ASSESSMENT ON THE POTENTIAL OF USING FISH GUTS IN BROILER CHICKEN DIETS

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2017

ABSTRACT

The study was carried out at Fuoni Village in Magharibi 'B' District of Zanzibar for period of six weeks, to evaluate the potential of using fish guts in broiler chicken diets. The two hundred and forty broiler chicks were used in four dietary treatments. Each treatment contained 60 chicks which were randomly allocated into four brooding pens and each treatment was replicated 3 times with 20 chicks each. Weight of feeds and refusal were measured daily whereas chick body weight was measured once per week. The DM intake was significantly ($P < 0.05$) higher for the birds fed diets containing 0% and 40% fish guts during the 2^{nd} and 5^{th} week of age, where as no significant differences were observed during the other weeks. There was significant effect ($P < 0.05$) for average feed conversion ratio and it was higher for birds fed diets containing 40% and 60% fish guts. The observed body weight and average daily gain were significantly ($P < 0.05$) heavier in birds fed diets 0% and 20% fish guts. However, no significant differences ($P > 0.05$) were observed for carcass weight, dressing percentage, meat tenderness and cooking loss between the four dietary treatments. The results on the chemical composition of meat showed that there was no significant ($P >0.05$) effect for percentage dry matter, crude protein and ash content while ether extract was highly significant ($P < 0.05$) in the meat of birds fed diets containing 40% and 60% fish guts. The study revealed that feed cost was low for diets containing 60% fish guts being Tshs 649.7 per bird while gross margin of Tshs 349.5 per bird was higher than control diet. The present study showed that 20% fish guts is an optimum level to replace fish meals in broiler diets without affecting performance significantly.

DECLARATION

I, JUMA RAJAB RAMADHAN, do hereby declare to the Senate of the 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 being submitted for a degree award in any other institution.

_______________________ ___________________

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The above declaration is confirmed by:

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PROFESSOR S. K. MUTAYOBA Date

(**Supervisor**)

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ACKNOWLEDGEMENTS

Firstly, I would like to give thanks to God who enabled me to complete my study. Secondly, I wish to express my gratitude to my supervisor Professor S. K. Mutayoba of the Department Animal, Aquaculture and Range Sciences for her intellectual contribution, professional guidance and tireless commitment during the entire period of my research proposal and research finding writing.

Thirdly, I would like to extend special thanks to all staff members of the Department of Animal, Aquaculture and Range Sciences, without forgetting my fellow students who in one way or another assisted toward making this study a success.

My heartfelt thanks are extended to my wife and children for their patience and encouragement during the study and I also thank Mr. Nassir who assisted me in rearing the birds during the experimental period.

Lastly I would like to thank the Zanzibar Higher Education Loan Board and Ministry of Agriculture, Natural Resource, Livestock and Fisheries in Zanzibar for financial support.

DEDICATION

This dissertation is dedicated to my beloved wife Patima A. Abdissalam, our children (Amina and Asia) and my mother Asha S. Haji.

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LIST OF ABBREVIATIONS

ADG	Average daily gain
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
AV	Average
BWT	Body weight
Ca	Calcium
CF	Crude fiber
CP	Crude protein
DAARS	Department of Animal, Aquaculture and Range Sciences
DF	Degree of freedom
DM	Dry matter
EE	Ether extract
FCR	Feed conversion ratio
FER	Feed efficiency ratio
FG	Fish gut
FWT	Final weight
G	Gram
INTWT	Initial weight
Kcal	Kilocalories
KG	Kilogram
ME	Metabolize energy
MJ	Mega joule
MS	Mean square

N	Newton
NIRS	Near infrared reflectance system
R^2	Coefficient of determination
SAS	Statistic Analysis System
SS	Sum square
SUA	Sokoine University of Agriculture
T	Dietary treatment
TSH	Tanzania shilling
TVLA	Tanzania Veterinary Laboratory Agency
TWTG	Total weight gain
WK	Week
WT	Weight
WTG	Weight gain

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

The success of poultry production mainly depends on provision of nutrients particularly protein and energy. Protein is an important nutrient because it is a major constituent of the biologically active compounds in the body. Broilers have high dietary protein requirements; therefore, provision of optimum protein concentration in broiler diets, for maximizing performance and profit, requires more knowledge about bird protein requirement, its effect on the birds' growth performance and development (Sterling *et al.*, 2006). It also requires knowledge about the available protein sources that can be used in poultry diets.

Successful broiler rearing depends on many factors that include availability of feed ingredients at reasonable cost, proper management and quality chicks. Among these factors, feed is the most important since it accounts for 65-70 percent of the total production costs (Blair, 2008). Moreover, protein ingredients are the most expensive accounting for about 45 percent of the total feed cost. Nowadays, the cost of feed ingredient has been increasing steadily all over the world due to scarcity of ingredients and higher prices (Chadd, 2008).

There are two sources of protein in poultry diets namely animal and plant origin. Plant protein sources are usually low in lysine and methionines thus have low biological value (Akhter *et al.*, 2008). In broiler diets, fish meal is predominantly the principal source of animal protein. Fish meal has higher biological value and essential amino acids profile when compared to most protein sources (Shahid *et al.*, 2005). Fishmeal can be used as the only source of animal protein in the formulation of poultry feed, but this is not the case due to limitations which include availability irregular supply and higher prices which are increasing day by day (Mohanta *et al.,* 2013).

The quality of fish meal is sometimes questionable because of adulteration with other materials such as fish bones, sand and fish scales. Successful substitution of fishmeal with cheaper protein sources may reduce the production cost of balanced poultry feed and at the same time reducing the dependence on fish meal as the major animal protein source. For this reason, it is important to search for alternative sources of protein that are cheap and have good nutritional value.

Kushak *et al.* (1990) reported that the cost of feeding chickens decreased when fish meal was replaced by other protein concentrates and also the cost of feed per kg live weight gain and overall production cost became lower when fish meal was completely replaced by other protein concentrates. On the other hand replacing fish meal with other protein concentrates using fish wastes resulted to better performance and no harmful effects were noted (Mbamba, 2000).

1.2 Problem Statement and Justification

The relatively cheap price of poultry meat compared to fish and red meat coupled with improved income of the people has led to increased demand of poultry products (MITM, 2009). This in turn calls for increased production of poultry although currently the biggest challenge facing poultry producers in Zanzibar is the high cost of poultry feed ingredients especially protein sources since they are imported from Tanzania mainland. Traditionally fish meal is mostly used as the only source of animal protein in the formulation of poultry feed since it has higher biological value when compared with other protein sources although it is very expensive (one kilogram of fish meal is about 3500 to 5000 shillings) and also there is high competition for its use with human beings.

Fish guts are readily available in Zanzibar and currently they can just be collected from fish mongers. Fish guts contain high protein content and also have adequate amount of essential amino acids. Therefore, the use of fish guts as protein source in broiler feeds may provide protein and amino acids to broiler as well as reducing the cost of feeds.

However, there is limited information about the use of fish guts as protein source in broiler diets. The few studies using fish waste composed of fish gills, fish gut, head and other fish visceral organs showed good results (Mbamba, 2000). Thus the aim of this study was to assess the possibility of using fish guts as a protein source in broiler diets.

1.3 Objective

1.3.1 Overall objective

Assessment of the potential of using fish guts in broilers diets and its effect on performance of broiler chickens.

1.3.2 Specific objective

i. To determine the chemical composition of feed ingredients and formulate diets containing fish guts,
ii. To evaluate the performance of broiler chickens fed diets containing fish guts,
iii. To determine the optimum inclusion level of broiler chickens fed diets containing fish guts,
iv. To determine carcass characteristics of broiler chickens fed diets containing fish guts.

1.4 Hypothesis

The inclusion of different proportion of fish guts in broiler diets increased feed intake, growth performance and carcass quality of broiler chickens.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

In order to produce poultry rations that are nutritionally balanced and cheap there is a need of identifying nutrients that are required by birds and the feed materials that can supply adequate amounts of the nutrients to meet the birds' requirements (Cobb, 2003). More than 40 specific chemical compounds or elements are required in poultry diets so as to support life, growth and reproduction. These nutrients can be divided into six basic classes depending on their chemical nature and physiological function and they are water, carbohydrates, protein, fat, minerals and vitamins (Cheeke, 2005).

2.2 Feeds and Nutrient Requirement in Broiler Birds

Nutrition is probably the most important aspect of the poultry environment and it entails the supply of resources upon which all processes of life depend. These resources are known as nutrients and are derived from the food ingested by the bird. Apart from supporting high productive performance, good nutrition enables birds to build up effective body defenses against disease causing organisms (Dairo *et al.,* 2010).

2.2.1 Energy

Energy is needed in the animal body to drive all the processes of life, e.g. synthesis of body tissues, blood circulation, respiration, nerve impulse transmission and excretion. Carbohydrates are the major energy yielding compounds in fowl's body (Ravindran, 2013). Energy is an important component of food that generates a lot of interest and challenges to nutritionists and it is used in the evaluation of the performance and production coefficients of farm animals. When performance of broiler chicks was evaluated it was noted that energy level of between 2800 - 3000 kcal/kg Metabolizable energy (ME) was adequate for starter diets of broiler birds (Olomu and Offiong, 1980; Onwudike, 1983 and Fetuga, 1984).

