

**UTILIZATION OF CASSAVA ROOTS AFFLICTED BY CASSAVA BROWN
STREAK DISEASE IN BROILER RATIONS**

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ABSTRACT

Cassava roots afflicted with Cassava Brown Streak Disease (CBSD) were used in a study involving 600 Hubbard broiler chicks to evaluate its utility as a substitute for maize meal in broiler rations. The chicks were allocated to three dietary treatments each with 60 birds in a complete randomized design. The CBSD cassava roots were ranked in to three classes (CL1, CL2 and CL3) based on severity of roots necrosis. Three diets were formulated to maintain ME content at between 12-12.55MJ/kgDM and CP around 18-20% in which CBSD replaced maize at 25%, 50% and 75%. Average voluntary feed intake per bird for CL1 at 25,50 and 75% inclusions were respectively 130.31 ± 8.46 , 110.86 ± 3.32 , 108.76 ± 5.01 ; the corresponding intakes for CL 2 were 104.33 ± 2.20 , 105.10 ± 7.02 , 105.31 ± 4.42 ; and for CL3 were 90.06 ± 14.71 , 90.06 ± 14.71 , 103.10 ± 4.90 . At 50% and 75 % levels of inclusions intakes were significantly lower ($P < 0.05$) than that of the Control diet (128.23 ± 6.53) regardless of class of root damage. The Average Daily Gain (ADG) per bird for CL1 at 25, 50 and 75% inclusion were respectively 30.48 ± 1.84 , 27.57 ± 0.62 , and 27.35 ± 0.94 ; for CL2 were 25.75 ± 1.57 , 26.15 ± 2.58 , 24.98 ± 0.84 ; and for CL3 were 22.17 ± 2.11 , 23.11 ± 2.87 , 24.29 ± 1.84 . While for control diet is 30.62 ± 1.59 . Cooking losses in breast were 19.03 ± 1.77 , 16.95 ± 1.79 , 17.29 ± 1.48 respectively CL1, CL2 and CL3 at 25% level; 21.17 ± 1.74 , 17.02 ± 1.66 , 17.78 ± 1.81 ; for 50% level; 23.67 ± 1.46 , 19.10 ± 0.37 , 20.29 ± 1.27 for 75% and 19.53 ± 1.58 for the control. Roots damage had no effect on cooking loss. At 25% inclusion level feed cost were lower and the gross margin higher than for the Control diet while ADG gain were similar .It is concluded that CBSD afflicted cassava can be used to replace Maize meal up to 25% inclusion level.

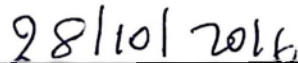
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I, **Mohamed Alfani Chando**, do hereby declare to the senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor concurrently submitted for a degree award in any other institution.



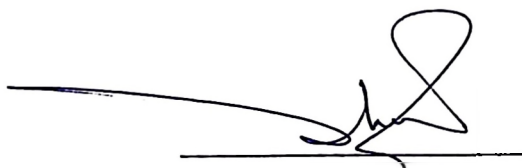
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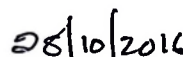
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TABLE OF CONTENTS

ABSTRACT.....	ii
DECLARATION	iii
COPYRIGHT.....	iv
ACKNOWLEDGEMENTS	v
DEDICATIONS	vi
TABLE OF CONTENTS	vii
LIST OF TABLES.....	xi
LIST OF PLATES	xii
LIST OF APPENDICES.....	xiii
LIST OF ABBREVIATIONS AND SYMBOLS.....	xiv
 CHAPTER ONE	 1
1.0 INTRODUCTION.....	1
1.1 Background Information.....	1
1.2 Problem Statement and Justification	2
1.3 Objectives	2
1.3.1 General objective	2
1.3.2 Specific objectives	3
 CHAPTER TWO	 4
2.0 LITERATURE REVIEW	4
2.1 Overview of the Poultry Industry in Tanzania	4
2.1.1 Magnitude of the poultry industry.....	4
2.1.2 Bottlenecks in the poultry industry	5

2.1.3	Factors affecting nutrient requirements of poultry.....	6
2.2	Cassava as an Optional Feed Source in Broiler Rations.....	8
2.2.1	Economic point of view of cassava in poultry diet	9
2.2.2	Limitations of using cassava in poultry diets	9
2.2.3	Effects of CBSD on economic losses and options for use in broiler rations	10
2.3	Growth Performance of Broilers	12
2.4	Carcass Evaluation of Chicken Meat.....	12
2.4.1	Meat tenderness.....	12
2.4.2	Factors affecting meat tenderness	12
2.5	Cooking Loss	14
2.5.1	Factors affecting cooking loss.....	14
2.5.1.1	Stage and time of cooking	14
2.5.1.2	Meat composition	14
2.5.1.3	Surface area	14
2.5.1.4	Cooking temperature	15
2.5.1.5	Method of cooking.....	15
2.6	Nutrients Composition of Chicken Meat.....	15
2.7	Comparison of Chicken with Other Species.....	16
2.8	Summary of the Review	16
CHAPTER THREE.....		18
3.0	MATERIALS AND METHODS.....	18
3.1	Study Area	18
3.2	Ration Preparation	18
3.2.1	Preparation of cassava meal	18

3.3	Management of Experimental Animals.....	22
3.4	Data Collection and Parameters Measured.....	22
3.4.1	Feed intake	22
3.4.2	Growth performances.....	23
3.4.3	Carcass components.....	23
3.4.4	Proximate analysis of the meat samples.....	24
3.4.5	Cost-benefit analysis	25
3.4.6	Statistical model and analysis	25
CHAPTER FOUR		26
4.0	RESULTS	26
4.1	Mortality Rate.....	26
4.2	Effect of Levels of Cassava Inclusion and Root damage on Voluntary Feed Intake.....	26
4.3	Effect of Levels of Cassava Inclusion and Root Damage on Growth Performance and Feed Utilization Efficiency	28
4.4	Effect of Level of Cassava Inclusion and Class of Root Damage on Carcass weight, Tissue Distribution and non-carcass Components	30
4.5	Effect of Dietary Treatments on Shear Force and Cooking Loss	34
4.6	Effect of Dietary Treatment on Chemical Composition of Broiler's Meat	34
4.7	Cost- Benefit Analysis	34
CHAPTER FIVE		38
5.0	DISCUSSION.....	38
5.1	Chemical Composition of Feed Ingredients used for Compounding Treatment Diets.....	38

5.2	Chemical Composition of the Experimental Diets	38
5.3	Health Status of the Experimental Birds	39
5.4	Effect of Levels of Cassava Inclusion and of Root damage on Voluntary Feed Intake	39
5.5	Effect of Levels of Cassava Inclusion and of Root damage on Growth Performance	40
5.6	Effect of Levels of Cassava Inclusion and of Root Damage on Carcass and Non Carcass Components	40
5.7	Effect of Levels of Cassava Inclusion and of Root damage on Meat Tenderness and Cooking Loss	41
5.8	Effect of Levels of Cassava Inclusion and of Root damage on Tissue Distribution	42
5.9	Effect of Levels of Cassava Inclusion and of Root Damage on Chemical composition of Broiler's Meat	42
5.10	Costs- Benefits Comparisons' of the Experimental Diets	42
 CHAPTER SIX		44
6.0	CONCLUSIONS AND RECOMMENDATIONS	44
6.1	Conclusions.....	44
6.2	Recommendations.....	44
 REFERENCES		45
APPENDICES.....		56

LIST OF TABLES

Table 2.1:	Nutrien requirements for broiler chickens	6
Table 2.2:	Nutrient composition of cassava chips and maize	8
Table 2.3:	Nutrient composition of poultry meat	16
Table 2.4:	Comparative nutritional composition of different meat.....	16
Table 3.1:	Nutritive values of the ingredients used for formulation of the experimentals diets	20
Table 3.2:	Chemical composition of the experimental diets	20
Table 3.3:	Percentage inclusion level of the ingredients on the experimental diets	21
Table 4.1:	Effect of levels of cassava inclusion and of root damage on voluntary feed intake g/bird/day	27
Table 4.2:	Effect of levels of cassava inclusion and root damage on initial, final wt, ADG and FCR	29
Table 4.3:	Effect of level of cassava inclusion and class of root damage on carcass weight, tissue distribution and non-carcass components	31
Table 4.4:	Effect of tissue distribution on breast, thigh and drumstick weight.....	32
Table 4.5:	Effect of treatment diets on carcass and non carcass components (%)	33
Table 4.6:	Means of shear force and cooking loss	35
Table 4.7:	Effect of dietary treatments on chemical composition of broiler's meat (Whole carcass)	36
Table 4.8:	Comparison of the costs of dietary treatments.....	37

LIST OF PLATES

Plate 1:	Ranking of cassava based on severity of root necrosis.....	19
Plate 2:	Grinding of the ingredients used for compounding experimental diets	19

LIST OF APPENDICES

Appendix 1:	Anova tables intake and body weight	56
Appendix 2:	Anova table carcass and tissue distribution	57
Appendix 3:	Anova table cooking loss and shear force.....	58
Appendix 4:	Anova table carcass composition	59

LIST OF ABBREVIATIONS AND SYMBOLS

ADG	Average Daily Gain
AOAC	Association of Official Agricultural Chemists
APOKA	Arusha Poultry Keepers Association
a.s.l	Above sea level
BRB	Breast Bone
BRF	Breast Fat
BRL	Breast Lean
CBSD	Cassava Brown Strike Disease
CF	Crude Fibre
CMD	Cassava Mosaic Disease
CRD	Complete Randomized Design
CTR	Control Diet Which Contain Maize 100%
DAARS	Department of Animal, Aquaculture and Range Sciences
DP	Dressing Percentage
DRB	Drumstick Bone
DRF	Drumstick Fat
DRL	Drumstick Lean
FAO	Food and Agricultural organization
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Ratio
HCN	Hydrocyanic acid
IBD	Infectious Bursal Disease
K	Potassium
KBS	Kenya Bureau of Standards

Kg	Kilogram
ME	Metabolizable energy
MLFD	Ministry of Livestock and Fisheries Development
ND	Newcastle Disease
NLP	National Livestock Policy
P	Phosphorous
SAS	Statistical Analysis Software
SUA	Sokoine University of Agriculture
TALIRI	Tanzania Livestock Research Institute
TBS	Tanzania Bureau of Standards
THB	Thigh Bone
THF	Thigh Fat
THL	Thigh Lean
Tshs	Tanzania Shilings
US\$	United State Dollar

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Poultry feed industry is faced with a number of challenges, not only the availability of feed ingredients, but also the ability to produce high quality products in a cost-effective manner (Chauynarong *et al.*, 2009). Cereal grains mainly corn are the conventional energy feeds in poultry rations which constitute over 50% of the diet for the different classes of poultry. The rapid growth of human population has intensified the competition between man and livestock for cereals, resulting to high cost of the cereal grains and consequently high prices of poultry products leading to low levels of per capita poultry meat and egg consumption in Tanzania. Thus there is a need to exploit alternative cheaper energy sources that can replace expensive cereals (corn and sorghum) for livestock production and to relieve the food-feed competition in the future. One such economical substitute feed for corn is cassava meal (Tesfaye *et al.*, 2013). Cassava (*Manihot esculenta*) is an annual tuber crop grown widely in the tropics and sub-tropics.

