal in broiler feeds as a partial maize substitute.

1.4.0 OBJECTIVE

1.4.1 Overall objective

Determine the chemical composition and feeding quality characteristics of sweet potatoes when used as partial replacement of maize as energy source broiler starter diets.

1.4.2 Specific objectives

1. Determine ~~appropriate~~ maize replacement levels by sweet potato for cost effective production of broilers chickens.
2. To determine the chemical composition of sweet potatoes

Dose-response trial = determine levels for optimal responses?

1.5.0 HYPOTHESIS

H: Sweet potato can successfully be used to partially replace maize as a source of energy in broiler rations.

HA: Sweet potato can not successfully be used to partially replace maize as a source of energy in broiler rations.

HO: There are significant differences in the nutritive value of sweet potato with that of maize.

HA: There are no significant differences in the nutritional value and feed quality between maize and sweet potatoes.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Growth condition of sweet potato

Sweet potatoes can be cultivated where there is enough rainfall of about 750-2000 mm to support their growth. When rainfall levels are below 850 mm irrigation may be necessary but it should be stopped before harvest in order to prevent the tubers from rotting. Being a warm-season annual crop, Sweet potato require 20-25°C average temperatures and full sunlight for optimal development. It needs a frost-free period of 110-170 days and growth may be hampered below 20°C average day temperatures. Sweet potato thrives in well-drained loamy soils with high humus content that provides warm and moist environment to the roots. They need optimal soil pH of between 5 and 7, can tolerate mildly drought conditions and can survive dry spells during the summer. However, low humidity impairs crop quality even if the plant resumes growth after a water stress (Paneque, 1992, Ecocrop, 2010).

2.2 Nutritional content of sweet potato

Sweet potato is one of the world's most important food crops. Its main nutritional importance has been its starch content. However, sweet potato can also be a source of other nutrients, such as vitamin A, ascorbic acid, thiamin, riboflavin and niacin. Low protein, fat and fibre levels were found in the roots of sweet potatoes, but the high nitrogen-free-extract fraction in this tuber is indicative of their main potential value as an energy source. Vines have lower carbohydrate content but are higher in fibre and protein and so their principal nutritive value is as a source of vitamins and protein (Dominguez, 1992). Sweet potato is generally considered a high-energy food and is the staple crop of many parts of the world (Huang, 1982). The carbohydrates of sweet potato is highly available and can be greatly utilized by non-ruminant animals (Oboh, 1987). The peel of the sweet potato is higher in proteins, minerals and other non-carbohydrate constituents than the rest of the tuber (Uadia 1984).

A comparison with other food crops shows that it yields more calories per unit area than either maize or irish potato and nearly as much as cassava, while its protein yield is far higher than the latter (Woolfe, 1992).

Sweet potato roots are high-moisture feedstuffs that serve primarily as an energy source. They contain approximately 80% moisture, 3% crude protein, 6.5% acid detergent fiber, and 25% neutral detergent fiber on a dry matter basis. Much of the total protein is not digestible. Sweet potatoes neither contain fat nor fat-soluble vitamins which vitamins A, D, and E (Parish, 1992).

Sweet potato is among crops that are highly used for livestock feed in Taiwan and china where the crop is ranked among low utility crops (Huang, 1982). Its vines contain high protein levels (Ondabu 2005). Tewe (1991) and Ravindran and Sivakanesan (1996) proved that levels of sweet potato meal in broiler diets had no effects on the mortality rate in their studies. Sweet potato when used in diets of broilers has no effect on the carcass composition (Maphosa et al, 2003).

2.3 Production levels of sweet potato in Zambia

Sweet potatoes are produced in most parts of Zambia. More than 7000ha of sweet potato were cultivated with an average yield of more than 2 metric tones per hecters in 2010 (CSO/MACO, 2010). The 2012/2013 crop forecast by CSO projects that 188 355 metric tonnes of sweet potatoes will be harvested in 2013 on 48, 458 hecters of land cultivated with an average yield of 3.82 metric/hector. In comparison to the 2011/2012 season's report this shows a 13.09% increase in hecters cultivated, 15.21% increase in yield per hector and 1.95% yield rate increase (CSO/MACO, 2013).

CHAPTER THREE

3.0.0 MATERIALS AND METHODS

3.1 Location of research

The research was conducted at the University of Zambia Animal Sciences Research station for a period of more than 21 days. The chemical analysis was done in the food chemistry and nutritional laboratory of the animal science department.

