EFFECT OF FEEDING LEVEL ON INTAKE, DIGESTIBILITY AND GROWTH PERFORMANCE OF MUSCOVY AND PEKIN DUCKS

BY

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ABSTRACT

The experiment was conducted with 66 Pekin and Muscovy ducklings aged 0 – 2 weeks at Ubena ranch poultry unit to evaluate the effect of feeding level on intake, growth performance, feed conversion efficiency and cost of production with the objective of improving the current level of performance of the breeding stock at the Ubena prison farm. The test feed compounded to provide 18% CP, however only 16% was available and the control diet had 10.6% CP, These diets were fed to ducklings at 07:00 h in the morning and 18:00 h in the evening for 56 days. Feed offered was adjusted weekly and water was provided *ad libitum*. Ducklings were randomly allotted in four groups of 18 ducklings each for the groups, while one group (control) had 12 ducklings. These groups are treatment I,II,III and the fourth group was farm diet(control)The test feed was offered at a rate of 2.5, 3.5, and 5% of body weight font treatment I,II and III respectively, while the control group was given *ad libitum* the control diet (Maize bran). The proximate analysis was done at Sokoine University of Agriculture, DASP, Nutrition Laboratory analysis showed that the fishmeal had a CP content of DM far below normal values. The Digestibility study was conducted at Sokoine University of Agriculture, poultry Unit. The experiment had acclimatization and data collection period, which lasted for 5 days each, Eight Pekin and 10 Muscovy aged 10 – 12 weeks old were used in the experiment, and were placed in individual cages and excreta collected daily in the morning before feed was offered. At day 56, the cumulative weight gained for Pekin in treatment I,II,III and Farm diet were 760g, 950g, 2140g, and 834g respectively, and 228.7g respectively and 42.2g, 42.2g, 121.1g, and 164g respectively for Muscovy ($P < 0.05$) For Pekin, respective feed efficiency was 3.3, 3.8, 4.4, and 18.5 and for Muscovy 3.3, 3.8, 4.0, and 22.4. Muscovy had higher cost of production (2.2 Tsh/g against 1.9 Tsh g of Pekin) A 16% CP Content diet offered at 5% was economically and biologically efficient in raising duckling of both breeds. It was shown that the Pekin had higher weight gain as compared to the Muscovy ducks, and higher gross margin, despite the high cost of production. It was further noted that to increase the production cheap locally available protein sources could be used to increase growth rate.It was observed Pekin to be more susceptible to feed stress thus concluded to establish a Pekin far for broiler meat production one should make sure there is good supply of feed while Muscovy can be kept even when feed supply is unreliable as they can sustain feed stress.

DECLARATION

I, **Iddi, Lipende**, do hereby declare to the senate of Sokoine University of Agriculture that, this dissertation is my own original work and has not been submitted for a degree award in any other university.

Signature...

Date...

DECLARATION

I, **Iddi Lipende**, do hereby declare to the senate of Sokoine University of Agriculture that, this dissertation is my own original work and has not been submitted for a degree award in any other university.

Signature..

Date.... 24th August 2007 ....

SIGNATURE OF SUPERVISOR

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Signature ……………………………………………………………

Date 24th August 2017 ……………………………………………

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DEDICATION

This Manuscript is dedicated to my mother, Amina Iddi and father, late Mr. Lipende. Almighty Allah rests his soul in peace.

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LIST OF ABBREVIATIONS

%...Percentage

ANOVA...............................Analysis of variance

AOAC..................................Association of official analytical chemist

CF ....Crude fiber

cm.......................................Centimeter

CP ....Crude protein

DASP...............................Department of Animal Science and Production.

DM ....Dry Matter

EE ....Ether Extract

g ....gram

i.e..That is

ID...Identification

Kcal .... Kilocalories

L..Liter

ME ....Metabolizable energy

№...Number

SAS ....Statistical analytical system

SUA .... Sokoine University of agriculture.

α...Level of significance

CHAPTER ONE

1.0 INTRODUCTION

Over the past 20 years, there has been a tremendous expansion of the poultry industry in Tanzania. At least three large commercial ventures are currently operational. This expansion is closely associated with relevant increase in affluence of the public, particularly in large urban centres. However, Tanzania's poultry industry is still operating within a narrow range of species. The species of choice has always been the commercial chicken; while other potentially viable species, such as ducks, guinea fowl and turkeys have not been fully exploited. Ducks are less exploited but can offer animal protein similar to the chicken at a relative lowest possible price of production. Ducks are very hardy, good scavengers and foragers, and at the same time require little attention in their management and husbandry (Ngapogora, 2000).