It can easily thrive in sandy-loam soil with low organic matter, receiving low rainfall (Wanapat *et al.*, 1997). But due to occurrence of diseases cassava is rapidly losing its role as a “food security crop”. In Tanzania about 10 to 30% of the cassava roots are discarded due to the effect of Cassava Brown Streak Diseases (Mohammed *et al.*, 2012). This disease is known to decrease the market value of the roots by 90%. (McSween *et al.*, 2006; Mohammed *et al.*, 2012). Afflicted roots would fetch less than 5 US \$ per ton compared to 55US \$ for fresh healthy roots (Mohammed *et al.*, 2012). It is estimated that African farmers collectively lose as much as 100 million US \$ annually due to CBSD

(Mohammed *et al.*, 2012). In East Africa the afflicted roots are usually discarded due to the effect of the disease leading to total loss to many farmers. Some roots may find a limited alternative use in making local brew, an activity that does not provide sustainable source of income to many farmers. Cassava as high energy root is widely used as energy source in formulating various livestock feeds. Several researches have been conducted in monogastric animals especially pigs and poultry which produced satisfactory outputs. In poultry cassava can completely replace maize as an energy source without causing health problems (Tewe and Egbunike, 1992).

1.2 Problem Statement and Justification

Cassava provides a frontline food security crop in many marginal areas of East Africa. When afflicted with CBSD many livelihoods are exposed to serious threat of hunger. It is imperative that ways are developed to eliminate the disease; and where possible, alternative uses for afflicted roots are developed. It is against this background that this study is put forward. This study proposes to utilize CBSD afflicted roots as source of energy in the formulation of broiler rations. It is expected that rations based on CBSD roots shall effectively replace those based on more expensive maize and other cereals. In this manner therefore, afflicted cassava roots shall still be able to generate income for the smallholder and minimize complete crop losses.

1.3 Objectives

1.3.1 General objective

To evaluate the potential use of cassava roots afflicted by CBSD on broiler production with the view to replace expensive cereals (maize) in feed formulations while helping farmers minimize losses from the CBSD.

1.3.2 Specific objectives

- i. To determine the effects of substitution of maize grain with CBSD-afflicted cassava roots on intake and growth performance of broiler chickens.
- ii. To determine the effects of various levels of inclusion of CBSD-afflicted cassava roots on carcass characteristics of broiler chickens.
- iii. To establish the economic optimum level of substitution of maize grain by CBSD-afflicted cassava roots.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of the Poultry Industry in Tanzania

The poultry industry in Tanzania has made minimal impact economically and nutritionally although chicken production on a commercial scale started in the 1960s'. The commercial sector which comprises of layers and broilers has performed poorly because of the expensive and poor quality commercial feeds, diseases, veterinary services, unreliable supply of day-old chicks and limited credit facilities (Msami, 2007). Recent statistics show that Tanzania has a population of 35.5, milioni indiginous poultry and 24.5 milion broilers and layers (MLFD, 2014). The per capita consumption of meat products in Tanzania is 12 kg of meat and 75 eggs which is far below the recommended standard of 50 kg of meat and 300 eggs set by FAO (MLFD, 2014).

2.1.1 Magnitude of the poultry industry

The Tanzanian poultry sector consists of traditional small-scale poultry production in the rural areas and commercial small to large scale poultry production in peri-urban and urban areas (Goromela, 2007). The traditional system is the largest, contributing over 70% of the flock, supplying most of the poultry meat and eggs consumed in rural areas and about 30% in urban areas (NLP, 2006). The indigenous poultry play a vital role in many poor rural households by providing an important source of high-quality nutrition and income at very low cost. Poultry are a renewable asset, important for insect pest control, for providing manure and for their role in social activities, religious ceremonies and the traditional treatment of illness (Buza and Mwamuhehe, 2001). Village flocks usually range from 10 to 30 birds per household and annual egg production ranges from 40 to 60 eggs per hen (Moges *et al.*, 2010).

The age at first lay for hens, ranges from six to eight months and on average, hen has three laying cycles per year. By estimate at least 5 chicks per clutch will survive to maturity, a household with a core breeding group of 5 hens will produce on average 25 chickens for sale or consumption per laying cycle (Buza and Mwamuhehe, 2001).

There are few companies in Tanzania which operates on large scale poultry production like APOKA (Arusha), Mkuza chicken (Kibaha), Ruvu JKT (Bagamoyo), Euro poultry (Mkuranga), Kenchick, Interchick and Twiga feeds and all are yet to satisfy the local market demand.

2.1.2 Bottlenecks in the poultry industry

Poor quality feed is a problem for commercial poultry farming in Tanzania especially for the chemical composition of the feeds. Msami (2007) reported that the quality of most feeds manufactured in Eastern and north-eastern Tanzania had lower quality than the feeding requirements of the chickens. Crude protein and metabolizable energy contents of the feeds were below the recommended levels and this contributed to the low performance of the chickens. Since feed cost is the prime input in commercial poultry production, efforts must be directed to minimize the costs without comprising the quality, thus cheap energy sources such as cassava can be used in broiler feed industry. Most unregistered feed producers do not usually carry chemical and nutritional analysis for their feed stuffs (Msami, 2007). Even among the registered feed companies, only a few occasionally send their samples for nutritional analysis to Sokoine University of Agriculture (SUA), Tanzania Bureau of Standards (TBS), Kenya (KBS) and to The Netherlands. However, most producers complain that the charges for feed analysis in Tanzania are too high and results take a long time to be processed (Msami, 2007).

Table 2.1: Nutrients requirements for broilers

Nutrients	Units	Starter	Grower	Finisher
		0-10 days	11-24 days	>25 days
Protein	%	22-25	21-23	19-21
Metabolisable energy	Mj/Kg	12.60	13.30	13.50
Total Arginine	%	1.48	1.31	1.11
Digestible Arginine	%	1.33	1.18	1.00
Total Lysine	%	1.44	1.25	1.05
Digestible Lysine	%	1.27	1.10	0.92
Total Methionine	%	0.51	0.45	0.39
Digestible Methionine	%	0.47	0.42	0.36
Total Methionine +Cystine	%	1.09	0.97	0.83
Digestible Methionine +Cystine	%	0.94	0.84	0.72
Total Threonine	%	0.93	0.82	0.71
Digestible Threonine	%	0.80	0.70	0.61
Total Tryptophan	%	0.25	0.22	0.19
Digestible Tryptophan	%	0.22	0.19	0.17
Total Valine	%	1.09	0.96	0.81
Digestible Valine	%	0.94	0.83	0.70
Calcium	%	1.0	0.90	0.85
Av.phosphorous	%	0.50	0.45	0.42
Sodium	%	0.16	0.16	0.16

Source: Filmer–Flockman, (2010)

2.1.3 Factors affecting nutrient requirements of poultry

The nutrient requirements of poultry (Table 2.1) are affected by a number of factors, including growth rates and production levels. Poultry will absorb and utilize nutrients from feed with different levels of efficiency. Therefore they will require feed with different nutrient compositions. The genetics of commercial poultry is constantly changing and hence their nutrient requirements.

Age

Nutrient requirements are related to both body weight and stages of maturity. Digestibilities of certain nutrients are very limited in young chicks. Stage of growth, for example; in broilers digestibility of protein and nitrogen retention decreases as the bird grew older (Fonolla *et al.*, 1981).

Sex

Prior to sexual maturity the sexes have only small differences in their nutrient requirements. Males and females can usually be fed similar diet to achieve acceptable growth rates. However differences in nutrient requirements are larger following the onset of sexual maturity thereafter different diet formulations are required for each sex (Filmer–Flockman, 2010).

Ambient Temperature

Poultry have increased energy requirements to maintain normal body temperature in cold ambient temperatures and the opposite in hot ambient temperatures. The maintenance requirement decreased with constant temperatures from 12 to 24°C, reach at minimum level at 24 to 28°C, followed by an increase as the temperature raised further (Hurwitz *et al.*, 1980). Food digestion processes produce body heat, called the heat increment of the diet. In cold temperatures it may be desirable to formulate a diet with a higher heat increment and the opposite in hot temperatures.

Housing System

The type of housing system will influence the level of activity of the birds and therefore their energy requirements. From the basic principles every metabolic weight of animal require 82kcal NE/kg^{0.73} and the activity is 50% of the basal metabolism thus increasing

activities means increasing Net Energy (NE) requirements (Katule, 2014 personal communication).

Production Aims

The optimal nutrient composition of the diet will vary according to production aims, such as optimizing weight gain or carcass composition, egg numbers or egg size. Poultry that are raised for breeding purposes may need to have their energy intake restricted to ensure that they do not become obese (Filmer–Flockman, 2010).

2.2 Cassava as an Optional Feed Source in Broiler Rations

The utilization of energy in cassava products by poultry has not been extensively studied, particularly under controlled environments (Bhuiyan, 2012). Cassava chips and pellets are two alternatives to cereal grains in cassava producing areas such as Asia and Africa. Both chips and pellets are not currently much used by the poultry industry in Tanzania, only 1% of cassava is used as animal feeds (Mtunda *et al.*, 2003), though their use may increase as the pressure on grain supplies intensifies especially maize which is competitive with human . Cassava also has an advantage in poultry nutrition due to its high metabolizable energy (ME) value ranging from 12.51 to 16.19MJ/kg (Tion and Adeka, 2000; Garcia and Dell 1999) compared to that of maize 13.95MJ/kg thus when used appropriately can replace maize in broiler rations (Table 2.2).

Table 2.2: Nutrient composition of cassava chips and maize

Feed stuff	DM%	ME mj/kg	CP%	EE%	CF%	Ash%	Ca%	P%
Cassava	88.00	12.51	2.50	0.40	3.70	4.10	0.20	0.09
Maize	89.00	13.95	9.40	4.3	1.7	1.2	0.02	0.32

Source: Garcia and Dale (1999)

DM = dry matter, ME = metabolizable energy, CP = crude protein, CF = Crude fibre, Ca = calcium, P = phosphorous

2.2.1 Economic point of view of cassava in poultry diet

Lekule *et al.* (2006) reported that studies conducted in Tanzania by Katambala (2001); Katakweba (2002) and in Nigeria by Tewe (1988) and in Latin America by Simith *et al.* (1992) suggested that cassava could replace 50 to 100% cereal based energy in animal rations without causing any health problems characterized by high production and economic earnings.