3.2 Materials and source

The Variety of sweet potato that was used was the yellow fleshed one that came from Kapiri Mphoshi district of Central province of Zambia and the tubers were purchased from traders at Lusaka's Soweto market.

150 COBB 500 day old chicks were purchased from Hybrid Poultry (Z) Ltd and were used for the feeding trial for a period of 21 days. Other ingredients that were used in balancing the ration were purchased from livestock services cooperative society of Zambia.

3.3 Processing of sweet potatoes

After the sweet potatoes were bought from the traders, they were washed under running water to remove soils and other foreign materials. The tubers were then sun dried for a 5 hours before chopping them to pieces of 1 cm cubes that were then sun dried to about 10% moisture content. The dried sweet potatoes chips were then ground through 3mm sieve size. Part of the milled meal was then used to formulate broiler starter rations.

3.4 Proximate analysis

A sample of milled sweet potato was collected and for proximate analysis. Determination of Crude protein (using the Kjeldahl method), total fibre, ether extract (using the Soxhlet method), calcium (using the permanganate method), phosphorous, ash and moisture content were done using the AOAC (1990).

3.5 Ration formulation

Four rations were formulated based on the chemical compositions to meet the nutritional requirements for growth for the 21 days. The starter rations were formulated to contain 0%, 5%, 15%, and 25% inclusion of sweet potato. The fifth ration was a commercial feed from one of the feed manufacturing companies in Zambia. The 0% sweet potato inclusion treatment and the commercial starter ration were used as controls in the study. The sweet

potato meal (SPM) was then blended with other ingredients to make sure the rations were balanced. The ration was then fed to the day old chickens for 3 weeks (21days).

The formulations are as below:

Table 1: Ration Formulations

INGREDIENTS	TRT 1 (0%)	TRT 2 (5%)	TRT 3 (15%)	TRT 4 (25%)
MAIZE	53	47.7	36	30
SBM	34	34	35	33
FISH MEAL	5	5	5	4.5
DCP	1.8	1.8	2	1.8
LIMESTONE	0.5	0.5	1	0.7
METHIONINE	0.1	0.2	0.2	0.2
LYSINE	0.1	0.2	0.2	0.2
PREMIX	0.2	0.3	0.3	0.3
SALT	0.3	0.3	0.3	0.3
VEG OIL	5	5	5	4
SPM	0	5	15	25
TOTAL	100	100	100	100
CRUDE PROTEIN	22.68	22.56	22.35	22.02
METABOLISABLE ENERGY	3128	3105.16	3031	2975.18

3.6 Feeding Trial

3.6.1 Design

A Completely Randomized Experimental Design (CRD) was used for the feeding trial. One hundred and fifty (150) Cobb 500 Day old chicks were used for the study which lasted for 21days. The birds were individually weighed and randomly assigned to 5 treatments. Each treatment was replicated 5 times with 6 birds per replicate.

3.6.2 Equipment and Housing Preparation

The poultry house was disinfected using viral kill. The floor of the pens was covered with wood shavings, while Infrared lamps placed were spread among pens to provide heating to the chickens. The place was warmed to raise the temperature a day before the chicks arrived. A plastic sheet was used to cover the sides of the poultry house to prevent cold stress during brooding.

3.6.3 Management practice during brooding

The experimental diets were fed together with clean drinking water at *libitum* throughout the experimental period. Standard management practices and routine vaccination were strictly observed. All the birds were vaccinated on day 12 and 15 against Infectious Bursal Disease and New castle Disease respectively.

3.7 Data collection and observations

During the feeding trials, the amount of feed consumed per day was recorded. This was done by way of weighing the feed that was put in the feed troughs the previous day and then from this subtract the weight found in the troughs the following day. This gave the weight of feed consumed per day.

Weekly weight gains were also taken once every week. Birds were weighed on arrival from the hatchery (on day one). Thereafter weights were taken every after 7days up to day 21. Mortalities were observed for every day and were recorded as and when they were observed. The birds were monitored on a daily basis for unusual behavior. The last parameter that was observed was the nature of the excreta. It was checked for caking. The figures from the weight gain and feed intake were used to calculate the feed conversion ratios (FCR).