Pekin ducks (*Anas platyrhynchos*.) are from the family of common ducks that originated from South China (Say, 1987; Smith, 1990; Zhang, 1988). They have faster growth rate, high feed conversion efficiency and are resistant to many poultry disease, (Ngapogora, 2000). Muscovy ducks (*Cairina moschata*), commonly kept in East Africa, originated from South America. They are good breeders among duck breeds but apparently slow growers (Say, 1987). Female Muscovy ducks are characterized by relatively slow growth rate, short laying persistency and expression of broody instincts with high sex dimorphism; the drake is 30 – 50 % heavier than female duck (Feltwell, 1980; Sauvier, 1990; Smith, 1990; Rose, 1997).

Ducks are extensively distributed all over the world, they are normally kept in small flocks, except in France, Taiwan and few European countries, where Pekin ducks are kept extensively (Zhang, 1988). The Muscovy duck (*Cairina moschata*) is the major duck species kept in Tanzania. A census in Tanzania reported a population of 1,214,329 ducks and geese with that of Morogoro alone being 19,429 ducks (MAF, 2003)

Commercial duck rearing is a new line of poultry enterprise in Tanzania. A recent study by Ngapogora (2000) showed that with improved management, the native Muscovy ducks can achieve performance levels comparable to those recorded in South East Asia. Also shown in the study was the fact that, despite positive returns, the overall profitability of ducks rearing was still inferior to that of commercial broiler chicken production. The main reason for this relative poor profitability is the cost involved in feeding (Adeola, 2005)

Fully confined ducks where shown to consume some 20 – 30g, more than the chicken of comparable physiological age (Ngapogora, 2000) and require 9.7 – 10 g of feed/ g gain. McDonald *et al* (1995) reported that ducks need a diet of 2.7 – 2.8 MJ/KgDM and 14 – 15 % CP, if they are to achieve 2.6 – 2.8 kg within 7 weeks. This is highly expensive under low input smallholder systems common in Tanzania.

Since feed cost makes up to 80% of the total production costs (Fajimi *et al.*, 1993; Tewe, 1997; Smith, 1990; Richard and Malden, 1990). It is imperative that efforts are made to formulate low cost rations that would optimize production under the smallholder system of Tanzania. Optimization may be achieved through a strategic ration plan, which encourages intake while promoting growth without adding excessively to production cost

However no study in Tanzania has been conducted to provide a guideline in proper rationing for ducks. It is common to note that ducks are either left to scavenge unknown quantities of feed (Nguyen *et al*, 2000) or given amounts proposed for domestic chickens. It is important to establish a feeding level that would optimize productivity, both economically and biologically. This study aims at providing information on the possible optimized rationing for growing Pekin and Muscovy ducks.

1.2 OBJECTIVE

1.2.1 General objective

» To determine intake and growth performance of Pekin and Muscovy ducks, when fed different levels of feed compounded using cassava leaf meal as locally protein source.

1.2.2 Specific objectives

- To determine feed intake, feed conversion ratio and growth performance of Pekin and Muscovy ducks when fed a cereal based diet supplemented with cassava leaf meal.

- To determine optimum (economic/ biological) level of feed offered with respect to growth performance.

- To determine the digestibility of diets containing cassava leaf meal by Pekin and Muscovy ducks at different levels of feed offered.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Ducks

From ancient times domestic ducks have served as a source of food and income for people in many parts of the world. In most developing countries ducks are kept for meat and eggs, ranking second to chicken as a source of eggs and meat for small scale poultry producers (Banks, 1979; Aquino, 1992). Ducks are able to subsist and grow to maturity on relatively simple diets, based on locally available feedstuffs (Smith, 1990). Duck meat and eggs are good dietary sources of high quality protein, energy, vitamins and minerals (Austic and Nesheim, 1990).