2.2.2 Protein

Proteins are made up of amino acids bonded in long chains called polypeptide chains. Amino acids are very vital for the normal functioning of the animal body. They are the building blocks of animal tissue (Aftab *et al.*, 2006). Lysine is one of the key amino acid for protein synthesis and muscle deposition, inadequate supply of lysine may reduce antibody response and cell-mediated immunity in chickens (Geraert and Adisseo, 2010). Decreasing dietary CP in broiler diets results in decreased average daily gain, feed efficiency and growth rate (Bregendahl, 2002).

2.2.3 Water

Water is necessary for most functions in the body, main constituent of cells and body and it forms about 55% of the body weight in a mature fowl. Water is a media in which all chemical processes of life (digestion, absorption, assimilation of nutrients, etc.) take place, often playing an active role in the chemical reactions (Fairchild and Ritz, 2012). Water is not only one of the most important nutrients in animal nutrition, but it also plays an essential physiological role related to the thermal homeostasis of birds and other animals, especially during heat stress (Lott, 1991 and Tabler, 2003).

2.2.4 Minerals

Minerals play a number of vital functions in the animal body (Bozkurt *et al.*, 2004). Calcium and phosphorus are required in poultry diets to sustain growth and for skeletal integrity. However, sources of Ca and P vary depending on geographical location's resources. Poultry feed industries are predominant users of meat and bone meal because of the high calcium, available phosphorus and lysine content (Miles and Jacob, 2007).

2.2.5 Vitamins

Vitamins are organic chemicals required for proper metabolic functioning of the animal body and are required in very small quantities. However, an omission or a deficiency in one or more of the vitamins in the diet of the animal results in reduced productivity. Severe cases of vitamin deficiency may lead to specific deficiency disease conditions (Shlig, 2009). The nutrient requirements for broilers are shown in Table 1.

Table 1: Nutrient requirements for broilers

Nutrients	Starter 0 - 10	Grower 11 - 22	Finisher 1 23 - 42	Finisher 2 43+
Crude Protein (%)	21.00	19.00	18.00	17.00
Metabolizable energy MJ/kg	12.50	12.90	13.29	13.29
Kcal/kg	2988	3083	3176	3176
Lysine (%)	1.20	1.10	1.05	1.00
Methionine (%)	0.46	0.44	0.43	0.41
Methionone + Cystine (%)	0.89	0.84	0.82	0.78
Tryptophan	0.20	0.19	0.19	0.18
Arginine	1.26	1.17	1.13	1.08
Leucine (%)	1.35	1.18	1.00	1.18
Lysine (%)	1.20	1.00	0.85	1.02
Isoleucine (%)	0.80	0.70	0.60	0.7
Linoleic acid (%)	1.25	1.25	1.00	1.00
Calcium (%)	1.00	0.96	0.84	0.80
Available Phosphorus (%)	0.50	0.48	0.40	0.38
Sodium %	0.20	0.17	0.16	0.16

Source: (Cobb, 2003)

2.3 Fish Gut Utilization in Poultry Diets

Dry ground fish gut is a good source of protein (Afolabi *et al.,* 1980). Depending on the type of fish, the total crude proteins of fish guts can reach up to 55.6% - 59.8% as shown in Table 2. In addition, the amino acid of fish gut is very similar to that of industrial fish meal. This relatively lower processing cost could make it economically feasible for ground dry fish guts to replace commercial fish meal as a feed ingredient in many livestock and poultry rations (Afolabi *et al.*, 1980).

Table 2: Chemical composition of fish guts

Ingredient	DM%	% CP	%EE	% Ash	Source
Fish gut	84.2	55.6	12.1	10.1	Afolabi *et al.(*1980)
Fish gut	87.2	59.8	15.4	14.2	Juma (2006)

Studies by Juma, (2006) in assessing digestibility and nitrogen utilization when fish gut (FG) was replacing copra cake (CC) in steers at levels of 44 to 100% of copra cake showed that inclusion of FG in the diet significantly improved the total nitrogen intake and retention in steers while cotton cake was associated with increased live weight gain. Efficiency of nitrogen digestion and retention (gN/kgN intake) was not influenced by neither nitrogen level of FG nor the dietary inclusion of cotton seed cake.

Moreover, studies by Al- Marzooqi *et al*. (2010) on feeding different levels of fish silage waste (guts and gills) on broiler performance (Table 3) showed that diets had significant effects on feed intake at 1st to 3rd weeks. Birds on diet 10% and 20% fish silage waste consumed high and mean weight gain for the overall period (0-35 days) was considered, birds fed diets containing 10% and 20% fish silage gained more than the other groups whereas there was no significant effects on feed conversion ratio (Table 3).

Table 3: Effect of diets with different levels of Fish silage waste (gut and gills) on feed intake, daily gain and feed conversion ratio of broiler chickens

Weekly Age	Parameter	Fish silage waste% 0	10	20	30	SEM	Significance
1	FI	18.30[b]	19.26[a]	19.41[a]	18.46[b]	0.087	***
	DG	15.04	15.44	16.84	15.19	0.882	NS
	FCR	1.23	1.20	1.18	1.23	0.086	NS
2	FI	49.17[c]	50.55[b]	51.94[a]	49.13[c]	0.337	***
	DG	34.14	35.40	36.35	34.13	0.528	**
	FCR	1.44	1.43	1.43	1.44	0.022	NS
3	FI	79.70	81.13	82.19	79.97	0.401	**
	DG	49.11	50.84	51.49	49.40	1.597	NS
	FCR	1.64	1.60	1.60	1.64	0.057	NS
4	FI	105.33	108.63	110.09	105.09	1.926	NS
	DG	63.35[c]	66.30[b]	67.32[a]	63.50[c]	0.999	***
	FCR	1.66	1.64	1.64	1.65	0.032	NS
5	FI	143.83	143.09	142.59	143.62	1.710	NS
	DG	77.60	78.24	79.10	77.43	1.509	NS
	FCR	1.86	1.83	1.81	1.86	0.036	NS
Average	FI	79.26	80.53	81.24	79.25	1.155	NS
	DG	47.85	49.44	50.23	47.93	0.593	**
	FCR	1.66	1.63	1.62	1.65	0.034	NS

Source: Al- Marzooqi *et al*. (2010)
Key: FI = Feed intake, DG = Daily gain, FCR = Feed conversion ratio, ** = (P < 0.01), *** = (P<0.001.), (SEM = Standard error of means and NS = Not significant difference

In addition studies done by Jose *et al.* (2016), on effect of diets with different levels of Fish silage waste on chemical composition of broilers chicken showed that there was no significant difference of moisture contents, crude protein and ash in diets with 10% to 30% fish silage waste. However, the inclusion of fish silage waste positively increased the fat content of meat compared to the control treatment as shown in Table 4.

Table 4: Effect of diets with different levels of Fish silage waste on chemical composition of broilers chicken

	FSW level in diet			
Parameter	0%	10%	20%	30%
Moisture %	74.32 ± 1.35	73.44 ±1.65	73.84 ± 0.95	75.60±1.65
Crude protein %	20.26 ± 0.76	20.86 ±0.48	20.39 ± 1.25	21.70±0.17
Ether extract %	2.90 ± 0.04[c]	3.39 ± 0.17[b]	3.69 ± 0.05[b]	4.37±0.31[a]
Ash %	0.98 ± 0.10	0.98 ± 0.05	0.89 ± 0.05	1.01±0.09

Source: Jose *et al.*, 2016
[a-b:] Means with different letter in a row indicate significant differences among treatments (P<0.05). FSWSM =Fish silage waste

2.4 Fish Gut Preparation

Contamination of fish gut with microorganisms quickly reduces its shelf life therefore fish gut should be boiled at 95 - 105^{0}C for 15 minutes before being sundried. After drying, fish gut may be packed and stored at 20 - 25^{0}C for less than 21 days before use in poultry rations (Juma, 2006). Arvanitoyannis (2008) reported that heat treatments of fish guts during industrial processing at 65, 80, 105 and 150^{0}C for 12 hrs to reduces moisture content up to 10 –12%.

2.5 Utilization of Fish Meal in Poultry Diets

Fish meal is an excellent source of highly digestible protein (61-72%), contains long chain omega-3 fatty acids, essential amino acids and minerals (Médale and Kaushik, 2009). Fish meal quality depends on the raw materials used and the processing method involved. Good quality fish meals contain crude protein levels above 66%, fat content around 8 to 11% and ash generally below 12% (Heuzé *et al.*, 2015). Table 5 shows protein content of the various fish meals.

Table 5: Nutrient content of the various fish meals

Ingredient	DM %	CP %	EE%	CF %	Ca%	Meth %	Lys %
Fishmeal, herring	93	72.0	10.0	1.0	2.0	2.20	5.70
Fishmeal, menhaden	92	62.0	9.2	1.0	4.8	1.70	4.70
Fishmeal, anchovy, Peruvian	91	65.0	10.0	1.0	4.0	1.90	4.90
Fishmeal, sardine	92	65.0	5.5	1.0	4.5	2.00	5.90
Fishmeal, white	91	61.0	4.0	1.0	7.0	1.65	4.30

Source: (Batal and Dale, 2010)

2.5.1 Potential constraints of using fish meal

Fish meal has a toxic substance called gizzerosine which is formed when fish meal is directly dried at 180°C in order to improve fish meal productivity. Gizzerosine is detrimental to poultry as it causes gizzard erosion and black vomit (Sugahara, 1995). This problem can be avoided if steam is used to dry fish meal (Hinrichsen *et al.*, 1997). Furthermore, in laying hens and broilers, inclusion of fish meal in poultry feeds may cause a fishy taste/taint in eggs and meat (Blair, 2008 and Chadd, 2008).