In poultry production feed cost accounts for 70 - 80% of the total poultry production cost (Durunna *et al.*, 1999), of which dietary energy sources occupy the greatest portion (70 - 75% of the diets (Hossain *et al.*, 2014). Aderemi *et al.* (2006) reported that feed cost per kg declined from 0.39 to 0.33 US \$ with increasing levels of cassava root meal in layers, therefore when cassava is used as source of energy maximum profit can be obtained.

2.2.2 Limitations of using cassava in poultry diets

High moisture level is one of the major reason for the spoilage of cassava products during storage and feeding, thus processing is necessary in order to utilize the product. Different physical processing methods have been tried for cassava, including sun - drying, boiling, mashing and pelleting to improve the nutritive value and reduce Cyanide content. In cassava both root and leaf products contain widely ranging levels of cyanogenetic glycosides namely *Linamarin* and *Lotaustralin*. Upon enzymatic hydrolysis during practical processing, hydrocyanic acid (HCN) is removed rendering the dried products safe feed for all classes of livestock including poultry. (Tewe and Egbunike, 1992). However, the residual glycosides in the products can still course some detrimental effects on the performance of cassava fed animals. It has been demonstrated that supplementation of methionine at 0.15 to 0.20% of diets could help to overcome the HCN toxicity and restore the performance of chicks fed on cassava based diets (Khajarearn and

Khajarearn, 1992). Fine grinding of less than 1mm can decrease the performance compared to coarse grinding, as fine grinding causes dust and can affect the respiratory tract of the birds hence reduces intake unless the feed is pelletized or some oil is added (Tewe and Egbunike, 1992). On the other hand, oil addition has a negative effect on storage quality since it results into rapid spoilage of feeds and feeds can stick on the mixing machine during compounding (Katule, 2014, personal communication). Cassava root products also have low level of protein, amino acids and all other nutrients and thus are mainly used as energy source.

In using cassava roots as cereal substitute approximately 15% to 20% extra protein source is needed (Khajarearn and Khajarearn, 1992). Therefore during feed formulation an appropriate protein source should be used and the limiting amino acid should be supplied to the rations. Results of studies to evaluate the replacement of cereals with cassava products in poultry feed showed wide variability due to differences in origin, variety, plant maturity at harvest, ecological conditions of plant growth and processing methods (Chauynarong *et al.*, 2009). However, variable responses on diets containing cassava products such as chips and pellets in broiler diets have been observed whereby the inclusion level can go up to 60% without adversely affecting growth performance (Ironkwe and Ukanwoko, 2012).

2.2.3 Effects of CBSD on economic losses and options for use in broiler rations

Tanzania is amongst the top ten largest cassava producers in the world and produces 5.5 million tons annually whereby 84% of the total production is consumed as human food, 15% as waste and 1% as livestock feeds (Mtunda *et al.*, 2003). Average yield in Tanzania has been fluctuating over the years (10 tons/ha in 1996; 7tons/ha in 2001) which is below 14 tons/ha potential yield of the crop (Mkamillo and Jeremiah, 2005). The low yield is

caused by many factors including major pests and diseases prevalent in the country. The most important diseases affecting cassava production in Tanzania are cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). Cassava brown streak disease is a viral disease which at first time was recorded to be endemic in all East Africa coastal cassava growing areas but restricted to low and medium altitude below 1000 m a.s.l (Pariyo *et al.*, 2015), but the disease is now occurring in areas that were believed to be unsuitable for the disease such as high altitude areas away from the Indian coastal belt in Kenya, Tanzania and Mozambique (Pariyo *et al.*, 2015). The earliest report of CBSD was reported from northern coastal areas of Tanzania in 1936 (Hillocks *et al.*, 2003). CBSD has become widespread in East Africa and constitutes the most severe threat to subsistence production of cassava. It causes an estimated yield loss of up to 70% by reducing the quantity and quality of the tuberous storage roots in sensitive cultivars (Mbanzibwa *et al.*, 2011).

The disease affects the tuberous roots which develop yellow/brown dry corky necrosis within the starch bearing tissues (Hillocks, 1997). Root necrosis accounts for both the quantitative and qualitative reduction in total yield through the presence of necrotic lesions or discolorations of the root, rendering them unpalatable and non marketable (Pariyo *et al.*, 2015).

In Tanzania Preliminary investigation showed an average yield loss of 34% due to CBSD (Mtunda *et al.*, 2003) and spread of the disease is through infected planting materials and the vector whitefly of two species, *Bemisia afer* and *Bemisia tabaci* (Legg and Raya, 1998; Maruthi *et al.*, 2005). However, there have been no corresponding studies whereupon the CBSD was shown to have a direct influence on the total nutritive value of cassava. Nevertheless, as necrotic tissue spread through the root, it may account for a

reduction in total recoverable starch, hence a lowering of the total caloric value of the root (Hillocks, 1997). Likewise, no studies have shown that consumption of CBSD afflicted roots has any effects on animals consuming the roots.

2.3 Growth Performance of Broilers

López *et al.* (2011), found that Male and female broilers slaughtered at 42 days of age were significantly different with respect to live body weight where, the males' broilers were heavier than females but had a lower dressing percentage when compared with females. The growth performance of animals can be assessed based on Feed conversion ratio (FCR) and feed conversion efficiency (FCE). FCR provides an indicator of management performance and the profitability at any feed cost. It measures how well a flock convert feed intake in to live weight, thus for profitability production efficiency conversion of feed into live weight is essential (Austic and Naishem, 1990). On the other hand the reciprocal of FCR is known as feed conversion efficiency (FCE) which plays the same role as that of FCR. For broiler chickens FCR ranges from 1.9 to 3.5 (Best, 2011).

2.4 Carcass Evaluation of Chicken Meat

2.4.1 Meat tenderness

Meat tenderness is among the organoleptic characteristics, which can be defined as how easy the meat can be chewed or cut and is considered as the most important by consumers (Wang *et al.*, 2009).

2.4.2 Factors affecting meat tenderness

The two most important quality attributes for poultry meat are appearance and texture. Appearance is critical for both the consumers' initial selection of the product as well as for final product satisfaction. Tenderness is affected by the maturity of the connective

tissues and by the contractile state of the myofibrillar proteins. But due to the modern industry of broiler production where birds are marketed at ages between 5 and 8 week, the issue of age-related, connective tissue toughness has eventually been eliminated (Fletcher, 2002). Incidence of toughness in broilers breast meat increases in parallel to a marked increase in the production of cut-up and deboned meat and more highly processed products thus slaughter plants are now required to cut up and debone as quickly as possible for economic and hygiene reasons (e.g. to avoid water loss from carcasses and to minimize microbiological risks associated with poultry meat). However, if the breast meat is removed from the carcass prior to the completion of rigor mortis, the muscle fibers will contract and shorten the muscle and the resulting meat will be less tender (Thielke *et al.*, 2005). Subsequent deep freezing of the fillets can increase adverse effects on meat quality due to the risk of cold shortening. Due to those, two approaches have now been developed to avoid these problems, accelerated processing based on electrical stimulation of the carcasses and the introduction of aging (Thielke *et al.*, 2005). Electrical stimulation systems in combination with high-current stunning 105 to 120 milliamps per bird have been established in several industrial plants in North America and Brazil but these systems are often associated with a higher incidence of other quality defects such as hemorrhages, broken bones, and reduced effectiveness of the defeathering and bleeding processes (Thielke *et al.*, 2005).

Aging is considered the most important way to assure sufficient tenderness in broiler breast meat (Fletcher, 2002), but there are significant differences in the minimum aging time proposed by various authors. Santos *et al.* (2004) reported that results for shear value showing complete tenderization being achieved between 4 and 8 hours, though samples with higher period of aging 8, 12 and 24 hours were preferred in sensorial analysis. Similar results were reported by other researchers who used aging periods of up

to 24 hours under temperatures between 0 and 5°C. Dransfield (1994) and Varnam and Sutherland (1995) have found a minimum aging time of up to 48 hours to be necessary.

2.5 Cooking Loss

The total loss that occurs during cooking of the meat includes losses known as drippings and the volatile losses. Greater part of the volatile loss originates from evaporation of water and volatile substances from the decomposition of fat and volatile aromatic substances. The drippings include fat, water, salts and both nitrogenous and non-nitrogenous extractives.

2.5.1 Factors affecting cooking loss

2.5.1.1 Stage and time of cooking

Meat well cooked gives much total loss than meat rare cooked and for a meat to be cooked well a longer time is necessary. Thus length of time of cooking and the stage to which the meat is cooked are two related factors (Combes *et al.*, 2004).

2.5.1.2 Meat composition

Meat containing a high percentage of fat cooked under standardized conditions gives greater cooking losses than lean meat. The amount of drippings is always greater for the fat meat than for similar lean cuts from the same kind of animal (Palka and Daun, 1999; Combes *et al.*, 2004).

2.5.1.3 Surface area

The shape and surface area of the meat also influence the loss that occurs during cooking, the greater the surface area of the meat, the greater the area at which losses may occur.

Compact pieces of meat with correspondingly small surface areas give smaller losses than irregular shaped pieces with greater surface areas (Barbanti and Pasquini, 2005).

2.5.1.4 Cooking temperature

The cooking temperature is in many instances the principal factor in determining the percentage of weight that is lost during cooking. Cooking losses is greater for halves of chicken roasted at 125°C than for the corresponding halves roasted at 175°C. Generally the higher the cooking temperature the greater the cooking losses and the lower the cooking temperature the smaller the cooking losses (Palka and Daun, 1999; Combes *et al.*, 2004; Barbanti and Pasquini, 2005).

2.5.1.5 Method of cooking

The method of cooking of meat may also influence the cooking loss. A broiled steak may have a far greater total loss than a pan-broiled one (Palka and Daun, 1999; Combes *et al.*, 2004).

2.6 Nutrients Composition of Chicken Meat

Nutritional value of meat can be assessed on the basis of parameters such as content and composition of proteins, amino acids, fat and also from the content of saccharides, mineral substances and vitamins. The most important mineral substances in poultry meat are potassium (0.4%), phosphorus (0.2%) and sodium (0.09%). The main quality features of poultry meat are chemical composition and the ratio of muscles to fat in carcass (Suchý *et al.*, 2002).

It is generally accepted, that feeding and management of meat-type poultry have a great impact on poultry meat quality, both in terms of the nutritional value and potential risks to

human health, whereby the greatest risk comes from microbial contamination which causes major illness and death worldwide. Appearance of carcasses must meet the consumer's expectations; looking clean, fresh and well shaped. Nutrient composition was originally the deciding factor for consumers when choosing poultry meat due to its favorable content of protein, profile of amino acids and fatty acids, low fat content and undesirable components such as purines and cholesterol (Grashorn, 2005).