There are two main species of duck found in the tropical Africa, Muscovy ducks that originated from South America, and Pekin ducks from China (Say 1987). Pekin ducks are white-feathered and have relatively faster growth rate, reaching about 90% of their adult weight at 7 weeks of age. Their growth rate under less favourable conditions will depend upon the quality of the diet they are fed, but even under less than optimum conditions, Pekin ducks can perform well (Bhuiyan *et al*, 2005).

Female Pekins lay up to 160 eggs per year during the first year of laying and are capable of laying in excess of 230. eggs per year. However, they are poor brooders (Panda and Mohapatra 1989; Smith, 1990), thus in most cases need assistance from artificial incubators or Muscovy ducks (Nind and Tu, 1998). Although Pekin ducks are usually bred for meat, some high egg producing commercial strains of Pekin or Pekin-like ducks have been developed. Meat from Pekin ducks is very tender and juicy and is known worldwide for its delicious taste. In China, Pekin ducks are used in reducing crop damage by pest infestation, to remove weeds from banks of waterways and clear aquatic weeds in ponds and canals (Smith, 1990; Lane *et al*, 1998).

The Muscovy (*Cairina moschata*) is distinctly different genetically from common ducks. This breed is believed to have originated from South America, (Say, 1987) although ancient records of this or a similar breed have been found in Egypt. There are both colored and white-feathered varieties of Muscovy (Smith, 2001) The Sudani is a breed of Muscovy found in Egypt. Unlike common ducks, the head and face of Muscovy ducks is covered with carbuncles (a fleshy growth that resembles wattles). Another prominent feature of Muscovy ducks is sex dimorphism where the drake weighs 30 - 50% more than the female (Feltwell, 1980; Sauveur, 1990; Ngapogora, 2001). Muscovy ducks tolerate hot weather and harsh environments much better than common ducks (Bogrene and Mihaly, 1994).

Table 1: Body weight of domestic breeds of ducks, Kg

BREED OF DUCK	MALE	FEMALE
Aylesbury	4.5	4.0
Campbell	2.2 – 2.4	2.0
Cayuga	3.6	2.2
Crested	3.2	3.2
Indian runner	1.6 – 2.2	2.7
Muscovy	4.5 – 6.4	1.4 – 2.0
Orpington	2.2 –3.3	2.2 –3.1
Pekin	4.0	3.6
Rouen	4.5	4.0

Source: Feltwell (1980)

Muscovy eggs require about 35 days to hatch. Muscovy ducks can be crossed with common ducks producing sterile offspring. Muscovy is strong flier, but they do not normally leave their home (Smith, 1990; Sauvier, 1990)

Ducks are a potential substitute of poultry meat and eggs at relatively cheap cost of production (Cavalchini *et al*, 1982), yet they are marginalized due to lack of information

2.2 Duck management

2.2.1 Water

Water is the most essential nutrient in the body of the animal, and a lack of water results in reduced feed intake and later complete anorexia. Water deficiency is marked by dry mouth, reduced digestive juice secretion, and ultimately there is disruption of bodily function (Smith, 1990; Payne, 1990). Intermittent water supply causes reduced feed intake, while in restricted water allowance there is reduction in feed intake and growth rate (Forbes, 1991).

Voluntary water intake usually is about twice the weight of Dry matter eaten. Many functions of water are related to digestion, and metabolism of feed (Payne, 1990). Usually poultry drink water before, during and after feeding because of a small stomach, which cannot hold much water. Water intake is depressed when it is difficult to obtain.

In most parts of the world water is not expensive, and thus is offered *ad libitum*. Water is required for wetting food in the mouth and stomach, and as medium for digestive reactions in stomach and intestines (Crissey *et al*, 1989). It is also the major component of the body and a medium for excretion of soluble material in the urine and sweat. Water requirement is thus influenced by amount of food eaten and environmental temperature (Forbes, 1991).

2.2.2 Feeding

Ducks experience difficulties in consuming feed in the form of dry mash, whilst feeding mash in place of pellets resulted in reduced weight gain and poor feed conversion efficiency (Wilson, 1975). It is a common practice to mix feed with water in a backyard duck production system, which improves dry matter intake and weight gain (Bolton, 1974). In tropical conditions wet feeding is useful partially in alleviating heat stress, hence increases feed intake and performance. Giving hens feed with 50% water added stimulates DM intake at 33.3 0C by 38% (Tadyanant *et al*, 1991) while an additional 33 or 50 % of water in feed increases both intake and body weight gain in the hot season (37^0C). Normally wet feeding reduces the amount of wasted feeds (Smith, 1990). Dry and wet feeding can both be employed in duck feeding.