2.6 Conclusion

The reviewed literature has shown that, fish meal is an excellent source of protein, essential amino acid and mineral and is commonly used as a protein source in broiler diets. The studies carried out using fish meal as a protein source in broiler diets on growth performance have shown good results, although the inclusion of fish meal in broiler diets increases the cost of feeds. On the other hand, the costs of feeding chickens decrease when fish meal is replaced by other protein sources in broiler diets. The literature has shown that, fish guts from carnivore fish can be a relatively good source of protein and essential amino acid. Few studies using fish guts in assessing digestibility and nitrogen utilization in steer bulls revealed good results, however there is limited knowledge from the literature on the use of fish guts as a protein source in broiler diets. Therefore, this study was carried out with the aim of assessing the possibility of using fish guts as a source of protein in broiler diets and its effect on performance of broiler chickens.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study to evaluate the use of fish guts in broiler diets was carried out at Fuoni Village in Magharibi 'B' District of Zanzibar for six weeks (42 days) from 17th December 2016 to 27th January 2017. The Village is situated at latitude 60 South, longitude 390 East and 12 km above sea level. The area receives an average annual rainfall of 1600 - 1900mm/annual while temperatures vary between 18^0C - 32^0C.

3.2 Fish Guts Preparation and Diet Formulation

The fish guts were collected from two fish types available in Zanzibar Mackerels (Vibua) and Yellow fin tuna (Sehewa) from the fish mongers at the Malindi and Mwanakwerekwe markets and they were put in pots with a capacity of 6 kgs and then 1.5 liter of fresh water was added. Thereafter, they were boiled at 105^0C for 15 minutes in order to kill microorganisms as well as accelerating the drying process. Firewood was used as a source of heat for boiling fish guts and sunlight for drying. Buckets with a capacity of 12 kg were used for collecting fresh fish guts, after drying the amount of fish guts was reduced to 2.5 to 3 kgs and this showed a range of about 75% to 80% of moisture content in fresh fish guts, more information is shown in appendix 9 and the summarized photograph of types of fish used and fish guts preparation.

Four dietary treatments T1, T2, T3 and T4 of fish guts replacing fish meal at 0%, 20%, 40% and 60% respectively were locally compounded and used in the feeding experiment. Diet T1 containing 100% fish meal and 0% fish gut was used as a control as shown in Table 6.

Table 6: Experimental diets

	Treatments			
Ingredients	T1	T2	T2	T4
Fish guts (FG)	0	2	4	6
Fish meals	10	8	6	4
Maize meal	40	40	40	40
Sorghum	7.5	7.5	7.5	7.5
Maize bran	11	11	11	11
Cooking oil	5	5	5	5
Sunflower cake	13	13	13	13
Cotton cake	10	10	10	10
Blood meal	2.5	2.5	2.5	2.5
Mineral premix	0.5	0.5	0.5	0.5
Vitamin premix	0.5	0.5	0.5	0.5
Total	100	100	100	100
% CP	**20.83**	**20.35**	**19.87**	**19.39**
Kcal/kg	**2767.23**	**2772.23**	**2777.23**	**2782.27**

Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20%fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

3.3 Experimental Animals and their Management

Two hundred and forty day old broiler chicks were procured from Zanzibar Quality Chicks Company and then housed at the poultry unit. Soon after arrival the chicks were wing banded and their initial weights were taken thereafter, weighing was done once every week throughout the experimental period. The weighed birds were then randomly allocated into four brooding pens with an area of $2.5m^2$ for 60 chicks in each brooding pen.

The chicks were given the experimental diets (Table 6) from day one of age. Feeds and water were given on an *ad libitum* basis. At seven days of age the chicks were transferred to the rearing house with a deep litter floor and each treatment was replicated 3 times with 20 chicks each. Electric bulbs were used as a source of heat as well as light for chicks during the night while at day time natural light was used. At 7 and 14 days of age the chicks were vaccinated against Newcastle and Gumboro diseases respectively.

The later was repeated at 21 days of age. Furthermore, the chicks were given coccidiostats and antibiotics regularly to control coccidiosis and bacterial infections.

3.4 Experimental Procedures and Data Collection

3.4.1 Feeds chemical composition

Chemical composition (i.e. DM, CP, EE, Ash and CF) of the formulated diets were determined using NIRS standard operating procedures at TVLA laboratories Temeke, Dar es salaam and according to AOAC (1990). Calcium (Ca) and Phosphorus (P) contents were analyzed at the Department of Soil and Geological Sciences at Sokoine University of Agriculture, Morogoro, Tanzania.

3.4.2 Growth performance

The individual experimental birds were identified using a wing tag. Initial weight for individual chick was taken soon after arrival before placing the chicks in the brooding pen. Thereafter, 20 chicks from each replicate weighed body weight.

Growth performance was calculated by using formula 1.

$$\textbf{Average daily wt gain (g/day)} = \frac{\textbf{Current body wt (g)} - \textbf{Previous body wt (g)}}{\textbf{Number of days}} \quad \ldots\ldots(1)$$

3.4.3 Feed intake and feed conversion ratio

A weighed amount of feed was placed in feeders for each treatment replicate daily and the remaining amount was weighed to get refusal. Feed intake was determined by measuring the difference between the amount of feed given each day and the refusal.

$$\textbf{Average feed intake/bird} = \frac{\textbf{Weekly feed given (g)} - \textbf{Refusal (g)}}{\textbf{Number of birds}} \quad \ldots\ldots(2)$$

Feed conversion ratio was determined by measuring the difference between the amount of feed consumed per day divided by weight gain in that period as shown in equation 3.

$$\textbf{Feed conversion ratio} = \frac{\textbf{Weekly feed consumed (g)}}{\textbf{Weekly weight gain (g)}} \quad \ldots\ldots\ldots\ldots(3)$$

3.4.4 Carcass and organs components

On the last day of the experiment (i.e. 6wks of age) the birds were starved of feed, but were given fresh drinking water for 18 hours overnight. Three (3) birds from each replicate were randomly selected, weighed, slaughtered and then de-feathered using hot water. The slaughtered birds were eviscerated and weighed again to obtain eviscerated weights. All edible organs were separated and weighed. Carcass yield and organs weight as indices of production were measured using a weighing balance. Edible organs (liver, heart and gizzard), the gizzard was split to remove contents and the inner membrane then was expressed as percentage of the organ components by using equation 4.

$$\textbf{Organ component (\%)} = \frac{\textbf{Weight of component}}{\textbf{Live weight}} \times 100 \quad \ldots\ldots\ldots\ldots(4)$$

Carcass yield was calculated as dressing percentage by using equation 5.

$$\textbf{Dressing \%} = \frac{\textbf{Carcass weight}}{\textbf{Live weight}} \times 100 \quad \ldots\ldots\ldots\ldots(5)$$

The tissue from the thigh and drumstick were separated and tissue distribution i.e. fat, muscle and bone were determined and expressed as tissue percentage by using formula 6.

$$\textbf{Tissue \%} = \frac{\textbf{Weight of tissue}}{\textbf{Weight of component (thigh and drumstick)}} \times 100 \ldots\ldots(6)$$

3.4.5 Meat tenderness and chemical composition determination

Meat sample from drumstick and thigh muscles used for the determination of tenderness were preserved in a deep freezer at -20^{0}C for 2 days and then refrigerated at 4^{0}C for one day. They were afterwards vacuum packed and were then transported to SUA – DAARS laboratory for analysis. At the laboratory the meat samples were thawed at 5^{0}C and then cooked in water bath at 71^{0}C for 1 hr after which they were allowed to cool to 40^{0}C before being refrigerated again for 24hrs. After refrigeration the samples were weighed and recorded, then sliced into 1 cm thick cube. After that they were placed in the Warner Blade Sheer Force Machine for determination of tenderness. The thoroughly mixed meat from the drumstick and thigh was ground and then used for the determination of chemical composition.

3.4.6 Cost benefit

The costs of the total feed intake in each dietary treatment were calculated and carcass yield and other components were also calculated. The final total carcass sales less the variable cost used for 6 weeks for each dietary treatment were calculated to obtain gross profit margin.

3.4.7 Statistical mode and data analysis

Data were analyzed by using SAS 2000 and comparison of means between treatments was determined at 5% level of significance.

The models for comparison of treatments effect were:-

3.4.7. 1 Model for analysis on weight gains and carcass characteristic

Yij = μ+ Tij + b(X2 - X1) + Eij

Where:

Yij = Effect of the i^{th} dietary treatments on the j^{th} bird

μ = Overall mean effect

Tij = Effect of i^{th} dietary treatment on j^{th} birds

b= Regression effect of initial weight of chicks

X2 = Final group mean weight k^{th} reared period

X1 = Initial group mean

Eijk = Random error.