Table 2.3: Nutrient composition of poultry meat

Nutrient	Calories	Fat (g)	Saturated Fat (g)	Protein (g)	Cholesterol (mg)	Iron (mg)
chicken	162	6.3	1.7	25	76.0	1.5

Source: www.HeartlandGoatAssociation.com

2.7 Comparison of Chicken with Other Species

Table 2.4: Comparative nutritional composition of different meats

	Rabbit	Chicken	Beef	Pork
Moisture (g/100 g)	68.5 ± 1.05	68.1 ± 1.19	53.2 ± 1.21	43.7 ± 2.13
Protein (g/100 g)	21.2 ± 0.79	20.1 ± 0.27	26.3 ± 0.16	27.3 ± 0.22
Fat (g/100 g)	9.2 ± 0.38	10.8 ± 0.08	19.6 ± 0.09	28.2 ± 0.13
Ash (g/100 g)	1.1 ± 0.08	1.0 ± 0.05	0.9 ± 0.07	0.8 ± 0.11
Calcium (mg/100 g)	21.4 ± 0.09	12.1 ± 0.04	10.9 ± 0.38	9.3 ± 0.47
Phosphorus (mg/100 g)	347 ± 0.26	252 ± 0.06	179 ± 3.62	176.4 ± 3.36
Sodium (mg/100 g)	40.5 ± 0.89	71.4 ± 0.92	63 ± 0.90	67.3 ± 0.91

Source: Nistor *et al.* (2013)

2.8 Summary of the Review

The use of cassava in poultry diet is well documented as a good substitute to maize as source of energy inspite of some reported limitations like HCN, difficult in processing and high moistures content. But due to technology development these limitations can be

overcome and render cassava to be an essential source of energy to livestock including poultry and pigs. Cassava grown in many parts of East Africa has been shown to suffer from CSBD as a serious contagious disease transmitted by two species of whitefly *Bemisia afer* and *Bemisia tabaci* (Legg and Raya, 1998; Maruthi *et al.*, 2005).

The CSBD affects mainly the roots, rendering them unsuitable for human consumption. However, with increasing competition for maize as energy source, it is prudent to think of possible use of afflicted cassava roots as an alternative, hence the need for this study. The literature is short of any indications where in CSBD afflicted cassava has been used for poultry diets. This pioneering study should open avenues for using afflicted roots which otherwise would become waste material.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

This study was conducted at Misenani Agri-Services Ltd in Ilemela district in Mwanza region. It is bordered to the north by the Nyamagana district, to the east by Magu district, to the east and south by Misungwi district and to the west by the Mwanza Gulf of Lake Victoria. Part of the region's capital, the town of Mwanza, is within Ilemela District. Ilemela has an estimated population of 265 911 habitants. Ilemela stands at around 1261 m a.s.l lying between latitude 1° 30' and 3° 0'S and 31° 45'- 34° 10' E. Ilemela enjoys warm temperatures ranging from 25.7°C to 30.2°C in hot season and 15.4°C to 18.6°C in cooler months. Rainfall ranges between 750 and 1200 mm per year falling in two fairly distinct seasons, between the months of October to December and between February to May. Types of livestock available in the district include Goats, sheep, cows, pigs, chickens of indigenous breed, commercial broilers and layers and donkeys.

3.2 Ration Preparation

3.2.1 Preparation of cassava meal

Cassava used in this study was obtained from Agricultural Research Institute Naliendele Mtwara. The roots were ranked into classes of 1 to 5 (plate 1) based on increasing severity of root necrosis as described by McSween *et al.* (2006). Based on CBSD root symptom severity Assessment chart class 5 roots were judged as completely unsuitable for human consumption. However, for the purpose of this study only classes 1 to 3 were used. This was due to difficulties in finding sufficient feeding materials of class 4 and 5. The unpeeled afflicted cassava roots were chipped and sun dried for three days and then coarsely ground to pass through 10 mm sieve to produce cassava meal (plate 2).

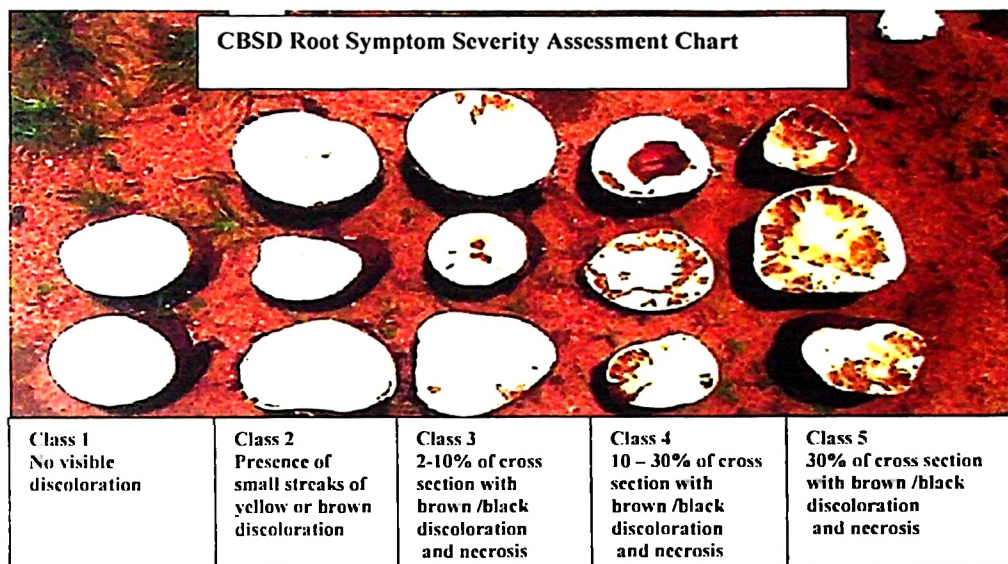


Plate 1: Ranking of cassava basses on severity of root necrosis

Source: McSween *et al.*, 2006



Plate 2: Grinding of the ingredient used for compounding experimental diets

The meal was then analyzed for its nutritive value. Alongside similar analyses were done on other ingredients used for compounding the experimental rations. Tables 3.1 and 3.2 gives summary of the chemical composition of the ingredients used in compounding the

experimental rations and the calculated nutritive value of the compounded rations and Table 3.3 gives the percentage inclusion levels of the ingredients used in formulation of the experimental rations.

Table 3.1: Nutritive values of the ingredient used for diets formulation

S/No	Ingredient	CP%	ME(mj/kg)	EE%	CF%	DM%	ASH%
1	Maize meal	9.65	15.30	1.57	3.08	93.90	1.24
2	Maize bran	12.17	14.50	4.57	5.88	94.10	4.05
3	Cassava I	3.09	15.04	1.36	3.27	88.10	2.84
4	Cassava II	2.98	14.91	1.57	3.25	85.20	3.58
5	Cassava III	3.09	14.76	1.26	3.80	89.60	3.30
6	Soy cake	37.87	13.84	10.44	12.06	94.40	5.84
7	S/flower cake	26.73	6.94	11.56	33.78	97.00	6.25
8	Fish/(uduvi)	32.91	7.66	8.66	2.55	95.60	59.48

CP = Crude protein, ME = Metabolizable energy, EE = Ether extract, CF = Crude fibre, DM = Dry matter

Table 3.2: Chemical composition of the experimental diets

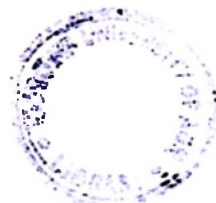
Diet	DM%	EE%	CP%	CF%	AS%	NFE%	ME(mj/kg)
25%CL1	92.48	7.19	18.20	8.31	14.17	45.76	11.65
50%CL1	92.32	6.00	18.05	6.18	12.25	51.02	12.41
75%CL1	92.32	5.45	20.32	6.77	13.06	48.07	12.08
25%CL2	90.75	7.16	19.87	7.78	7.98	49.33	12.59
50%CL2	92.43	6.13	19.85	7.29	9.51	50.88	12.58
75%CL2	92.35	6.01	21.53	7.58	8.48	50.10	12.68
25%CL3	91.90	6.32	17.91	5.16	9.75	53.98	13.11
50%CL3	87.57	6.38	19.92	6.22	9.03	47.32	12.27
75%CL3	92.79	5.87	19.84	5.94	13.86	48.54	12.33
CTR	90.29	7.12	18.99	6.57	11.69	47.08	12.25

CTR = control 100% maize, DM = dry matter, EE = ether extract, CP = crude protein, NFE = nitrogen free extract, ME = metabolizable energy, 25%CL1= Cassava Class One and Level One of Inclusion 25%, 25%CL2 = Cassava Class Two and Level One of Inclusion 25%, 25%CL3 = Cassava Class Three and Level One of Inclusion 25%, 50%CL1= Cassava Class One and Level 2 of Inclusion 50%, 50%CL2 = Cassava Class Two and Level Two of Inclusion 50%, 50%CL3 = Cassava Class Three and Level Two of Inclusion 50%, 75%CL1= Cassava Class One and Level Three of Inclusion 75%, 75%CL2 = Cassava Class Two and Level Three of Inclusion 75%, 75%CL3 = Cassava Class Three and Level Three of Inclusion 75%

Table 3.3: Percentage inclusion levels of the ingredients on the experimental diets

S/No	INGREDIENTS	Percentage inclusion (as fed)									
		CTR	25%CL1	50%CL1	75%CL1	25%CL2	50%CL2	75%CL2	25%CL3	50%CL3	75%CL3
1	Maize meal	48.20	36.15	24.10	12.05	36.15	24.10	12.05	36.15	24.10	12.05
2	Maize bran	12.00	8.20	8.20	5.20	9.00	7.20	3.00	11.20	7.00	5.00
3	Cassava chips	0.00	12.05	24.10	36.15	12.05	24.10	36.15	12.05	24.10	36.15
4	Soy cake	17.00	17.00	22.00	23.00	21.00	21.00	27.20	19.00	25.00	25.20
5	Sunflower cake	11.00	15.00	10.00	9.00	14.00	13.00	15.00	9.00	10.20	9.00
6	Fish	9.00	9.00	9.00	12.00	5.00	8.00	4.00	10.00	7.00	10.00
7	Limestone	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
8	Premix(Broilers)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
9	Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Calculated CP%		18.99	18.20	18.04	20.31	19.86	19.84	21.52	17.91	19.92	19.84
Energy ME _{inj} /kgDM		12.25	11.65	12.41	12.08	12.59	12.58	12.68	13.11	12.27	12.33

CTR=control 100% maize, 25%CL1= Cassava Class One and Level One of Inclusion 25%,25%CL2=Cassava Class Two and Level One of Inclusion 25%, 25%CL3=Cassava Class Three and Level One of Inclusion 25%,50%CL1=Cassava Class One and Level 2 of Inclusion 50%,50%CL2=Cassava Class Two and Level Two of Inclusion 50%,50%CL3 = Cassava Class Three and Level Two of Inclusion 50%,75%CL1=Cassava Class One and Level Three of Inclusion 75%, 75%CL2= Cassava Class Two and Level Three of Inclusion 75%,75%CL3= Cassava Class Three and Level Three of Inclusion 75%



3.3 Management of Experimental Animals

A total of 600 day old broiler chicks of Hubbard breed were obtained at Misenani and reared at Misenani Agri-services Ltd, at Illemela district. The chicks were brooded for two weeks, receiving *ad-lib* quantities of standard starter feed based on maize grain, purchased from Misenani Agri- Services which contain 23%CP and metabolizable energy of 13.40MJ/kgDM.