3.8 STATISTICAL ANALYSIS

All collected data was subjected to Analysis of various (ANOVA) using MINITAB 16 Statistical Software Package. Significant differences among means were separated using Turkey's test. For data entry Microsoft Excel 2007 was used even for the calculation of feed conversion ratios (FCRs)

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 CHEMICAL COMPOSITION OF SWEET POTATO

TABLE 2: Chemical/Nutritional composition of sweet potato in comparison with that of maize

NUTRIENT	Raw Sweet Potato	Maize
Dry matter	89.2	91.16
crude protein	3.41	8.27
Crude Fibre	1.7	4.57
Ether Extract	0.85	5.99
Ash	3.3	0.8
calcium	2.88	0.04
Phosphorus	0.009	0.3
Metaboisable Energy (Mcal/kg)	3.096	3.384

Table 1 shows the nutritional composition of sweet potato compared to that of maize. There was no much difference in terms of dry matter content between the maize and sweet potato. However, sweet potato had lower dry matter than maize at 89.2 and 92.11 respectively. Maize was found to contain more crude protein than sweet potato. Sweet potato was found to contain 0.85 ether extract compared to 1.44 for maize. Of the two crops, sweet potato and maize, in terms of calcium and phosphorus sweet potato contained more calcium than maize and they had almost the same amount of phosphorus.

4.2 PERFORMANCE OF BROILERS

Table 3: Feed intake of broilers per week

TREATMENT	WEEK 1	WEEK 2	WEEK 3
0	148.47	436.56	548.43 ^a
5	147.08	428.48	507.12 ^a
15	124.91	403.65	237.51 ^b
25	123.25	407.09	534.90 ^a
Commercial feed	168.06	430.48	653.90 ^a

Numbers in the same column with same superscript are not significant different from each other

Table 4: weight gain of broilers per week

TREATMENT	WEEK 1	WEEK 2	WEEK 3
0	93.00 ^b	226.60 ^a	309.80
5	94.80 ^{ab}	216.60 ^a	268.40
15	96.20 ^{ab}	218.40 ^a	318.40
25	82.40 ^b	164.40 ^b	264.40
Commercial feed	114.80 ^a	246.20 ^a	350.60

Numbers in the same column with same superscript are not significant different from each other

Table 5: feed conversion ratios of broilers per week

TREATMENT	WEEK 1	WEEK 2	WEEK 3
0	1.5935	1.9442 ^{ab}	1.8248 ^a
5	1.5574	2.0510 ^{ab}	1.9305 ^a
15	1.3488	1.8609 ^{ab}	0.7401 ^b
25	1.5050	2.5641 ^a	2.1418 ^a
Commercial feed	1.4706	1.7505 ^b	1.8729 ^a

Numbers in the same column with same superscript are not significant different from each other

There were no significant differences in feed intake in the first and second week of the study. In the third week there was a significant difference between the 15% treatment with the rest. The feed finished in the second week and some more made or mixed for the third week so this difference may have been due to this change in feed. In terms of weight gain, there were no significant differences among the sweet potato containing diets but there were significant differences among all the treatments. This is because the 25% treatment was significantly different from the commercial feed due to the differences in processing of the two types of feeds. The Feed Conversion Ratio was not significantly different in the first week but there was a statistically significant difference in the second and third week.

Table 6: overall of broilers at 3 week of age

TREATMENT	FEED INTAKE	WEIGHT GAIN	FCR
0	1133.4 ± 3.02	629.20 ± 2.23 ^{ab}	1.8269
5	1107.4 ± 2.33	560.00 ± 2.26 ^{ab}	1.9982
15	1037.2 ± 2.47	625.40 ± 2.63 ^{ab}	1.6917
25	1082.0 ± 2.38	511.20 ± 2.31 ^b	2.1810
Commercial feed	1201.6 ± 3.03	711.20 ± 1.94 ^a	1.6903

Numbers in the same column with same superscript are not significant different from each other

Weight gain reduced with increased sweet potato levels in the diet. There were however no statistically significant differences among the treatments that contained sweet potatoes. The treatment with 25% sweet potatoes was significantly different from that of the commercial diets. This could have been due to differences in the processing of the diets.

There was a decrease in feed intake as sweet potato inclusion levels increased from 0% to 5%. However there was a change in the trend when it came to 15% and 25 % sweet potato inclusions. According to Maphosa et al (2003) and Afolayan (2012) it was expected to see a decrease in feed intake as sweet potato inclusion increased. This means that the order of increasing feed intake was expected to be 0%, 5%, 15% and 25% inclusion. This study revealed that it was true for 0% and 5%. However this was contrary when it came to treatments 15% and 25%. This had to do with the energy content as birds eat to meet their energy needs. The 15% ration had 3033ME while 25% treatment had 2975 ME. This meant that the birds ate more of the ration with lower energy content (25%) to meet their energy requirements as opposed to the one that had high (15%) concentrations of energy. But overall there were no significant differences in feed intake ($P > 0.05$)

There were no significant differences ($P>0.05$) among all treatments when it came to Feed Conversion Ratio (FCR). The treatment that had the highest was the 25% treatment with the commercial feed having the best.