3.4.7.2 Model for analysis of feed intake

Yij =μ+ Ti+ßij + eij

Where:

Yij = Expected observation in each experimental unit

μ = Overall mean for all observation

Ti = Effect of i^{th} treatment in the j^{th} replication

ßij = Effect of j^{th} replication within i^{th} treatment

Eij = Experimental random error.

CHAPTER FOUR

4.0 RESULTS

4.1 Health Status of the Birds

Birds were in good health throughout the experimental period. The mortality rate was 3.33%, 1.67%, 6.67% and 13.33% for dietary treatment T1, T2, T3 and T4 respectively. The results showed increased mortality rates when fish guts were added to the diets.

4.2 Chemical Composition of Feed Ingredients and Experimental Diets

4.2.1 Analysis of feed ingredients

The chemical composition of experimental feed ingredients is presented in Table 7. The chemical composition for the feed ingredients observed in the present study was within the expected values although slight variations were observed such as low CP content for maize meal and high CF in sunflower seed cake and maize bran. On the other hand, fish guts had higher CP and P than other feed ingredients with the exception of fish meal.

Table 7: Chemical composition of feed ingredients

	Percentage composition						
Ingredient	DM	CP	EE	CF	Ash	Ca	P
Fish gut	90.5	58.9	7.3	-	7.6	0.96	1.35
Fish meal	89.1	69.0	4.4	-	9.2	3.18	1.92
Cotton cake	89.7	17.0	19.8	12.9	5.5	0.30	1.00
Sunflower cake	92.8	24.0	15.2	22.8	5.8	0.30	0.73
Maize meal	89.1	5.7	1.4	-	2.3	0.13	0.80
Sorghum	86.1	13.9	-	2.8	4.5	0.13	0.39
Maize bran	88.3	10.1	5.9	12.2	6.4	0.14	0.78

Key: DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fiber, Ca = Calcium and P = Phosphorous

4.2.2 Chemical composition of experimental diets

The chemical composition of experimental diets is presented in Table 8. All dietary treatments had similar percentage of DM, CP, EE, CF, Ash and P. However, differences between the dietary treatments were noted for ME and Ca. Diets containing 20%, 40% and 60% of fish guts had slightly higher ME than diets containing 0% of fish guts whereas diets with 0% and 40% had higher Ca than the other diets.

Table 8: Chemical composition of experimental diets

	Treatments			
Nutrient	T1	T2	T3	T4
Dry matter %	88.4	88.5	88.3	88.4
Crude protein %	21.0	21.4	21.4	21.0
Ether extract %	8.2	8.4	7.8	8.2
Crude fiber %	7.4	7.0	6.9	7.2
Ash %	5.7	5.8	6.0	5.7
ME/Kcal/kg DM	3058	3106	3113	3096
Calcium %	0.99	0.89	1.87	0.77
Phosphorus %	0.98	0.86	1.00	0.84

Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

4.3 Effects of Level of Fish Guts in Broiler Diets on weekly DM intake and FCR

Least square means and standard error of the effect of level of fish guts on DM intake is presented in Table 9. The results showed significant ($P < 0.05$) higher DM intake in diets containing 0% and 40% fish guts during the 2nd and 5th week of age, whereas there was no significant difference during the other weeks of the experiment. This trend was similarly observed for total weekly DM intake and average weekly DM intake in both four dietary treatments.

Table 9: Effects of level of fish guts in the diets on weekly DM intake (g)

	Treatments				
Age	T1	T2	T3	T4	Pr > F
2	258.20±5.22^{a}	233.57±5.14^{c}	257.17±5.22^{a}	250.42±5.22^{b}	0.0346
3	406.60 ±11.74	392.50±11.74	399.27 ±11.74	402.30±11.74	0.8561
4	568.80±9.85	558.10±9.85	565.20±9.85	546.00±9.85	0.4265
5	789.83±9.39^{a}	785.27±9.39^{a}	767.07±9.39^{b}	752.30±9.39^{c}	0.0490
6	900.47±9.89	882.92±9.89	875.67±9.89	865.67±9.89	0.1655
Total DM intake/bird	2922.16±33.27	2852.32±33.27	2864.35±33.27	2816.65±33.27	0.2370
Av weekly DM intake/bird	83.49±0.95	81.50±0.95	81.84±0.95	80.48±0.95	0.2368

$^{a, b, c,}$ Least square means with the same row with the difference superscript letters are significant different (P < 0.05) Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal.

Table 10 shows the effect of level of fish guts in the diets on weekly feed conversion ratio. The results showed that level of fish gut inclusion had no significant effect (P> 0.05) on feed conversion ratio in the 2nd, 3rd and 4th weeks of age whilst significant effects (P< 0.05) were noted in the 5th and 6th weeks of age. Diets containing 40% and 60% fish guts had higher feed conversion ratio in the 5th and 6th weeks than other diets. A similar trend was observed for average feed conversion ratio.

Table 10: Effects of level of fish guts in broiler diets on weekly feed conversion ratio

	Treatments				
Age FCR	T1	T2	T3	T4	Pr > F
2	1.89± 0.056	1.88± 0.056	1.87± 0.056	1.94± 0.056	0.7962
3	1.74± 0.04	1.75± 0.04	1.86± 0.04	1.87± 0.04	0.0754
4	1.77±0.06	1.75±0.06	1.81±0.06	1.82±0.06	0.8547
5	2.06±0.08^{d}	2.24±0.08^{c}	2.37±0.08^{b}	2.45±0.08^{b}	0.0328
6	2.56± 0.05^{b}	2.45± 0.05^{c}	2.59± 0.05^{b}	2.76± 0.05^{a}	0.0118
Av FCR	2.01±0.03^{c}	1.99±0.03^{c}	2.10±0.03^{b}	2.17±0.03^{a}	0.0126

$^{a, b, c,}$ Least square means with the same row with the difference superscript letters are significant different (P<0.05). Key: FCR = Feed conversion ratio, Av FCR = Average feed conversion ratio, T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

4.4 Effects of Level of Fish Gut in the Diets on weekly Body Weight and Average Daily Gain of Birds

Least square means and standard error of the effect of level of fish guts on weekly body weight of birds is presented in Table 11. The levels of fish guts in the diets had significant effect (P <0.05) on body weight. Birds fed diets containing 0% and 20% fish gut had heavier body weight at 6 weeks of age than birds fed diets containing 40% and 60% fish guts.

Table 11: Effects of level of fish gut in the diets on weekly body weight (g)

	Treatments				
Age	T1	T2	T3	T4	Pr > F
1	129.66±2.43[a]	123.81±2.41[b]	116.96±2.47[c]	112.50±2.52[c]	<.0001
2	266.64±5.26[a]	256.27±5.21[b]	254.52±5.35[b]	240.00±5.45[c]	0.0067
3	500.86±10.33[a]	481.27±10.24[a]	469.46±10.51[b]	456.76±10.71[c]	0.0243
4	821.64±12.23[a]	800.34±12.13[b]	781.96±12.45[b]	759.63±12.68[c]	0.0043
5	1203.45±15.91[a]	1149.58±15.78[b]	1105.98±16.20[c]	1067.69±16.49[d]	<.0001
6	1557.59±19.34[a]	1510.93±19.17[b]	1444.82±19.68[c]	1381.57±20.04[d]	<.0001

[a, b, c,] Least square means with the same row with the difference superscript letters are significant different (P < 0.05). Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

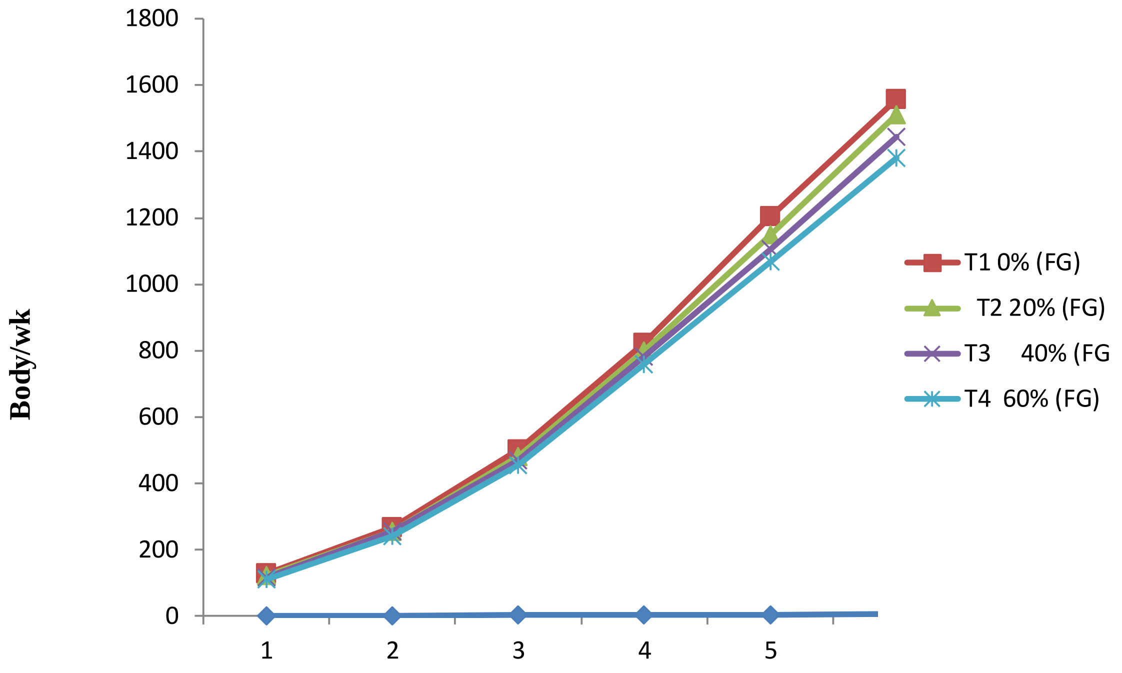

Figure 1: Body weight trends for different treatments

Table 12 shows the effect of level of fish guts on average daily gain of birds. The results showed that there was no significant difference (P > 0.05) of initial weight between the four dietary treatments while average daily gain was highly significant (P< 0.05) being higher in birds fed diets containing 0% and 20% fish guts.