Nutritional requirement standards for ducks were simply assumed to be similar to those of chicken (ARC, 1975). Ducks have higher growth rate, coupled with higher nutritional requirements (Mc Donald et al, 1995). Though little research has been done with regard to ducks, it was revealed that ducks have a high ability to consume and digest organic matter, crude fiber, nitrogen free extract and crude protein, and better than chicken (Siregar *et al*, 1982[b]). Therefore, the metabolic energy requirements for ducks is slightly higher than those of chickens, and consequently its justified to use ME values for chickens to formulate diets for ducks (Crissey *et al*, 1989; Leclerc and Carville, 1995)

2.2.2.1 Feed intake

Feed intake of ducks is affected by state of feed, palatability and climatic conditions. Ducks adjust their feed intake to maintain their relative constant metabolic energy (Siregar *et al*, 1982[b]; Dean, 1978). Feed intake of ducks decreases as the stocking rate increases (Osman, 1993). Intake tends to be higher in outdoor ducks than indoor (Paci *et al*, 1992). Grit and sand should be freely available. Adult ducks normally consume 170 g – 230 g of feed per day, but some adult ducks in full lay can consume as much as 280g of feed (Payne *et al*, 1990).

Ducklings should be fed at least four times a day until they are 2 weeks old and 3 times for a further 2 weeks, after which the frequency of feeding can be reduced gradually, if they are extensively managed and as bird's foraging power develops (Payne, 1990)

Crude protein requirement in ducks depends on the age and level of production. Dean (1978) suggests 16 % crude protein as the level sufficient to give maximum growth rate in grower Pekin ducks. Diets with crude protein levels lower than 16% may significantly lower the growth rate (Johnson, 1971). Bui *et al* (1996) reported that varying crude protein, 18, 20, 22% for starter and 16, 18, 20% for growers did not affect feed intake or growth.

Feed intake of growing ducks is depressed significantly as dietary energy of the feed is increased from 3.0 to 3.4 Kcal/g. This phenomenon is common in birds reflecting intake control mitigated via the chemoreceptors

2.2.2.2 Growth

The growth of an animal is determined by several factors such as species, breed, sex, age, of the animal, level of nutrition and the quality of feed the animal consumes (Tadyanant, 1991). The growth assay technique is based on the animal body weight gain, gain: feed or feed: gain ratio and nitrogen retention (Borin *et al*, 2006)

In birds the male normally grows faster than female. However at a younger age they may possess similar growth rate. The male ducks continue up to 14 weeks of age while the females reach maximum growth at the 8th week. This phenomenon is described as sex dimorphism (Campbell, 1985; Feltwell, 1990). The Muscovy duck has higher sex dimorphism among duck breeds (Nguyen, 1996; Sauvier, 1990). It was observed by Leclerc and Carville, (1995) that the Muscovy ducks have weight gain of 80 g/day in males at the 7th week and 50 g/day for females at the 6th week.

Growth rate can be manipulated through increasing the level of nutrition and the quality of feed offered to the animal. Normal growth is achieved through a range of dietary energy requirements. However increasing the metabolizable energy of the diet increases the growth rate of the animal only when protein: energy ratio is maintained. Therefore, in order to have higher growth rate in ducks, feeding is the most important factor to consider.

2.2.2.3 Feed Conversion Efficiency

Feed Conversion ratio for ducks is affected by basal metabolism, protein accretion, livability, appetite, digestibility, carcass composition and level of production (Emmerson, 1991). The efficiency also varies with age and rearing system. Male ducks have higher growth rate and higher feed conversion ratio than female ducks (Bachno *et al.* 1992; 1994; Sharma and Nanda, 1989; Petre *et al.*, 1990; Bui, 1996). Nguyen, (1996) reported that feed conversion ratio was 3.5 for male ducks and 4.5 for female ducks.