4.3 Mortality

The results on mortality were not related to treatment effect. During the whole study only six birds died at different times of the study period. Deaths were one each for treatments 0%, 5%, and 25% sweet potato inclusion levels. The mortality was highest in the commercial diets where 3 birds died. These deaths were more of natural causes rather than treatment effects. There was no mortality in the treatment with 15% potato inclusion level.

4.4 Cost analysis

It was observed that Inclusion of sweet potatoes leads to feeds becoming expensive. This is because sweet potato is low in protein and to balance this up there is need to incorporate other expensive ingredients to balance the protein up like fish meal, vegetable oil which are expensive and are not mostly used in most pure maize rations. The other issue about sweet potato is that the moisture content in the sweet potato varieties is quite high and can be as high as 62.58% (Ingabire, 2011). And so if one needs 200kg for example of Dry matter of sweet potato there will be need to transport over 530 kg especially that sweet potato are grown in areas that are far from the line or rail where most of poultry production and feed manufacturing is done.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions.

Sweet potatoes contain nutrients needed by non ruminants as contained in maize. Compared to maize, they are very deficient in protein making them not be able to replace maize completely in starter rations of broiler chickens. Sweet potato can however, be included in the starter diets at 5 and 15% inclusion levels without experiencing differences in live weight gain. There is reduction in weight gain and increased FCR with increasing sweet potato levels in the starter rations. The only problem is that the cost of feed per kilogram increases with increasing levels of sweet potatoes in starter rations.

There is no mortality associated with sweet potato inclusions in broiler rations of starter feeds up to 25% inclusion levels.

5.2 Recommendations

From the findings in this study the following can be recommended.

1. The study should be carried out on a larger scale with trials extending to grower and finisher phase of broilers.
2. The study should be carried out that should compare the performance of broilers fed on different levels of sweet potatoes with varying levels of exogenous enzyme inclusion levels.
3. A further study on the in-vitro and in-vivo digestibility should be carried out.
4. There will be need to evaluate the effect of sweet potato meal on the meat quality of broiler chickens and determine the anti-nutritional factors in sweet potatoes.

CHAPTER SIX

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CHAPTER SEVEN

7.0 APPENDICES

APPENDIX A: ANALYSIS OF VARIANCE TABLES

ONE-WAY ANOVA: INTAKE

SOURCE	DF	SS	MSS	F	P
TREATMENT	4	75009	18752	1.37	0.281
ERROR	20	349473	13723		
TOTAL	24	274464			

ONE-WAY ANOVA: WEIGHT GAIN

SOURCE	DF	SS	MSS	F	P
TREATMENT	4	115374	28844	3.99	0.015
ERROR	20	144502	7225		
TOTAL	24	259876			

ONE-WAY ANOVA: WEIGHT GAIN

SOURCE	DF	SS	MSS	F	P
TREATMENT	4	0.8940	0.2235	2.24	0.101
ERROR	20	1.9920	0.0996		
TOTAL	24	2.8860			

APPENDIX B: TURKEY'S TEST RESULTS FROM MINITAB 16

Grouping Information Using Tukey Method

TREATMENT	INTAKE MEAN	WEIGHT GAIN MEAN	FCR MEAN
COMMERCIAL FEED	1201.6 a	711.2a	1.83a
0%	1133.4 a	629.2ab	1.83a
5%	1107.4a	560ab	1.998a
15%	1037.2a	625.4ab	1.69a
25%	1082a	511.2b	2.18a

Means that don't share a letter are significantly different.

APPENDIX C: FORMULAE USED IN THE DATA ANALYSIS

(Little and Hill, 1978).

1. Mean Values

1.1 Treatment Means = $\Sigma(\text{Treatment totals}) \div \text{No. of replications (R)}$

1.2 Grand Mean (GM) = $\Sigma(\text{Treatment means}) \div \text{No. of treatments}$

2. F. calculated (F.C)

F.C = $\text{MSS} \div \text{Error MSS}$

3. F. tabulated (F.t)

F.t obtained from the Statistical F values at Probability ($P = 0.05$) i.e. at 95% confidence levels (Little and Hill, 1978).

4. Coefficient of Variation (C.V)

C.V = $[\sqrt{(\text{Error MSS}) \div \text{Grand Mean}}] \times 100$

5. Feed Conversion Ratio (FCR) = Feed Intake \div Change in Wt. Gain

APPENDIX C