Table 12: Effects of level of fish guts in the diets on average daily gain (g)

	Treatments				
Parameter	T1	T2	T3	T4	Pr > F
INTWT	40.60±0.61	39.41±0.60	38.66±0.62	38.61±0.63	0.0777
FWT	1557.59±19.34[a]	1510.93±19.17[a]	1444.82±19.68[b]	1381.57±20.04[c]	<.0001
TWTG	1516.98±19.25[a]	1471.53±19.09[b]	1406.16±19.59[c]	1342.96±19.95[d]	<.0001
ADG	36.12±0.46[a]	35.04±0.45[b]	33.48±0.47[c]	31.98±0.48[d]	<.0001

[a, b, c, d] Least square means with the same row with the different superscript letters are significant different (P < 0.05). Key: INTWT = Initial weight, FWT = Final weight, TWTG = Total weight gain and ADG = Average daily gain, T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

4.5 Effects of Level of Fish Guts in the Diets on Carcass Weight, Dressing Percentage and Main Carcass Component

Table 13 shows the effect of level of fish guts in the diets on carcass weight, dressing percentage and main carcass components. No significant differences (P > 0.05) were observed for carcass weight, dressing percentage and main carcass weight components (i.e. half carcass, drumstick, thigh and breast) from birds fed diets containing different levels of fish guts.

Table 13: Effects of level of fish guts in the diets on carcass weight, dressing percentage and main carcass component (g)

	Treatments				
Parameter	T1	T2	T3	T4	Pr > F
Slaughter wt	1465.56±60.09	1472.22±60.09	1439.44±60.09	1418.89±60.09	0.9177
Carcass wt	1035.00±41.19	1032.78±41.19	993.11±41.19	985.56±41.19	0.7566
Dressing %	70.58±0.58	70.17±0.58	69.04±0.58	69.60±0.58	0.2853
Half carcass	539.44±30.47	532.22±30.47	486.67±30.47	488.89±30.47	0.4825
Drumstick	69.44±3.34	67.22±3.34	66.67±3.34	63.88±3.34	0.7070
Thigh	88.33±5.32	93.33±5.32	86.67±5.32	80.00±5.32	0.3840
Breast	277.78±18.24	272.78±18.24	267.78±18.24	236.67±18.24	0.3927

Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

However, the results on edible organs and non-edible components showed that neck weight was significantly (P< 0.05) higher in birds fed diets with 40% and 60% inclusion fish guts, whereas in the remaining organs there were no significant differences (P > 0.05) between birds fed different dietary treatments (Table 14).

Table 14: Effects of level of fish gut in the diets on edible organs and non-edible components

	Treatments				
Parameter	T1	T2	T3	T4	Pr >F
Gizzard %	2.41±0.15	2.05±0.15	2.01±0.15	1.84±0.15	0.0605
Liver %	2.17±0.16	2.27±0.16	2.53±0.16	2.68±0.16	0.1039
Heart %	0.94±0.09	0.92±0.09	0.93±0.09	0.91±0.09	0.9955
Neck %	4.08±0.27[c]	4.55±0.27[b]	5.07±0.27[a]	5.95±0.27[a]	0.0002
Head %	2.56±0.16	2.99±0.16	3.00±0.16	3.13±0.16	0.0774
Feet %	3.93±0.23	4.39±0.23	4.45±0.23	4.54±0.23	0.2554
Abd fat %	1.72±0.21	1.79±0.21	1.61±0.21	2.03±0.21	0.5326
Gut %	8.11±0.45	7.84±0.45	7.46±0.45	8.64±0.45	0.3253

[a, b, c,] Least square means with the same row with the difference superscript letters are significant different ($P < 0.05$). Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

4.6 Effects of Level of Fish Guts in the Diets on Tissue Composition, Tenderness and Cooking Loss

Least square means and standard error of the effect of level of fish guts on tissue composition, tenderness and cooking loss are presented in Table 15. The results showed that level of fish gut in the diet had no significant effect ($P > 0.05$) on lean and bone tissues for the drumstick and thigh. However, differences were observed for fat whereby the thigh fat tissue was significantly ($P < 0.05$) higher for birds on 20% and 60% fish gut in diets but no significant difference ($P > 0.05$) was noted for drumstick fat. Dietary treatments had no significant effect ($P > 0.05$) on meat tenderness and cooking loss.

Table 15: Effects of level of fish guts in the diets on tissue composition, tenderness and cooking loss

	Treatments				
Parameter	T1	T2	T3	T4	Pr >F
Drumstick					
Bone (%)	26.69±1.86	29.50±1.86	28.40±1.86	27.45±1.86	0.7382
Lean (%)	58.39±1.87	58.36±1.87	58.04±1.87	57.18±1.87	0.9645
Fat (%)	1.18±0.26	1.16±0.26	1.024±0.26	1.91±0.26	0.1040
Cooking loss%	17.93±0.93	17.95±0.93	14.72±0.93	17.73±0.93	0.0631
Tenderness (N)	8.13±0.95	8.38±0.95	9.09±0.95	8.26±0.95	0.8933
Thigh					
Bone (%)	16.40±1.21	16.49±1.21	15.63±1.21	17.81±1.21	0.6485
Lean (%)	58.79±2.64	54.78±2.64	59.84±2.64	54.45±2.64	0.3777
Fat (%)	3.68±0.75[c]	6.83±0.75[a]	4.59±0.75[b]	5.91±0.75[a]	0.0362
Cooking loss %	16.74±1.23	17.86±1.23	16.26±1.23	16.67±1.23	0.8160
Tenderness (N)	10.88±1.34	9.61±1.34	9.97±1.34	12.77±1.34	0.3640

[b, c] Least square means with the same row with the different superscript letters are significant different (P <0.05). Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

4.7 Effects of Level of Fish Guts in the Diets on Meat Chemical Composition

Table 16 present the results of chemical composition of the broiler chickens meat. The results showed that Dry matter percentage did not differ significantly (P > 0.05) between birds fed different dietary treatments. Similar results were observed for crude protein and Ash %. The ether extract % in carcasses from diets containing 40% and 60% of fish guts were significantly (P < 0.05) higher than other dietary treatments.

Table 16: Effects of level of fish guts in the diets on meat chemical composition in % (drumstick and thigh)

	Treatments				
Parameter	T1	T2	T3	T4	Pr > F
Dry matter %	29.43±0.89	29.73±0.89	28.97±0.89	31.07±0.89	0.4711
Crude Protein %	20.43±0.70	19.45±0.70	18.79±0.70	18.69±0.70	0.3862
Ether extract %	5.56±0.00[d]	4.79±0.0.00[c]	7.02±0.00[a]	6.22±0.00[b]	<.0001
Ash %	3.20±0.29	3.48±0.29	2.51±0.29	3.03±0.29	0.2573

[a, b, c,] Least square means with the same row with different superscript letters are significant different (P < 0.05). Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

4.8 Cost Benefit

Table 17 shows the comparison of the cost of dietary treatments, the feed cost per kilogram was higher in diets containing 0% and 20% fish guts and it was lowest in diets containing 60% fish guts. Returns from sales of the carcass showed that gross margin was greater in diets containing 60% fish guts than the other dietary treatments.

Table 17: Comparison of the costs of the dietary treatments

	Treatments			
Cost	T1	T2	T3	T4
Carcass weight (g)	1035	1032	993	985
Day to slaughter	42	42	42	42
Price of carcass/kg	6000	6000	6000	6000
Total sales of carcass	6210	6192	5958	5910
Total feed intake/bird	2922.16	2852.32	2864.35	2816.65
Price of feed/ kg	1352.5	1292.5	1232.5	1172.5
Total feed costs/bird	3952.22	3686.62	3530.31	3302.52
Cost of Drugs/bird	412.5	412.5	412.5	412.5
Gross margin/bird	1845.28	2092.88	2015.19	2194.98

Key: T1 = diet with 0% fish gut, T2 = diet with fish gut replacing 20% fish meal, T3 = diet with fish gut replacing 40% fish meal and T4 = diet with fish gut replacing 60% fish meal

CHAPTER FIVE

5.0 DISCUSSION

5.1 Health Status of the Birds

Health status of the experimental birds showed that dry ground fish guts had no effect on survival of the broiler chickens. The mortality rate of birds under different treatments was within the normal range indicating that dietary supplementation of fish gut in the diets of broiler chickens had not adverse effect similar findings were reported by (Hammoumi, 1998). This showed that fish gut contain adequate nutrients and has no harmful components when it is well prepared.