2.2.2.4 Digestibility in ducks

Feed conversion efficiency is one of the common criteria used in the growth assay of the animal, and may be expressed as gain: feed ratio or Feed: gain ratio (Borin *et al*, 2006). Smith (1990) and Nguyen, (1996) observed higher feed conversion efficiency in commercial duck breeds, while their crosses and indigenous breeds have the lowest feed conversion ration. However, ducks kept under the deep litter system had better feed conversion ration (Bui, 1996)

The potential value of feed can be determined using proximate analysis, but this scheme only tells about the value of nutrients present in the feeds but not the availability for the animal (William, 1978; Bond, 1987; McDonald *et al* 1995). The digestibility study on the other hand provides a clue on the effectiveness of the feed.

The higher the digestibility vale of the feed the more useful that feed is to the animal. Digestibility studies help to estimate the digestible nutrient in the feeds, which also measure the quality of feed (Khanum *et al.* 2005)

McDonald *et al* (1995) reported that the nutrient excreted in faeces are not only from undigested portion of the feed being determined, but also part of the excreta comes from the digestive juices, mucus and won out cells, products from the intestinal walls and bacteria. Meanwhile Schneider, (1975) suggests that feeding small amounts at regular intervals results in better utilization of the feed material, whereas offering too much at a time reduces digestibility of the feed.

2.3 Cassava

Cassava (*Manihot esculenta, Crantz*), sometime known as manioc, yucca or tapioca native of South America, western and eastern Mexico, is a tropical crop with a high yield potential (Lekule *et al*, 1998; Muzanila, 1998). Lekule *et al*. (1998) reported that smallholder farmers in Tanzania cultivate cassava, producing about 7 million tons of cassava per annum. A hectare of cassava produces large amount of cassava leaves, which varies considerably due to climatic conditions, cultivars, age of plant, plant density, soil fertility and harvesting frequency, (Gomes and Valdivieso, 1984).

The utilization of the cassava leaves in animal feed to a large extent is limited due to the presence of cyanogenetic glycosides. linamarin and lotaustralin (Magoon, 1972; Khajarern *et al*, 1977) which may lead to toxicity in animals and may depresses growth.

Various workers have suggested different methods of detoxification to improve cassava leaves utilization (Maner and Gomez, 1973; Coursey, 1973 Gomez, 1977; Wanapat *et al* 1997; Aletor and Fasuyi, 1997). These methods include boiling for 40 minutes, chopping and drying, addition of methionine, maceration, roasting, fermentation or combinations of these methods. Generally all these methods aim at lowering cyanide and reducing tannin level, hence improving acceptability.

Table 2 presents typical values for nutrient constituents of cassava leaves. Other workers have reported CP values ranging from 17.8 – 39.3% (Luyken *et al*, 1961; Johnson and Raymond. 1965; Montilla, 1976; Doto *et al* 2004). In Tanzania Doto *et al*, (2004) gave a summary of findings from various parts of the country, wherein cassava leaves were shown to contain at least 23.1 % CP. Cassava leaves are a common staple in Tanzania. However, use of cassava leaves in animal feeds is very limited. In south East Asia cassava leaf meal is a common ingredient in monogastrics diets (Duong *et al*, 2000).

Table2: Nutrient composition of 100 g fresh cassava leaves

Component	Level
Water	80.0g
Carbohydrate	7.0g
Protein	6.0 g
Fat	1.0 g
Calcium	0.2g
Iron	0.3 mg
Vitamin B1 (Thiamine)	0.2mg
B2 (Riboflavin)	0.3mg
C	200mg
A	10,000.0 IU
Niacin	1.5mg
Kilocalories (Kcal)	50.0g

Source: Onwuene, 1978

When harvested at an early stage of growth (3 months) cassava leaf meal contains up to 25 % crude protein, with a good profile of amino acids (Wanapat *et al*, 2000[b]). Mature leaves (> 3 months) have been found to have higher concentration of condensed tannins. Cassava leaves are usually sun dried (for 3 – 7 days) to eliminate some 90% of hydrocyanide (HCN) and store the product with 10 – 20 % moisture (Wanapat *et al* 1997)

2.4 Summary of the review

In most parts of Africa south of the Sahara, ducks (especially Muscovy) are common feature in the rural poultry stocks. Generally, they are reared as scavengers in combination with native chicken and guinea fowls. There are no commercial scale enterprises for duck production. However, in South-East Asia, where conditions are tropical. duck production is one of the fastest growing poultry sectors. When reared properly ducks outperform the native chicken, both as a meat and egg producers. The muscovies are less prone to diseases common in tropics, grow faster and yield larger and more eggs than the native chickens.