The birds were also vaccinated against Newcastle Disease (ND) and Infectious Bursal Disease (IBD) at the age of 7 and 14 days and repeated at 21 and 28 days respectively. Thereafter, the chicks were allocated in ten dietary treatments formulated (Table 3.3) under complete randomized design. Each treatment had 60 chicks replicated in 3 groups of 20 chicks each. The 20 chicks from each replicate were further divided into smaller groups of 5 chicks where they were reared in cages. The chicks were reared for a further period of 6 weeks to complete a holding time of 8 weeks from day old chicks. Clean water and experimental feed were provided *ad-libitum* every morning throughout the experimental period.

3.4 Data Collection and Parameters Measured

3.4.1 Feed intake

Chicks received *ad-libitum* amount of feed placed into feeders daily and the remaining feed weighed on the next day at 1:00 pm using a digital weigh scale to get the refusals. The arithmetic difference between offered and refused feeds gave estimates of intake for the group. Individual intake was then estimated by means of dividing the group intake by number of birds in the group i.e.

$$\text{Intake} = \frac{\text{Feed offered} - \text{refusal}}{\text{Number of birds}} \dots\dots\dots (1)$$

3.4.2 Growth performances

Chicks' initial weight for every group was taken on arrival day before they were introduced to the brooders and experimental cages. Thereafter live body weight was measured weekly for a group 20 birds from each replicate and treatment throughout the experimental period of six weeks. The growth performance was expressed in terms of Feed Conversion Ratio by the formula;

$$\text{FCR} = \frac{\text{Feed intake}}{\text{Weight gain}} \dots\dots\dots (2)$$

3.4.3 Carcass components

After eight weeks, two broiler chickens were selected randomly from each replicate for slaughter then scalded at 70°C followed by plucking. The feet were carefully cut off at the tibia femur joint and the abdomen incised at mid ventral using a sharp knife and the gastro intestinal tract was removed (eviscerated). Edible organs (liver, heart and gizzard) were separated from gut then weighed and recorded as weight of giblet expressed as percentage of live weight by using the following formula:

$$\text{Giblet\%} = \frac{\text{Weight of component}}{\text{Live weight}} \times 100 \dots\dots\dots (3)$$

The contents from the gizzard were removed before weighing. Then after removal of all internal organs, the carcass weight was measured using a digital weighing scale. Tissue distribution i.e. fat, muscles and bones were separated from the carcass and weighed by using digital weighing scale and their weight expressed as a percentage by the following formula:

$$\text{Tissue \%} = \frac{\text{Weight of component}}{\text{Weight of carcass}} \times 100 \dots\dots\dots(4)$$

$$\text{Dressing out percentage was calculated as Dressing \%} = \frac{\text{Carcass Weight}}{\text{Live weight}} \times 100 \dots(5)$$

Meat samples from thigh, breast and drumstick muscles were then taken from each bird for chemical analysis and tenderness test. Meat samples for determination of tenderness were preserved in deep freezer at -20°C for 48hrs then weighed and refrigerated for overnight at 4°C. After refrigeration the meat samples were reweighed and vacuum packed. Thereafter, meat was cooked in the water bath at 70°C for 45 minutes, cooled for 2hrs and then refrigerated again for 12 hours. After refrigeration the samples were weighed.

Cooking losses were calculated as the arithmetic difference before cooking and after cooking of the meat expressed in percentage. Thereafter the meat were sliced into 1cm cube thickness by using a sharp knife and then placed in the Warner Blade Sheer force machine for determination of tenderness.

3.4.4 Proximate analysis of the meat samples

Proximate analysis was done after the meat samples were deboned and minced. Determination of Protein, Ether Extract, Dry matter, Ash and Minerals were done according to the standard procedures of AOAC (2005). Nitrogen free extract and metabolizable energy were calculated from the proximate data by using the formulas, $\text{NFE} = 100 - (\text{Moisture \%} + \text{CP \%} + \text{EE \%} + \text{CF \%} + \text{Ash \%})$ and $\text{ME} = ((0.018 \times \text{CP}) + (0.032 \times \text{EE}) + (0.016 \times \text{NFE}) + (0.015 \times \text{CF})) \times 10$ respectively..... (6)

3.4.5 Cost-benefit analysis

Total values of feed intake, carcass yield and edible offal for each treatment were used to estimate feed costs and revenues from experimental chickens. The weights of feed consumed were recorded from which the costs of feed were calculated. Thus total feeds and other production costs were calculated to estimate the economic benefits of the rations.

3.4.6 Statistical model and analysis

The data were analyzed by using SAS (2000) and significant differences between treatment means were determined at 5% level of significance. The model for comparisons of treatment effects was:

$$Y_{ijk} = \mu + C_i + T_j + (T \times C)_{jk} + e_{ijk} \dots\dots\dots (7)$$

Where Y_{ijk} = response variable (weight changes and carcass characteristics)

μ = General mean effect

T_j = Effect due to the i^{th} level of substitution of maize by CBSD cassava root ($i = 1, 2, 3$)

C_i = effect of class within the i^{th} treatment (1, 2, 3)

$(T \times C)_{jk}$ = effect of interaction between damage class and level of cassava inclusion

e_{ijk} = Random error.

CHAPTER FOUR

4.0 RESULTS

4.1 Mortality Rate

Most experimental animals survived throughout the experimental period without suffering from major ailments. Mortality rates of the birds before allocation to the treatment diets was 6.2% and that after allocation to treatment diets was reduced to 2.3% which suggests that survival and health status of the birds was not affected by addition of CBSD afflicted cassava roots on the diets for the broiler chickens.

4.2 Effect of Levels of Cassava Inclusion and Root damage on Voluntary Feed

Intake

Table 4.1 presents effect of levels of cassava inclusion and root damage on VFI. Generally there was a trend of increase in feed intake with age in all dietary treatments. The highest intake was observed on the control diet followed by diets with 25% level of cassava inclusion irrespective class of root damage. The lowest intake was observed in diets with 75% level of cassava inclusion. The effects of level of root damage had no significant ($P > 0.05$) influence on intake; showing inconsistent trend at all levels of cassava inclusion.

Table 4.1: Effect of levels of cassava inclusion and of root damage on voluntary feed intake g/bird/day

	Level of Cassava inclusion											
	25%				50%				75%			
	Class of Damage			1	Class of Damage			1	Class of Damage			Pr > F
	1	2	3		1	2	3		1	2	3	
WK 3	71.71±5.43 ^a	69.56±4.73 ^a	58.99±2.38 ^a	48.12±11.50 ^a	48.12±11.50 ^a	63.25±5.06 ^b	63.25±5.06 ^b	51.89±2.45 ^c	49.27±4.38 ^c	50.47±18.82 ^c	75.79±8.88 ^c	0.0025
WK 4	89.51±1.95 ^a	83.26±1.76 ^b	77.95±2.94 ^b	84.55±5.08 ^b	84.55±5.08 ^b	81.78±6.75 ^b	80.43±2.21 ^b	80.15±6.01 ^b	74.45±0.68 ^c	78.45±7.34 ^b	86.36±4.26 ^a	0.0226
WK 5	141.55±12.57 ^a	121.24±6.27 ^b	109.54±5.97 ^c	101.62±17.34 ^d	101.62±17.34 ^d	123.91±14.70 ^b	115.11±26.94 ^c	94.70±18.56 ^d	89.57±10.61 ^d	115.02±41.38 ^b	116.14±6.78 ^b	0.1213
WK 6	154.57±7.21 ^a	151.02±2.91 ^a	128.92±13.88 ^b	142.86±8.09 ^b	142.86±8.09 ^b	137.70±15.56 ^b	133.99±5.75 ^c	122.06±13.82 ^c	124.32±12.90 ^c	116.08±12.40 ^d	163.35±7.550 ^a	0.0004
WK 7	153.22±17.14 ^a	141.80±15.47 ^b	126.64±9.55 ^c	126.12±9.83 ^b	126.12±9.83 ^b	140.19±10.13 ^b	155.30±15.44 ^a	133.52±13.80 ^c	101.28±52.28 ^d	119.61±5.93 ^d	148.98±22.73 ^a	0.1181
WK 8	171.32±23.73 ^a	98.30±10.72 ^d	150.51±6.27 ^b	122.72±16.07 ^c	122.72±16.07 ^c	83.78±10.69 ^d	92.57±5.92 ^d	88.17±3.62 ^d	101.49±17.39 ^d	138.96±8.07 ^a	178.76±5.98 ^a	<.0001
AVFI	130.31±8.46 ^a	110.86±3.32 ^b	108.76±5.01 ^b	104.33±2.20 ^c	104.33±2.20 ^c	105.10±7.02 ^c	105.31±4.42 ^c	90.06±14.71 ^d	90.06±14.71 ^d	103.10±4.90 ^c	128.23±6.53 ^a	0.001

WK= Voluntary feed intake per bird per day from week 3 to week 8, AVFI = Average voluntary feed intake a-d, Means bearing different letters within the row differs significantly at P<0.05

4.3 Effect of Levels of Cassava Inclusion and Root Damage on Growth

Performance and Feed Utilization Efficiency

Table 4.2 shows the effect of levels of cassava inclusion and root damage on initial weight, final weight, average daily gain and feed utilization efficiency. The results show that there was a significant difference in growth performance of the chickens among the dietary treatments. Average daily gain (ADG) was significantly higher ($P < 0.05$) in birds on control diet and those on diets containing 25% CBSD than those on diets containing 50% and 75% CBSD. The Class of Cassava damage did not significantly ($P > 0.05$) affect growth performance of the chickens. Chickens on control diet and those on 25% cassava inclusion had significantly higher final weight than chickens on 50% and 75% levels of cassava inclusion. Feed conversion ratio (FCR) was similar in all classes of root damage and at all levels of cassava inclusion.