5.2 Composition of Feed Ingredients

Chemical composition of the feed ingredients (i.e. maize meal, sunflower cake, cotton seed cake, maize bran and sorghum) in the present study was within the range values reported in other studies (Mbamba, 2000 and Mutayoba *et al.*, 2011). However, the values of crude protein and fat value for maize meal, maize bran and sunflower seed cake meal were slightly lower than those observed by (Mutayoba *et al.*, 2011). The variation in the results might be caused by differences in environmental factors (i.e. age of harvesting, rainfall, temperature, soil fertility and storage conditions). Also varietal difference or genetic factors can affect chemical characteristics of the cereal grains and other plant products (Conan *et al.*, 1992; Peltonen-Sainio *et al.*, 2012).

Crude Protein content for fish guts was within the range reported by (Juma, 2006) but slightly higher than the values reported by (Afolabi *et al.*, 1980). Reasons for the observed differences could be processing, type of fresh fish guts, duration of heating, type of dryer used, temperatures and storage period. DM, EE and Ash were slightly lower than value had been reported by (Afolabi *et al.,* 1980; Juma, 2006) probably due to differences in type of species of fish used and methods of preparation. Crude protein and Dry matter value from fish meals were within the range reported (Médale *et al.*, 2009; Heuzé *et al.*, 2015) while EE, CF, Ash, Ca and P were slightly low probably due to differences in type of fish meal used.

5.3 Composition of Experimental Diets

The average dry matter content for the dietary treatments was 88.4% and crude protein average 21%. The mineral contents (i.e. calcium and phosphorous) were higher in diets 0% to 40% inclusion level of fish gut since the fish by-products used are important sources of these nutrients, the results were slightly different from those of (Mbamba, 2000). The crude fibre and Ether extract contents were slightly higher than value reported by (Ochetim, 1992; Darsana, 2009). Higher fiber and fat concentrations in chicken diets may have negative effects on nutrient digestion and absorption (Krogdahl, 1986; Baião, 2005).

The Metabolizable energy obtained in this study was within the range reported by (Olomu and Offiong, 1980; Onwudike, 1983; Fetuga, 1984) for diets containing 0% fish guts and whereas it was slightly higher in the other diets. High Metabolizable energy in broiler diets leads to a reduction in total feed intake and nutrients (Leeson *et al.*, 1996; Albuquerque *et al.,* 2003).

5.4 Effects of Level of Fish Guts in the Diets on DM intake and FCR

Total feed intake and average feed intake on dry matter basis observed in the present study were not significantly different (P>0.05) similar results were reported by (Espe *et al.*, 1992) who included up to 50% of fish wastes (offal and intestine) in broilers diet.

Santana-Delgado *et al*. (2008) and Jose' *et al.* (2016) showed that the inclusion of up to up 30% of dried fish waste meal silages did not affect feed intake.

However, other related studies observed higher feed intake in broilers when more than 50% of fish waste was added in the diets (Ochetim, 1992; Mbamba, 2000). The contrasting results might be associated with various factors that modulate feed intake in birds such as genetic variation between strain, environmental temperature, energetic content of the diet, texture and palatability of the feed (Abdullah *et al*., 2010; Siegel, 2014).

The average feed conversion ratio was higher in diets containing 40% and 60% inclusion of fish guts. These results conformed to the findings of a study by (Mbamba, 2000 and Darsana and Sreekumar, 2012). The higher feed conversion ratio recorded from birds fed diets containing 40% and 60% inclusion of fish guts in the diets could be an indication of unsatisfactory availability and absorption of nutrient by the birds (McDonald *et al*., 2002). However, comparisons of FCR among different species of birds may be of little significance unless the feeds involved are of similar quality and suitability (Mike, 2009). Generally the results showed that inclusion of fish guts in broiler diets at 0% and 20% could lead to improved feed conversion and feed efficiency ratio to the birds and also could improve feed biological value, availability of nutrients as well as digestibility and thus resulting to a reasonable body weight gain (Hammoumi *et al*., 1998).

5.5 Effects of Level of Fish Gut in the Diets on Body Weight and Average Daily Gain of Birds

The higher final live weight and average daily gain (ADG) from birds fed diets containing 0% and 20% of inclusion level of fish guts compared to the other treatments might be due to good digestibility and absorption of nutrients. High performance of birds fed 0% and 20% level of fish guts conformed to the findings of (Darsana *et al*., 2009; Al- Marzooqi *et al*., 2010; Jose *et al.*, 2016; Panda *et al*., 2017) who stated that increased levels of fish waste silage (fish guts and gills) in broiler diets up to 30%, did not affect digestibility and absorption of nutrients in the gastro-intestine tract of broiler chicks and led to improved body weight gain probably resulting from the supply of well-balanced protein.

These results were also comparable to the growth performance observed by (Ochetim, 1992; Mbamba, 2000), using fish waste in broiler diets. From their studies they concluded that fish waste was a good protein source for broiler but should be included up to a level of between 30% and 37.5%. However, for the present study showed that fish gut could be a valuable animal protein source for broiler up to 20% level in both starter and finisher broiler diets without affecting performance.

5.6 Effects of Level of Fish Guts in the Diets on Carcass Weight, Dressing%, Carcass Component and Edible and Non Edible Components

The dressing percentage obtained in the present study was within the range that was reported by (Ochetim, 1992) but was different from the higher dressing percentage and carcass weight results reported by (Mbamba, 2000) in birds fed diets containing 0% to 37.5% of inclusion of fish wastes. The contrasting results between the two studies might be associated with type of fish waste used and length of experimental period. The carcass components and their relative distribution (i.e. half carcass, drumstick, thigh and breast) were within range observed by (Darsana *et al*., 2009). However, the percentage of edible organs (i.e. Giblets) did not differ significantly between treatments similar results were reported by Al- Marzooqi *et al*. (2010) whereby effect of fish waste silage on broiler performance was assessed. The reason for the higher percentage of neck in birds fed 40% and 60% was not clear. The current study evidently showed that fish guts could replace fish meal up to 60% in broiler diets without effecting dressing percentage, carcass weight, edible and non edible components.

5.7 Effects of Level of Fish Guts in the Diets on Tissue Composition, Tenderness and Cooking Loss

Dietary treatment had no significant effect on lean and bone tissue composition in the drumstick and thigh but thigh fat tissue was significantly higher for birds fed diet containing 20% and 60% of level of fish gut. These results were different from those reported by (Darsana and Sreekumar, 2012). This might be due to high proportion of fish guts inclusion which had higher lipid content that encourages higher fat deposition in the body (Smitha, 2005). Dietary treatment had no significant effect on meat tenderness and cooking loss. The value of tenderness ranged between 8 – 9N for drumstick meat and 9 – 12 N for thigh meat. These low tenderness values might be due to the young slaughter age of birds (Guhne, 1970; Lyon and Wilson, 1986).

5.8 Effects of Level of Fish Guts in the Diets on Meat Chemical Composition

The analysis of the proximate composition showed that level of dry matter, crude protein and ash percentages in the raw broiler meat was similar in both dietary treatments. The results were in agreement with the report of (Al- Marzooqi *et al.*, 2010; Darsana and Sreekumar, 2012). The higher ether extracts content from meat in diets containing 40% and 60% fish guts compared to other diets was probably a reflection of higher ether extracts in fish guts. Also the high proportion of fish guts inclusion encourages higher deposition of fat in the body (Smitha, 2005; Muhammed *et al*., 2014).

5.9 Effects of Level of Fish Guts on Cost Benefit of the Dietary Treatments

Broiler feed cost accounts for 65-70 percent of the total production costs as reported by Blair, (2008). Moreover, the price of protein ingredients is relatively higher than most feed ingredients being about 45 percent of the total feed cost (Mohanta *et al.*, 2013). The findings of the present study indicated that inclusion of fish gut in the diets reduced feed cost and increased gross margin of produced carcass. The feed cost was lower in diets containing 60% fish guts inclusion at approximately Tsh 649.7 per bird while it was higher gross margin being about Tsh 349.5 per bird than control diets. This is in agreement to the observation by Kushak *et al.* (1990) who reported that the cost of feeding chickens decreased when fish meal was replaced by other protein concentrates.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusions

i. The present study conclude that 20% fish guts is an optimum level to replace fish meals in broiler diets for reasonable performance and carcass characteristics.

ii. The inclusion of fish guts in broiler chicken diets at 40% to 60% led to a slight decrease in body weight, weight gain, feed efficiency ratio of broiler chickens but it had no significant effect on dressing percentage, carcass quality, tissue distribution and it could be economically profitable in broiler production.

iii. The study also revealed that supplementation of fish guts in broiler diets could decrease production cost as well increase gross margin of the carcass yield.

6.2 Recommendations

i. It is recommended that knowledge and skills should be provide on using fish guts in broiler diets as an alternative of protein source.

ii. It is also recommended that further studies using fish guts in other diets of domestic animals and its effect on production performance should be done.

REFERENCES

Abdullah, A., Al-Beitawi, N., Rjoup, M., Qudsieh, R. and Ishmais, M. (2010). Growth performance, carcass and meat quality characteristics of different commercial crosses of broilers strains of chickens. *The Journal of Poultry Science* 47(1): 13-21.

Afolabi, A.O. (1980). *Nutrition Reports International* 21 (6): 901 – 906.