An experimental introduction of Pekin ducks in Tanzania has demonstrated that they can survive and reproduce well under local conditions. This opens up an opportunity for expanding the poultry industry in the country. However, there are no studies made to evaluate their growths potentials or guidelines in their management. This study attempts to look into practice that would optimise productivity of both Muscovy and Pekin ducks.

One of the various approaches to feeding ducks is the amount given to them for optimal growth. The literature shows a wide spectrum of feeding levels, many of which are based on requirement for chickens. This approach may not meet the needs of the fastest growing ducks. It is important that such feeding guidelines be evaluated.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

This study was conducted at Ubena prison ranch in the Coast region. Ubena area receives about 800 mm of rain, normally in a bimodal pattern. The main rainy season extends from April to June, whereas shorter rain periods are experienced between November and January. Temperature ranges between 14.8^{0}C in the coolest months to 32.4^{0}C during the hottest season. Day length varies from 11 -13 hours. The prison farm has a small dam in which fish farming is integrated with Pekin duck rearing. Muscovy ducks are kept for the purpose of brooding Pekin eggs and ducklings.

3.2 Cassava leaf preparation

Cassava leaves of different stages of maturity were harvested in and nearby the prison farm. Cassava leaves harvested were sun dried on a concrete floor for about 3 -7 days with at least three turnings daily to ensure proper drying. Dried cassava leaves were ground using mortar and pestle to form a fine powder, which was then packed in bags ready for compounding the experimental diet.

3.3 Preparation of experimental diets

Composition of the test diet is as shown in Table 3. These amounts were enough to supply 16% CP when supplemented in the basal diet. All the experimental diets were hand mixed.

Table3: Composition of compounded test diet

INGREDIENTS	AMOUNT (g/kg)
Maize Bran	550
Cassava Leaf	300
Fish Meal	120
Growers Premix*	10
Dicalcium Phosphate (DCP)	10

Experimental diets were compounded using feed ingredients locally available at Ubena. Maize bran that was used as the basal diet was collected from local wet milling machines around the area. Fishmeal was used to balance the requirement for crude proteins, grower's premix, as shown in T 4 and Dicalcium phosphate (DCP), were procured from the veterinary shops in Morogoro.

Table 4: Commercial Growers Premix from ANUPCO Ltd.

Ingredient	Amount	Ingredient	Amount
Vitamin A	*8,000, 000 I.U.*	*Panthothenic acid*	*5, 000mg*
VitaminD3	*3,000, 000I.U.*	*Folic Acid*	*500mg*
Vitamin E	*8, 000 I.U.*	*Choline Chloride*	*150, 000mg*
Vitamin K	*2, 000mg*	*Iron (Fe)*	*20, 000mg*
Vitamin B1	*1, 000mg*	*Manganese (Mn)*	*80,000mg*
VitaminB2	*2, 500mg*	*Copper (Cu)*	*8,000mg.*
VitaminB12	*5,000mcg*	*Zinc (Zn)*	*50,000mg.*
Niacin	*10, 000mg*	*Cobalt (Co)*	*225mg*
Selenium (Se)	*100mg,*	*Iodine (I)*	*2,000mg.*
		Antioxidant	*1,000ppm*

3.4 Experimental animals and their management

Pekin and Muscovy ducklings (*Anas platyrhynchos* and *Cairina moschata* respectively) were used for the experiment. All the ducklings were hatched from parent stock reared on the ranch. The ducklings were expected to be raised as "on-farm replacement" of the breeding stock. Hatching was done by natural incubation using Muscovy ducks.

Experimental animals were housed in a well-ventilated building. Feeding was done daily in the morning and evening at around 07:30 and 18:00 hours respectively. Feeding was offered on a body weight basis at 2.5%, 3.5% and 5% of the body weight. The control group received only maize bran *ad libitum*. Water was provided to ducks *ad libitum* placed in water troughs made up of used plastic containers. To avoid some common water borne diseases, water used was treated with Antibiotics (Oxytetracycline 5%). To extend the feeding time for the ducks 100 watts bulbs were used to provide light.