Table 4.2: Effect of levels of cassava inclusion and root damage on initial, final wt, ADG and FCR

Parameters	Level of Cassava inclusion											
	25%						50%					
	Class of Damage			Class of Damage			Class of Damage			Class of Damage		
	1	2	3	1	2	3	1	2	3	1	2	3
Initial wt (g)	290±0.00 ^a	290±0.01 ^a	260±0.01 ^b	270±0.02 ^b	270±0.02 ^b	250±0.02 ^c	250±0.3 ^c	250±0.01 ^c	250±0.03 ^c	290±0.02 ^a	290±0.02 ^a	0.0201
Wk8	920±0.03 ^a	920±0.01 ^a	830±0.02 ^b	830±0.03 ^b	850±0.06 ^b	810±0.04 ^c	730±0.07 ^d	740±0.04 ^d	760±0.05 ^d	900±0.03 ^a	900±0.03 ^a	<.0001
Final wt (g)	1450±0.01 ^a	1320±0.03 ^b	1310±0.04 ^b	1250±0.06 ^c	1250±0.11 ^c	1210±0.04 ^c	1090±0.10 ^d	1130±0.11 ^d	1180±0.05 ^c	1450±0.07 ^a	1450±0.07 ^a	<.0001
ADG (g/d)	30.48±1.84 ^a	27.57±0.62 ^b	27.35±0.94 ^b	25.75±1.57 ^c	26.15±2.58 ^b	24.98±0.84 ^c	22.17±2.11 ^d	23.11±2.87 ^d	24.29±1.84 ^c	30.62±1.59 ^a	30.62±1.59 ^a	<.0001
FCR	4.27±0.02 ^a	4.02±0.05 ^a	3.97±0.06 ^a	4.06±0.16 ^a	4.03±0.13 ^a	4.21±0.05 ^a	4.29±0.04 ^a	3.88±0.17 ^b	4.24±0.01 ^a	4.19±0.01 ^a	4.19±0.01 ^a	<.0001

WK8 = weekly weight week 8, ADG = Average Daily Gain, FCR = Feed Conversion Ratio a-d. Means bearing different letters within the row differs significantly at

P<0.05

4.4 Effect of Level of Cassava Inclusion and Class of Root Damage on Carcass weight, Tissue Distribution and non-carcass Components

The final carcass weight, dressing percentages and weight of carcass components are shown in Table 4.3. Carcasses from birds on a control diet were significantly heavier than all other carcasses in the test diets ($P<0.05$) whereas those on 75% cassava inclusion were significantly lower than other treatments. A similar trend was observed for all carcass components i.e. thigh, breast and drumstick. The class of root damage had no significant effect on carcass weight, dressing percentage and weights of all carcass components.

Table 4.4 shows the tissue distribution in the main carcass components. Breast lean was highest in birds on control diets and lowest in those birds on 75% inclusion level ($P<0.05$). At 25 and 50% inclusion, the breast weight of lean were similar and both were significantly higher than those observed in birds on 75% .Weight of breast fat in control diet was significantly lower ($P<0.05$) than in both 25 and 50% but was similar to the BF in birds on 75%. Only the Thigh fat tissue was significantly ($P<0.05$) higher for birds on control diet compared to those on other treatments. Similar observations were observed on fat tissue distribution on the drum stick. Table 4.5 shows the weight recorded on non-carcass components. Diets had no significance effect on the weight of non-carcass components.

Table 4.3: Effect of level of cassava inclusion and class of root damage on carcass weight, tissue distribution and non-carcass components

Parameter	Level of Cassava inclusion										Pr > F
	25%			50%			75%				
	Class of Damage			Class of Damage			Class of Damage				
	1	2	3	1	2	3	1	2	3	Control	
Slaughter wt (g)	1726.67±145	1665.00±210	1561.67±281	1476.67±182	1521.67±226	1498.33±127	1340.00±268	1356.67±248	1433.33±168	1871.67±189	0.0010
	28 ^a	40 ^a	81 ^b	28 ^b	49 ^b	50 ^b	48 ^c	97 ^a	25 ^b	89 ^a	
Carcass wt (g)	1073.33±167	1143.33±174	1080.00±211	1031.67±138	1046.67±171	1026.67±100	925.00±196	923.33±184	1001.67±108	1311.67±161	0.0080
Dressing %	62.54±1.57 ^b	68.50±2.43 ^a	69.23±5.20 ^a	69.81±1.37 ^a	68.94±6.63 ^a	68.50±2.55 ^a	68.91±1.18 ^a	67.95±2.85 ^a	70.04±4.34 ^a	69.96±1.87 ^a	0.3677
BRwt g	145.59±22.36 ^a	154.19±37.86 ^a	150.48±9.03 ^a	143.35±34.36 ^a	155.6±40.26 ^a	140.75±32.49 ^a	115.60±31.61 ^b	124.06±38.34 ^b	138.42±29.98 ^b	177.16±33.64 ^a	0.4892
DRSwt g	71.37±5.47 ^a	75.15±12.84 ^a	73.87±15.36 ^a	73.96±13.87 ^a	76.10±14.88 ^a	81.98±6.87 ^b	67.37±17.80 ^a	62.17±16.45 ^a	69.76±9.98 ^a	89.22±2.39 ^b	0.1051
THwt g	81.11±8.78 ^a	91.18±14.18 ^a	89.06±22.11 ^a	81.62±12.79 ^a	87.79±17.29 ^a	88.33±10.04 ^a	68.30±21.22 ^b	68.34±20.32 ^b	75.19±7.29 ^b	95.14±6.69	0.1005

Table 4.4: Effect of tissues distribution on breast, thigh and drumstick weight

Parameter	Level of Cassava inclusion												Pr > F	
	25%						50%							
	Class of Damage			Class of Damage			Class of Damage			Class of Damage				
	1	2	3	1	2	3	1	2	3	1	2	3		control
BRF (g)	13.01±6.53 ^a	14.74±8.40 ^a	19.26±3.82 ^a	14.33±12.32 ^a	16.67±3.83 ^a	-	-	-	-	10.01±8.69 ^a	10.43±5.99 ^a	10.43±5.99 ^a	11.87±7.11 ^a	0.1924
BRL (g)	1115.60±20.19 ^b	120.23±29.17 ^a	113.51±11.68 ^b	106.80±21.51 ^a	120.81±30.76 ^b	120.98±26.28 ^a	94.86±26.13 ^d	98.71±27.29 ^d	109.83±23.62 ^a	109.83±23.62 ^a	143.81±27.31 ^a	109.83±23.62 ^a	143.81±27.31 ^a	0.4191
BRB (g)	16.98±4.56 ^b	19.22±3.66 ^a	17.71±3.87 ^b	22.22±4.40 ^a	18.38±11.37 ^a	14.16±1.04 ^a	16.56±3.57 ^b	15.34±6.53 ^a	18.16±5.58 ^b	18.16±5.58 ^b	21.48±3.48 ^a	18.16±5.58 ^b	21.48±3.48 ^a	0.5846
THF (g)	3.85±1.97 ^b	-	4.57±1.24 ^a	2.32±2.95 ^a	2.24±2.59 ^a	3.50±3.00 ^b	1.95±2.58 ^d	2.98±3.44 ^b	3.12±1.11 ^b	3.12±1.11 ^b	4.91±3.22 ^b	3.12±1.11 ^b	4.91±3.22 ^b	0.0394
THL (g)	62.38±6.88 ^b	68.90±11.67 ^a	68.69±17.58 ^a	63.96±8.19 ^b	68.24±13.09 ^a	68.88±5.87 ^a	52.39±16.80 ^a	52.26±14.73 ^a	58.91±7.87 ^a	58.91±7.87 ^a	76.41±4.46 ^a	58.91±7.87 ^a	76.41±4.46 ^a	0.0627
THB (g)	14.88±1.40 ^a	13.28±2.36 ^b	15.81±3.66 ^a	15.35±3.18 ^a	17.31 ±2.81 ^a	15.96±1.36 ^a	13.96±3.23 ^a	13.10±2.71 ^a	13.17±0.31 ^a	13.17±0.31 ^a	14.02±1.65 ^b	13.17±0.31 ^a	14.02±1.65 ^b	0.1048
DRF (g)	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.00±0.00 ^b	0.67±1.38 ^a	0.00±0.00 ^b	0.67±1.38 ^a	0.4662
DRL (g)	50.28±3.92 ^b	57.18±9.74 ^a	51.87±10.59 ^b	54.75±11.46 ^b	52.89±9.27 ^b	58.66±5.52 ^a	46.93±12.50 ^d	42.89±13.44 ^d	51.44±9.05 ^a	51.44±9.05 ^a	67.22±2.63 ^a	51.44±9.05 ^a	67.22±2.63 ^a	0.0464
DRB (g)	21.09±2.22 ^a	17.97±3.25 ^b	21.99±4.91 ^a	19.21±4.05 ^b	24.11±5.63 ^a	23.32±2.39 ^a	20.45±5.34 ^a	19.28±3.08 ^b	18.32±1.07 ^b	18.32±1.07 ^b	21.31±3.29 ^a	18.32±1.07 ^b	21.31±3.29 ^a	0.1141

BRF = Breast fat, BRL = Breast Lean, BRB = Breast bone, THF = Thigh fat, THL = Thigh lean, THB = Thigh bone, DRF = Drumstick fat, DRL = Drumstick Lean,

DRB = Drumstick Bone, a - d Means bearing different letters within the row differs significantly at (P<0.05)

Table 4.5: Effect of treatment diets on carcass and non carcass components (%)

Parameter	Inclusion level											
	25%			50%			75%					
	Class of Damage			Class of Damage			Class of Damage					
	1	2	3	1	2	3	1	2	3	Control	Pr>F	
HWT%	0.01±0.00	0.01±0.01	0.01±0.00	0.01±0.00	0.01±0.01	0.01±0.01	0.01±0.01	0.01±0.00	0.01±0.00	0.01±0.00	0.3677	
GWT%	0.02±0.01	0.03±0.01	0.02±0.01	0.02±0.00	0.03±0.00	0.02±0.01	0.03±0.01	0.03±0.01	0.03±0.01	0.02±0.01	0.7252	
LvWT%	0.02±0.01	0.03±0.01	0.03±0.01	0.03±0.00	0.03±0.01	0.03±0.01	0.03±0.01	0.03±0.01	0.03±0.01	0.02±0.01	0.2309	
CsWT%	1073.33±167	1143.33±174	1080.00±211	1031.67±138	1046.67±171	1026.67±100	925.00±196	923.33±184	1001.67±108	1311.67±161	0.0080	

HWT = % Heart weight, GWT = % Gizzard weight, LvWT = % Liver weight, CsWT = Carcass weight (g)

4.5 Effect of Dietary Treatments on Shear Force and Cooking Loss

Table 4.6 shows effect of dietary treatments on shear force and cooking loss. The results show that there were no significant differences on shear force values ($P > 0.05$) among the test diets except for 50%CL2 diet. However, cooking losses were apparently higher in samples from birds receiving 75% cassava inclusion. Shear force values for the thigh, were significantly lower than those of both drum and breast.

4.6 Effect of Dietary Treatment on Chemical Composition of Broiler's Meat

Table 4.7 presents the results of chemical composition of the broiler chickens. The result show that % CP was relatively lower only in carcasses of chickens receiving diets with 50 and 75% cassava particularly those diets with 50%CL3 of cassava damage but did not differ. The EE content in carcasses from control and the diets containing 25% and 75% cassava of class 1 and 3 were significantly lower than other treatments.

4.7 Cost- Benefit Analysis

The cost – benefits observations are presented in Table 4.8. The feed costs per kg were higher on the control diet and lowest on 75%CL2. Generally addition of CBSD afflicted cassava roots in the diets decreased the cost of feed as compared to the control diet. The feed cost per unit gain was lowest in 50%CL3 and highest in both the control diet and diet with 25%CL1.