Aftab, U., Ashraf, M. and Jiang, Z. (2006). Low protein diets for broilers. *World Poultry Science Journal* 62: 688 – 701.

Akhter, S., Khan, M., Anjum, M., Ahmed, S., Rizwan, M. and Ijaz, M. (2008). Investigation on the availability of amino acids from different animal protein sources in golden cockerels. *Journal Animals, Plant Sciences* 53: 54.

Albuquerque, R., Faria, D.E., Junqueira, O.M., Salvador, D., FariaFilho, D.E. and Rizzo, M.F. (2003). Effects of energy levels in finisher diets and slaughter age of on performance and carcass yield in broiler chickens. *Brazilian Journal of Poultry Science* 5(2): 99-104.

Al-Marzooqi, W., Al-Farsi, M.A., Kadim, I.T., Mahgoub, O. and Goddard, J.S. (2010). The effect of feeding different levels of sardine fish waste silage on broiler performance, meat quality and sensory characteristics under closed and open sided housing systems. *Asian- Australasian Journal of Animal Sciences* 23: 1614 -1625.

AOAC. (1990). Official Methods of Analysis of the Association of Official Analytical Chemists, In: Association of Official Analytical Chemists (14th Edn) Arlington, VA, USA, pp. 1102.

Arvanitoyannis, I.S. and Kassaveti, A. (2008). Fish industry waste: treatments, environmental impacts, current and potential uses. *International Journal of Food Science Technology* 43 (4): 726 –745.

Baião, N.C. and Lara, L.J.C. (2005). *Oil and fat in broilers nutrition. Brazil Journal Poultry Science* 7: 129-141.

Batal, A. and Dale, N. (2010). Feedstuffs Ingredient Analysis Table: 2011 edition. [Online]. Feed stuffs. [http://fdsmagissues.feedstuffs.com/fds/Reference_issue_ 2010/03_Ingredient%20Analysis%20Table%202011%20Edition.pdf)] site visited on 17 10/ 2013.

Belay, T. and Teeter, R.G. (1993). Broiler water balance and thermo balance during thermo neutral and high ambient temperature exposure. *Poultry Science* 72: 116 – 124.

Blair, R. (2008). Nutrition and feeding of organic poultry. Cabi Series, CABI, Wallingford, UK.

Bozkurt, M., Basmacioglu, H. and Ergul, M. (2004). "Effect of Dietary Concentration Meat and Bone Meal on Broiler Chickens Performance."*International Journal of Poultry Science* 11: 719 – 723.

Bregendahl, K., Sell, J.L. and Zimmerman, D.R. (2002). The effect of low-protein diets on growth performance and body composition of broiler chicks. *Poultry Science* 81: 1156 – 1167.

Chadd, S. (2008). Future trends and developments in poultry nutrition in: FAO. 2008. Poultry in the 21st Century: avian influenza and beyond. In: *Proceedings of the International Poultry Conference*, held 5–7 November 2007, Bangkok, Thailand. Edited by O. Thieme and D. Pilling. *FAO Animal Production and Health Proceedings*, No. 9. Rome 2008.

Cheeke, P.R. (2005). Livestock feeds and feeding (3rd Ed.) Pearson Prentice Hall, Upper Saddle River, New Jersey.

COBB, (2003). Cobb broiler nutrition guide. [http/www.agr.ankara.edu.tr/animal science/10068. Cobb 500Man Nutri Pg pdf] Site visited on 4/7/2016.

Conan, L., Metayer, J.P., Lessire, M. and Widiez, J.L. (1992). Metabolizable energy content of cereal grains in poultry. Recent yearly surveys in France. *INRA Production Animal* 5: 329–338.

Dairo, F.A.S., Adesehinwa, A.O.K., Oluwasola, T.A. and Oluyemi, J.A. (2010). High and low dietary energy and protein level for broiler chickens. *African Journal of Agriculture Research* 5 (15): 2030 – 2038.

Darsana, M.G., Sreekumar, K.P. and Jalaludheen, A. (2009). Effect of feeding processed fish wastes on the growth and haematology of broilers. *Indian Journal Poultry Science* 44: 213-217.

Darsana, M.G. and Sreekumar, K.P. (2012). Effect of processed fish wastes supplementation on blood biochemical and meat composition of broiler chicken. *Iranian Journal of Veterinary Research, Shiraz University* 13 (3): 40.

Espe, M., Haaland, H. and Njaa, L.R. (1992). Substitution of fish waste silage protein and a free amino acid mixture for fish meal protein in a chicken diet. *Journal of the Science Food and Agriculture* 58: 315-319.

Fairchild, B.D. and Ritz, C.W. (2012). Poultry drinking water primer. Bull. 1301. Cooperative Extension, University of Georgia, Athens.

Fetuga, B.L. (1984). Techniques in feed formulation. *Paper presented at the Feed mill Management Training Workshop*. Department of Agricultural Economics, University of Ibadan, 40pp.

Geraert, P.A. and Adisseo, Y.M. (2010). Amino Acids: Beyond the Building Blocks. SAS France, Antony, France.

Guhne, W. (1970). Tenderness of broiler meat dependent on weight, sex and age of the birds. *World's Poultry Science Journal* 26:739.

Hammoumi A., Faid M., Elyachioui M. and Amarouch H. (1998). Characterization of fermented fish waste used in feeding trials with broilers. *Process Biochemistry* 33(4): 423–427.

Heuzé, V., Tran, G. and Kaushik, S. (2015). Fish meal. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. [http://www.feedipedia.org/node/208lastupdated] site visited on11/5/2015.

Hinrichsen, J.P., Neira, M., Lopez, C., Chiong, M., Ocaranza, M.P., Gallardo, R., Rutman, M., Blamey, J. and Lavandero, S. (I997). Omeprazole, a specific gastric secretion inhibitor on oxynticopeptic cells, reduces gizzard erosion in broiler chicks fed with toxic fish meals. *Comparative Biochemistry and Physiology Part C*: Pharmacology, Toxicology and Endocrinology 117 (3): 267 - 273.

Jacob, R.A. (1995). The integrated antioxidant system. *Nutrition Research* 15(4): 755-766.

Jose, C.R.R., Jose, I.I.E., Ranferi, G.L., Jose, A.U. and Petra, R.U. (2016). Use of biological fish waste silage in broilers feed: Effect on growth performance and meat quality. *Journal of Animal and Plant Science 27* (3): 4293-4304.

Juma, M.A. (2006). Small-scale dairy farming in Zanzibar: Studies on system and feeding of dairy cow. A thesis for Award of Doctor of Philosophy at the University of Reading. UK, 420 pp.

Khan, M.A.A., Hossain, M.A., Hara, K., Ostomi, K., Ishihara, T. and Nozaki, Y. (2003). Effect of enzymatic fish-scrap protein hydrolysate on gel-forming ability and denaturation of lizard fish Saurida wanieso surimi during frozen storage. *Fisheries Science* 69 (6): 1271–1280.

Krogdahl, Å. (1986). Anti- nutrients affecting digestive functions and performance in poultry. In: *Proceedings of the 7th European Poultry Conference, Paris.*1: 239-248.

Kushak, R.I., Travid, I.L., Basova, N.A., Yukhno, E., Fillpchenkova, L.P., Isidorov, G.E. and Val'dman, A.R. (1990). Effectiveness of different dose of fish protein concentrates in feeding of chickens. Dolady Vsesoyuzhoi Ordena Lenina I orde NA Trudovogo Krasnogo Znameni Akademii Sel'skhozyaistvennyauk in Lenina 1(6): 51 – 54.

Leeson, S., Caston, L. and Summers, J.D. (1996). Broiler response to diet energy. *Poultry Science* 75(4): 529-535.

Lott, B.D. (1991). The effect of feed intake on body temperature and water consumption of male broilers during heat exposure. *Poultry Science*70: 756 – 759.

Lyon, C.E. and Wilson, R.L. (1986). Effects of sex, rigor condition, and heating method on yield and objective texture of broiler breast meat. *Poultry Science* 65: 907-914.

Mbamba, S.S.I.A. (2000). Effect of replacing fish meal by fish waste on growth performance and carcass quality of broiler chickens. A dissertation submitted in partial fulfillment of the requirement for ward the degree of Master of Science in Sokoine university of Agriculture pp 91.

McDonald, P., Edward, R.A., Greenhalph, J.F.D. and Morgan, C.A. (2002). Animal nutrition (6th Ed) Personal Education Limited, United Kingdom.

Médale, F. and Kaushik, S. (2009). Protein sources in feed for farmed fish. Editor(s): Lazard, J., Lesel, R., *Cahiers Agricultures* 18 (2-3): 103 - 111.

Miles, R.D. and Jacob, J.P. (2007). Using Meat and Bone Meal in Poultry Diets. IFAS Extension. University of Florida.

Mike, V. (2009). Taking control of feed conversion ratio. Pig Progress, Last update: Jan 26, 2011.

MITM. (2009). Livestock products prices for 2002-2009, Marketing Department, MITM, Dar es Salaam.

Mohanta, K.N., Subramanian, S. and Korikanthimath, V.S. (2013). Evaluation of Different Animal Protein Sources in Formulating the Diets for Blue Gourami *Trichogaster Trichopterus* Fingerlings. *Journal Aquaculture Research Development* 4: 164.