Table 4.6: Means of shear force and cooking loss

Parameter	Level of Cassava Inclusion												Pr>F						
	25%						50%							75%					
	Class of Damage			Class of Damage			Class of Damage			Class of Damage				Class of Damage			Class of Damage		
	1	2	3	1	2	3	1	2	3	1	2	3		1	2	3	control		
BRCL %	19.03±1.77 ^a	16.95±1.79 ^a	17.29±1.48 ^b	21.17±1.74 ^a	17.02±1.66 ^b	17.78±1.81 ^b	23.67±1.46 ^b	19.10±0.37 ^a	20.29±1.27 ^a	19.53±1.58 ^a	19.53±1.58 ^a	19.53±1.58 ^a	0.0006						
THCL %	22.76±3.93 ^a	20.85±1.68 ^a	19.96±1.46 ^b	22.25±2.37 ^a	20.54±4.13 ^a	24.47±1.95 ^a	22.57±5.39 ^a	23.66±2.55 ^a	23.03±4.19 ^a	21.83±3.60 ^a	21.83±3.60 ^a	21.83±3.60 ^a	0.8319						
DRCL %	21.76±0.13 ^a	19.51±0.30 ^a	18.11±2.43 ^b	23.26±8.29 ^a	18.79±2.97 ^b	20.03±2.02 ^a	21.69±4.05 ^a	20.32±4.30 ^a	21.52±4.51 ^a	18.66±4.01 ^b	18.66±4.01 ^b	18.66±4.01 ^b	0.8438						
BRSF	16.20±0.84 ^a	14.78±2.98 ^a	12.74±4.20 ^b	15.33±4.23 ^a	18.25±6.95 ^a	19.50±1.60 ^a	16.56±2.17 ^a	15.01±1.85 ^a	15.28±4.70 ^a	16.68±2.88 ^a	16.68±2.88 ^a	16.68±2.88 ^a	0.6229						
THSF	9.71±0.33 ^a	12.32±1.29 ^a	8.69±0.71 ^a	10.41±3.45 ^a	11.90±5.83 ^a	10.81±1.27 ^a	11.70±2.16 ^a	9.05±0.94 ^a	9.08±1.63 ^a	11.35±1.71 ^a	11.35±1.71 ^a	11.35±1.71 ^a	0.5797						
DRSFN	9.24±2.88 ^a	12.20±2.08 ^a	6.78±1.20 ^b	12.63±2.31 ^a	11.46±1.63 ^a	8.53±2.25 ^b	11.05±4.20 ^a	10.51±4.94 ^a	6.18±1.93 ^b	8.43±3.09 ^b	8.43±3.09 ^b	8.43±3.09 ^b	0.1305						

BRCL%=Breast cooking loss, THCL%=Thigh cooking loss%, DRCL%=Drumstick cooking loss, BRSF=Breast shear force value in Newton's, THSF= Thigh shear force value in Newton's, and DRSF = Drumstick shear force value in Newton's, a-c means bearing different letters within the row differs significantly at P<0.05

Table 4.7: Effect of dietary treatments on chemical composition of broiler's meat (Whole carcass)

Parameter	Level of Cassava inclusion											
	25%						50%					
	Class of damage			Class of damage			Class of damage			Class of damage		
	1	2	3	1	2	3	1	2	3	1	2	3
DM%	64.41±10.64a	64.10±20.63a	50.43±0.36b	63.31±2.75a	53.94±4.70b	64.66±10.04a	66.18±0.45a	79.78±0.61c	59.87±4.96a	57.52±7.05a	0.0081	
CP %	31.29±4.72	32.52±8.13	33.50±1.57	29.24±5.09	34.58±0.66	-	30.97±2.22	-	30.61±0.57	31.63±3.47	0.0002	
EE %	3.24±2.61 ^b	8.39±3.20 ^a	6.85±0.39 ^a	7.94±4.32 ^a	8.22±6.86 ^a	9.21±6.74 ^a	3.18±0.13 _b	7.20±5.70 ^a	4.31±2.29 ^b	3.29±1.11 ^b	0.0001	
ASH %	2.84±0.52	2.53±1.37	2.45±0.23	2.884±0.09	2.48±0.20	2.96±0.25	2.81±0.27	3.01±0.54	2.55±0.33	2.38±0.24	0.2507	
Ca %	0.01±0.000	0.01±0.001	0.01±0.001	0.01±0.003	0.01±0.002	0.01±0.000	0.01±0.000	0.01±0.001	0.01±0.000	0.01±0.000	0.0102	
P %	1.35±0.05	0.80±0.11	1.05±0.17	0.98±0.09	1.04±0.07	1.19±0.07	1.07±0.16	1.05±0.12	1.06±0.01	0.95±0.05	0.0001	
K %	0.07±0.003	0.04±0.006	0.05±0.009	0.05±0.004	0.05±0.004	0.06±0.004	0.06±0.009	0.05±0.006	0.06±0.000	0.05±0.003	0.0001	

DM= Dry matter, CP = Crude protein, EE = Ether extract, Ca = Calcium, P = Phosphorous, K = Potassium. a-c means bearing different letters within the row differs significantly

Table 4.8: Comparison of the costs of dietary treatments

Cost item	CTR	25%CL1	50%CL1	75%CL1	25%CL2	50%CL2	75%CL2	25%CL3	50%CL3	75%CL3
Number of birds	58	55	49	56	55	55	55	56	56	57
Days to slaughter	42	42	42	42	42	42	42	42	42	42
Total live wt/bird (g)	1450	1450	1320	1310	1250	1250	1210	1090	1130	1180
Price/50kg of feed	34 345.0	31 538.8	31 527.5	31 381.3	30 950.8	30 282.5	28 096.3	33 353.8	31 749.5	31 186.3
Total feeds consumed/bird (kg)	5376	5460	4620	4536	4368	4410	4410	3780	3780	4326
In 42 days										
Cost of feed/kg (Tsh)	686.9	630.8	630.6	627.6	619.0	605.7	562.0	667.1	635.0	623.7
Total feed cost /bird(Tsh)	3692.8	3444.2	2913.3	2846.8	2703.8	2671.1	2478.4	2521.6	2400.3	2698.1
Return /bird	657.8	905.8	1046.6	1083.2	1046.2	1078.9	1151.6	748.4	987.7	841.9
Unit cost	2.55	2.38	2.21	2.17	2.16	2.14	2.05	2.31	2.12	2.29
Cost ratio	1	0.93	0.87	0.85	0.85	0.84	0.80	0.91	0.83	0.90
% cost ratio	0	7	13	15	15	16	20	9	17	10

CTR = control 100% maize, 25%CL1 = Cassava Class One and Level One of Inclusion 25%, 25%CL2 = Cassava Class Two and Level One of Inclusion 25%, 25%CL3 = Cassava Class Three and Level One of Inclusion 25%, 50%CL1 = Cassava Class One and Level 2 of Inclusion 50%, 50%CL2 = Cassava Class Two and Level Two of Inclusion 50%, 50%CL3 = Cassava Class Three and Level Two of Inclusion 50%, 75%CL1 = Cassava Class One and Level Three of Inclusion 75%, 75%CL2 = Cassava Class Two and Level Three of Inclusion 75%, 75%CL3 = Cassava Class Three and Level Three of Inclusion 75%

CHAPTER FIVE

5.0 DISCUSSION

5.1 Chemical Composition of Feed Ingredients used for Compounding Treatment Diets

Compositions of the feed ingredient used in this study were within the range reported in other studies. Garcia and Dale (1999), reported metabolizable energy of cassava to be slightly less than what was observed in the present study. The variation in energy are to be expected as they are usually subject to the stage of maturity, variety and conditions of the crop at point of harvest (Laswai *et al.*, 2002; Chauynarong *et al.*, 2009).

For CP the value reported in this study closely corresponds with values widely published in the literature (Oguntimein, 1992). Most reports show that cassava is poor in CP with contents ranging from 0.95% to 6.42% (Ceballos *et al.*, 2006). The apparent shift in CP content as the degree of damage increases was mainly due to the effect of reduced starch content in the tuberous root of the cassava as reported by Hillocks (1997).

5.2 Chemical Composition of the Experimental Diets

The diets compounded for this experiment were designed to supply at least 12.55MJ/kg of ME and CP of between 18-20% and these are common values employed in feed formulations. Using cassava to replace maize was expected to reduce the CP level in the diets as cassava is known to be poor in protein. To adjust for such reduction soybean was added, especially in the formulations where cassava replaced 75% of maize meal. Analysis of the diets indicated that all the formulations were within the recommended levels of ME 11.65- 12.68MJ/kg and CP 180-190g/kgDM) for such type of birds; making the diets fairly comparable.

5.3 Health Status of the Experimental Birds

The survival and health status of the experimental birds in this study indicates that CBSD afflicted cassava roots had no detrimental effect on performance and carcass characteristics of broiler chickens. Studies conducted on non diseased cassava suggested that cassava can replace maize as a source of energy in diets for poultry of all classes by up to 100% without any negative effect (Lekule *et al.*, 2006).

5.4 Effect of Levels of Cassava Inclusion and of Root damage on Voluntary Feed Intake

The total feed intake ranged from 3.7 to 5.4 kg for the whole period of the experiment which is equal to an average of 88 g to 128 g per bird per day. This level of intake was within the range reported by Filmer–Flockman, (2010). The total intake was highest on control and 25% CL1, CL2 and CL3 and low on 50 and 75% of cassava inclusion. This high intake is likely to be associated with the form of the diets. The more cassava meal added to the diet the dustier the diet became (Tewe and Egbunike, 1992). It is suggested that cassava need to be offered in form of chips, or pellets to ensure adequate intake. On other hand, some oil can be added to the diet to minimize the dust. However, oil addition can cause the feed to stick on the mixing machine and the feed tends to spoil rapidly due to rancidity (Katule, 2014 pers.comm). Furthermore, the dust from cassava can cause respiratory problems thus reducing voluntary intake and hence the performance of the birds. The level of root damage did not seem to influence the nutritional properties of the formulations. Even those formulas using class 3 roots were of adequate nutrient content and were consumed to the same level as roots of class 1 damage.

5.5 Effect of Levels of Cassava Inclusion and of Root damage on Growth Performance

The low average daily gain (ADG) of the birds on 50% and 75% level of cassava inclusion were caused mainly by the effect of low intake. These diets had high amount of cassava which is known to suppress voluntary feed intake when offered in finely milled form. The low ADG was recorded despite equivalent levels of CP and energy density as was in the other diets. It has been suggested that when using cassava as source of energy pelleting could be a better option than milling (Tewe and Egbunike, 1992).

The feed conversion Ratio (FCR) was lower than what has been reported by other workers (Thornton, 2012), Best, 2011). At all levels of cassava inclusion, the FCR was shown to be at least half the expected value compared to similar diets reported by Hossain *et al.* (2014). However, the lower levels of CP in the diets compared to the levels reported by Ceballos *et al.* (2006) and Balagopalan *et al.* (1991) could account for the difference in FCR. It is generally known that at early stages of growth, broiler chickens tend to be more sensitive to low CP than low ME in the diet.

However, this observation varies with that reported by Kamran *et al.* (2011) who noted no effect on broiler growth rate on low CP diets. This result suggests that when using cassava it is prudent to increase the concentration of CP in the diet to compensate for the effect of low intake arising from the dustiness of the diet (Austic and Naishem, 1990).

5.6 Effect of Levels of Cassava Inclusion and of Root Damage on Carcass and Non Carcass Components

The dressing percentage from this study was within the range of 60 to 70% for broiler chickens as reported by Dietas *et al.* (2008). The weight of carcass components and their

relative distribution were within the range reported in the literature (Shahin *et al.*, 2005). There were no significant differences among the diets on non carcass relative distribution. Generally, chicken from the control group and those given 25%CL1, 25%CL2 and 25%CL3 gave higher drumstick, thigh and breast than both 50% and 75% CL1, CL2 and CL3. The difference observed can be attributed to the better intake and growth performance recorded in chicks under Control (CTR), 25%CL1, 25%CL2 and 25%CL3 diets.

5.7 Effect of Levels of Cassava Inclusion and of Root damage on Meat Tenderness and Cooking Loss

The shear force values ranged from 9- 14 Newton's for (breast, thigh and drumstick). However, the thigh was shown to be significantly tenderer than the Drumstick and Breast. This could be due to the fact that the birds were raised in cages where movements were minimal, thus the thigh muscles were less exercised. Wang *et al.* (2009) also reported that production system has effect on the shear force values of poultry as those under free range system shows higher values due to their greater motor activity. However, this observation is drawn just retrospectively as management system was not included in the original plan of the experiment. In addition, the distribution of fatty acids; a factor that accounts for tenderness, is known to be higher in the thigh than in the breast muscle (Cortinas *et al.*, 2004). Cooking loss was apparently high on level 75% of cassava inclusion an observation similar to that of Palka and Daun (1999) and Combes *et al.* (2004).

5.8 Effect of Levels of Cassava Inclusion and of Root damage on Tissue

Distribution

Breast lean was highest in birds on control diets and lowest in those on 75% cassava inclusion as it was observed on the live and carcass weight from these treatments. At 25% and 50% inclusion, the weight of lean in the breast were similar and both were significantly higher than that observed in birds on 75%. Weight of breast fat in control diet was lower than in both 25 and 50% but was similar to the breast fat in birds on 75%. This might be due to high proportion of soya bean meal inclusion which tends to encourage higher deposition of fat in the body (Beukovic *et al.*, 2012). Thigh fat was significantly higher for birds on control diets compared to those on all other treatments. Similar observations applied to fat tissue distribution on the drum stick; this was due to low inclusion of soya bean meal in the control diet.

5.9 Effect of Levels of Cassava Inclusion and of Root Damage on Chemical composition of Broiler's Meat

Analysis of the proximate composition showed that carcass of chickens on 50% and 75% CL1, CL2 and CL3 diets had significantly lower CP% and higher EE% contents compared to those on Control and 25%CL1, 25%CL2 and 25%CL3 diets. The inverse relationship between CP and Fat contents is in agreement with that reported by Neto *et al.* (2000). When compared with other meat (Table 2.4) shows that the CP of poultry from this experiment is above that of rabbit, beef and pork.

5.10 Costs- Benefits Comparisons' of the Experimental Diets

In poultry production feed costs accounts for 70- 80% of the total poultry production cost as reported by Durunna *et al.* (1999), of which dietary energy sources occupy the greatest portion (70 -75 %) of the diets (Hossain *et al.*, 2014). This study shows that the feed cost

was reduced by Tsh 6249, when maize was replaced by cassava at 75% level of inclusion. This is in agreement to the observation by Aderemi *et al.* (2006) who reported that feed cost per kg declined with increasing levels of cassava root meal in the diets. On diet 75%CL2 birds attained a final weight of 1210 g which was 240 g less than the final weight achieved on control diet (1450 g). The unit feed cost for the two groups were 2.5 and 2.04 Tsh respectively for control and 75%CL2 diets. This means that birds on 75%CL2 were 20% cheaper to produce than birds given the control diet. If the birds were sold at the current price of 3000 Tshs, per bird, the gross margins that can be achieved with 75%CL2 should exceed that of a Control diet by approximately Tsh 500. This would mean that in spite of low final weight achieved on 75%CL2 diet, it is still profitable to replace maize meal with cassava at 75% level. There it is suggested that, if the birds are sold based on live weight 25% inclusion level of CBSD, afflicted cassava should be encouraged in the formulation of broiler diets.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

- i. The CBSD afflicted cassava roots of class 1 to 3 can be used as an energy source in diets for broiler chickens without causing any detrimental effect on growth performance and health status of the birds.
- ii. Inclusion of ground CBSD afflicted cassava roots at level higher than 50% in the diets for broilers could lead to reduced feed intake.
- iii. Ground CBSD afflicted cassava can be used to replace maize meal up to 25% inclusion level and achieve results similar to birds given commercial formulation (control diet).

6.2 Recommendations

- i. Based on the findings from this study it is recommended that the inclusion level of CBSD afflicted cassava roots should not go beyond 50% regardless of the class of severity of the root necrosis/ damage.
- ii. More research on inclusion of CBSD cassava roots should be directed at investigation of other forms of feed preparation e.g. pellets.

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APPENDICES

Appendix 1: ANOVA TABLES INTAKE AND BODY WEIGHT

Dependent Variable	R ²	Source of variation	P-V
Initial body weight	0.218932	Level*Damage	0.5214
		Level	0.7629
		Damage	0.4754
Final body weight	0.773985	Level*Damage	<.0001
		Level	0.6793
		Damage	0.1295
Weight gain	0.777201	Level*Damage	0.1280
		Level	<.0001
		Damage	0.7407
Average daily gain	0.777201	Level*Damage	0.1280
		Level	<.0001
		Damage	0.7407
Gross Intake	0.804655	Level*Damage	0.0169
		Level	<.0001
		Damage	0.0955
Intake/bird week 3	0.600646	Level*Damage	0.3303
		Level	0.0034
		Damage	0.2965
Intake/bird week 4	0.421701	Level*Damage	0.7620
		Level	0.0747
		Damage	0.0545
Intake/bird week 5	0.421432	Level*Damage	0.2007
		Level	0.0406
		Damage	0.8258
Intake/bird week 6	0.646932	Level*Damage	0.5235
		Level	0.0010
		Damage	0.0332
Intake/bird week 7	0.423105	Level*Damage	0.4325
		Level	0.0312
		Damage	0.3686
Intake/bird week 8	0.888021	Level*Damage	<.0001
		Level	<.0001
		Damage	<.0001
Average Intake/bird	0.652040	Level*Damage	0.2476
		Level	0.0011
		Damage	0.0623
Variable: FCE	0.533014	Level*Damage	0.5042
		Level	0.1422
		Damage	0.0046

Appendix 2: ANOVA TABLE CARCASS AND TISSUE DISTRIBUTION

Dependent Variables	R ²	Source of Variation	P-V
Dressing percent	0.185882	Sex	0.6990
		Level	0.2749
		Damage	0.4013
		Level*Damage	0.2268
Live weight	0.428330	Sex	0.1628
		Level	0.0011
		Damage	0.9625
		Level*Damage	0.6189
carcass weight	0.363845	Sex	0.1373
		Level	0.0290
		Damage	0.8478
		Level*Damage	0.8584
Gizzard weight	0.124023	Sex	0.2962
		Level	0.6456
		Damage	0.5890
		Level*Damage	0.8201
Liver weight	0.216183	Sex	0.0832
		Level	0.4485
		Damage	0.8428
		Level*Damage	0.3222
Heart weight	0.170279	Sex	0.8711
		Level	0.5179
		Damage	0.7765
		Level*Damage	0.2941
Breast fat	0.339784	Sex	0.8402
		Level	0.0571
		Damage	0.5405
		Level*Damage	0.1512
Thigh fat	0.442048	Sex	0.7806
		Level	0.0073
		Damage	0.1730
		Level*Damage	0.1820
Drumstick fat	0.256410	Sex	0.3256
		Level	1.0000
		Damage	1.0000
		Level*Damage	1.0000
Breast Lean	0.250646	Sex	0.7550
		Level	0.2540
		Damage	0.6509
		Level*Damage	0.9287
Thigh Lean	0.415677	Sex	0.0806
		Level	0.0152
		Damage	0.4378
		Level*Damage	0.0342
Drumstick Lean	0.432932	Sex	0.0964
		Level	0.0878
		Damage	0.6221
		Level*Damage	0.5914

Appendix 3: ANOVA TABLE COOKING LOSS AND SHEAR FORCE

Dependent Variables	R ²	Source of Variation	P-V
Breast cooking loss %	0.527605	Damage	0.0101
		Level	0.0474
		Damage*Level	0.8491
Thigh cooking loss %	0.192106	Damage	0.3250
		Level	0.2320
		Damage*Level	0.2067
Drumstick cooking loss %	0.175351	Damage	0.2453
		Level	0.4967
		Damage*Level	0.9380
Breast shear force (N)	0.207976	Damage	0.2844
		Level	0.0797
		Damage*Level	0.4854
Thigh shear force (N)	0.239301	Damage	0.4316
		Level	0.1523
		Damage*Level	0.6065
Drumstick shear force (N)	0.387423	Damage	0.0102
		Level	0.4744
		Damage*Level	0.7362

Appendix 4: ANOVA TABLE CARCASS COMPOSITION

Dependent Variables	R ²	Source of Variation	P-V
Crude Protein%	0.596549	Parts	<.0001
		Sex	0.5419
		Level	0.0200
		Damage	0.9900
		Level*Damage	0.1691
Dry Matter%	0.504164	Parts	<.0001
		Sex	0.6708
		Level	0.0534
		Damage	0.3978
		Level*Damage	0.2597
Ether Extract%	0.518904	Parts	<.0001
		Sex	0.0938
		Level	0.0444
		Damage	0.9849
		Level*Damage	0.1225
Ash%	0.393418	Parts	<.0001
		Sex	0.8894
		Level	0.3741
		Damage	0.3451
		Level*Damage	0.3044
Potassium %	0.499289	Parts	<.0001
		Sex	0.1183
		Level	0.6316
		Damage	0.0137
		Level*Damage	0.7095
Calcium%	0.224377	Parts	0.0083
		Sex	0.8090
		Level	0.5923
		Damage	0.5923
		Level*Damage	0.3947
Phosphorous%	0.501046	Parts	<.0001
		Sex	0.1128
		Level	0.6562
		Damage	0.0141
		Level*Damage	0.6971

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