Muhammed, M.A., Domendra, D., Muthukumar, S.P.,Sakhare, P.Z. and Bhaskar, N. (2014). Effects of fermentative recovered fish waste lipids on growth and composition of broiler meat. *Journal British Poultry Science* 52: 79-87.

Mutayoba, S.K., Dierenfeld, E., Mercedes, V.A., Frances, Y. and Knight, C.D. (2011). Determination of Chemical Composition and Anti-nutritive Components for Tanzanian Locally Available Poultry Feed Ingredients. *International Journal of Poultry Science* 10 (5): 350-357.

Ochetin, S. (1992). Performance of broiler and layers fed locally produced fish waste meal. School of Agriculture, University of the South pacific, western Somoa 5(1): 91-95.

Olomu, J.M. and Offiong, S.A. (1980). The effect of different protein and energy levels and time of change from starter to finisher ration on the performance of broiler chickens in the tropics. *Poultry Science* 59: 828 – 835.

Onwudike, O.C. (1983). Energy and protein requirements of broiler chicks in humid tropics. *Tropical Animal Production* 8: 39 – 44.

Panda, S., Babu, L., Panda, A., Tanuja, S. and Panigrahy, K. (2017). Dietary Supplementation of Fermented Fish Silage (gills and intestine) in Broiler Japanese Quails (*Coturnix coturnix japonica*): A Review. *International Journal of Livestock Research* 7(4): 31-48.

Peltonen-Sainio, P., Jauhiainen, L. and Nissilä, E. (2012). Improving cereal protein yields for high latitude conditions. *Europe Journal of Agronomy* 39: 1–8.

Ravindran, V. (2013). Poultry feed availability and nutrition in developing countries: main ingredients used in poultry feed formulations. *Poultry development review*. Rome, Italy: FAO; 2013. pp. 67 – 90.

Santana-Delgado, H., Avila, E. and Sotelo, A. (2008). Preparation of fish silage from Spanish mackerel (*Scomberomorus maculates*) and its evaluation in broiler diets. *Animal Feed Sciences Technology* 141: 129-140.

Siegel, P. (2014). Evolution of the modern broiler and feed efficiency. *Annual Review of Animal Biosciences* 2: 375-385.

Shahid, R. and Talat, N.P. (2005). Effect of different levels and source of fish meal on the performance of broiler chicks. *International Journal of Scientific and Engineering Research* 6 (7): 78.

Shlig, A.A. (2009). Effect of Vitamin E and Selenium Supplement in Reducing Aflatoxicosis on Performance and Blood Parameters in Broiler Chicks. *Iraqi Journal of Veterinary Sciences* 23: 97 – 103.

Smitha, N.F. (2005). Growth performance of broiler chicken fed on fermented fish waste ration. MVSc. Thesis, Kerala Agricultural University. pp 86.

Sleman, S.M., Robert, A. and Paul, A.L. (2015). Specialized protein products in broiler chicken nutrition: *A review Animal nutrition* 1: 47- 53.

Sterling, K.G., Pesti, G.M. and Bakalli, R.I. (2006). Performance of different broiler genotypes fed diets with varying levels of dietary crude protein and lysine. *Poultry Science* 85: 1045 – 1054.

Sugahara, M. (1995). Black vomit, gizzard erosion and gizzerosine. *World Poultry. Science Journal* 51: 293 - 306.

Tabler, G.T. (2003). Water intake: A good measure of broiler performance. Avian advice 5(3): 7 – 9.

Waldroup, P.W. (2001). Dietary nutrient allowances for chickens and turkeys. *Feedstuffs* 73(29): 56 – 65.

APPENDICES

Appendix 1: Anova tables weekly feed intake in DM basis

D -Variable	DF	SS	M S	F Value	Pr > F	R2
Intake/bird wk 2	3	1166.170625	388.723542	4.76	0.0346	0.640700
Intake/bird wk 3	3	315.8139583	105.2713194	0.25	0.8561	0.087108
Intake/bird wk 4	3	906.9275000	302.3091667	1.04	0.4265	0.280193
Intake/bird wk 5	3	2532.984167	844.328056	4.00	0.0490	0.600011
Intake/bird wk 6	3	1938.155625	646.051875	2.20	0.1655	0.452322
Total intake	3	17285.81896	5761.93965	1.74	0.2370	0.394175
Average intake	3	14.09450000	4.69816667	1.74	0.2368	0.394284

Appendix 2: Anova table weekly feed conversion ratio (FCR)

D -Variable	DF	SS	M S	F Value	Pr > F	R2
FCR wk 2	3	0.05133333	0.01711111	1.66	0.2525	0.383085
FCR wk 3	3	0.04846667	0.01615556	3.37	0.0754	0.557943
FCR wk 4	3	0.00775833	0.00258611	0.26	0.8547	0.087739
FCR wk 5	3	0.25762500	0.08587500	4.86	0.0328	0.645636
FCR wk 6	3	0.14560000	0.04853333	7.16	0.0118	0.728729
Total FCR	3	1.57769167	0.52589722	7.02	0.0125	0.724767
Average FCR	3	0.06095833	0.02031944	6.99	0.0126	0.723756

Appendix 3: Anova table weekly body weight and average daily gain

D -Variable	DF	SS	M S	F Value	Pr > F	R2
BWT wk 1	3	9624.245700	3208.081900	9.38	<.0000	0.112098
BWT wk 2	3	20080.61668	6693.53889	4.17	0.0067	0.053172
BWT wk 3	3	59340.14569	19780.04856	3.20	0.0243	0.041228
BWT wk 4	3	117230.6857	39076.8952	4.50	0.0043	0.057115
BWT wk 5	3	575304.0807	191768.0269	13.06	<.0001	0.149399
BWT wk 6	3	993964.8723	331321.6241	15.27	<.0001	0.170462
TWTG	3	972074.5175	324024.8392	15.07	<.0001	0.168580
ADG	3	551.0219088	183.6739696	15.07	<.0001	0.168571

Appendix 4: Anova table on carcass weight, dressing percentage and main carcass component

D -Variable	DF	SS	M S	F Value	Pr > F	R2
Live (wt)	3	16302.08333	5434.02778	0.17	0.9177	0.015435
Carcass (wt)	3	18145.88889	6048.62963	0.40	0.7566	0.035811
Dressing %	3	12.12326673	4.04108891	1.32	0.2853	0.110053
Half carcass (wt)	3	21040.97222	7013.65741	0.84	0.4825	0.072930
Drumstick (wt)	3	140.9722222	46.9907407	0.47	0.7070	0.041986
Thigh (wt)	3	452.0833333	150.6944444	0.81	0.4979	0.070554
Breast (wt)	3	9252.083333	3084.027778	1.03	0.3927	0.088016

Appendix 5: Anova table on edible organs and non-edible components

D -Variable	DF	SS	M S	F Value	Pr > F	R2
Gizzard %	3	1.57778889	0.52592963	2.72	0.0605	0.203389
Liver %	3	1.51076389	0.50358796	2.23	0.1039	0.172831
Heart %	3	0.00460000	0.00153333	0.02	0.9955	0.002056
Neck %	3	17.22134167	5.74044722	8.94	0.0002	0.456068
Head %	3	1.68156389	0.56052130	2.50	0.0774	0.189677
Feet %	3	2.00851111	0.66950370	1.42	0.2554	0.117385
Abd Fat %	3	0.87760000	0.29253333	0.75	0.5326	0.065380
Gut %	3	6.60602222	2.20200741	1.20	0.3253	0.101174

Appendix 6: Anova table on tissue composition, tenderness and cooking loss of drumstick

D -Variable	DF	SS	M S	F Value	Pr > F	R2
Bone %	3	26.25537038	8.75179013	0.42	0.7382	0.059729
Lean %	3	5.70211909	1.90070636	0.09	0.9645	0.013380
Fat %	3	2.91763657	0.97254552	2.34	0.1040	0.259880
Cooking loss %	3	44.73609810	14.91203270	2.85	0.0631	0.299734
Tenderness (N)	3	3.28951408	1.09650469	0.20	0.8933	0.029511

Appendix 7: Anova table on tissue composition, tenderness and cooking loss of thigh

D -Variable	DF	SS	M S	F Value	Pr > F	R2
Bone %	3	14.81716675	4.93905558	0.56	0.6485	0.077296
Lean %	3	136.0930386	45.3643462	1.09	0.3777	0.140095
Fat %	3	35.18650954	11.72883651	3.45	0.0362	0.340856
Cooking loss %	3	8.43197804	2.81065935	0.31	0.8160	0.044670
Tenderness (N)	3	36.08078437	12.02692812	1.12	0.3640	0.144008

Appendix 8: Anova table on meat chemical composition

D -Variable	DF	SS	M S	F Value	Pr > F	R2
Dry matter %	3	4.86325000	1.62108333	1.02	0.4711	0.434174
Crude protein %	3	3.87223750	1.29074583	1.31	0.3862	0.496302
Ether extract %	3	5.40895000	1.80298333	Infty	<.0001	1.000000
Ash %	3	1.01005000	0.33668333	1.99	0.2573	0.599241

Appendix 9: Photograph of fish used to collect fish guts

Mackerels fish (Vibua)

Yellow fin tuna fish (Sehewa)

Fresh fish guts

Dried fish guts