3.5 Determination of proximate constituents cassava leaf and experimental diets

Proximate analysis for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash content of cassava leaves, maize bran, fish meal and test diet was performed using methods described by AOAC (1990) in the laboratory of Sokoine University of agriculture at the Department of Animal Science and Production, Nutrition laboratory

3.6 Experimental layout

A total of 66 (33 Pekin and 33 Muscovy) ducklings aged 3 days to 2 weeks were used for the experiment. The ducklings were randomly assigned into four groups each with 3 replicates of equal numbers of Pekin and Muscovies, three of which had 18 ducks (9 Pekin and 9 Muscovies), while the fourth group (Farm diet) had 12 (6 Pekin and 6 muscovies). The experimental rations were; T1 = 2.5%, T2 =3.5% and T3= 5% of body weight, as shown in T 5, while the Farm diet (maize bran only) was fed *ad libitum* as is commonly practiced on the farm. The test diets given were composed as shown in T 3.

Feeding was done twice daily (i.e. at 07:30 and 18:00 hours) with the daily ration divided into two equal portions. The ducklings were group fed, while water was provided to the ducklings *ad libitum*. The experiment was done for 56 days.

Table 5: Experimental layout of growth study

Birds	Treatment									
	2.5%			3.5%			5%			
	T1R1	T1R2	T1R3	T2R1	T2R2	T2R3	T3R1	T3R2	T3R3	Control
Pekin	4	2	3	3	3	3	3	3	3	6
Muscovy	3	2	4	3	3	3	4	2	3	6

3.7 Data collection

3.7.1 Feed intake

Feed intake was assessed by collecting refusals before subsequent meals. The arithmetic difference between offered and refusal represents the amount consumed. Feed allowance was calculated on the basis average weight of the group, adjusted once weekly at the beginning of the week.

3.7.2 Weight changes

A sensitive electronic weighing balance (Toledo), calibrated to read at 20g units was used to collect data on the growth rate. Birds in each replicate were weighed individually and their weight recorded for monitoring individual weight changes. Assessment of the group performance was based on the average weight of the replicates. The average weight of the group was used for calculating amount of feed for the succeeding week.

3.7.3 Digestibility trial

A digestibility trial was conducted to complement the observation made during the growth study. The experiment was conducted at Sokoine University of Agriculture, Department of Animal Science and Production, poultry unit houses; to determine the digestibility of the experimental diets offered at the same rate as were used for the growth study.

Twenty Muscovy and Pekin ducks aged 10 to 12 weeks used in the digestibility trial were confined in individual battery cages with dimension of 12 cm by 12cm x15cm throughout the preliminary and data collection period. The preliminary period and data collection periods lasted for 5 days each. Diets tested were compounded in the same manner as those used in the growth study. The birds were offered individual rations thereby allowing the assessment of individual intakes.

Table 6: Experimental layout for digestibility trial.

Birds	Treatment T I 2.5%	T II 3.5%	T III 5%
Pekin	3	3	4
Muscovy	3	3	2

3.7.3.1 Faecal collection

Faecal collection was done daily for 5 days using a polythene sheet as a receptacle; the excreta collected were frozen and bulked for each individual bird. Chemical analysis was made on individual bulked samples.

Figure 1: Duck in the cage during digestibility trial

3.8 Statistical analysis

Data collected and those obtained by calculation were subjected to analysis of variance (ANOVA) in a completely randomised Block design as described by Snedecor and Cochran. (1989) using General Linear Model's procedure of SAS (1999), and means were compared using Duncan's Multiple range test at ($P < 0.05$) level of significance, based on the following

Statistical model: $Y = \mu + Ti + Sj + E\ ij$

Where: Y is an observation for a dependent variable,

μ = General mean common to all observations;

Ti = Effect of Diet;

Sj = Effect of species of animal

E ij = Random error

CHAPTER FOUR

4.0 RESULTS

4.1 Overview

This chapter presents the findings from the study. For clarity of presentation the chapter is divided into subsections corresponding to specific parameters, the growth and digestibility studies are presented separately. For growth study birds ranged in age from 3 days to 2 weeks, the majority being 1 week. The experimental rations were offered on the basis of the average body weight for the group. This may have led to a few birds within the group receiving rations above treatment levels. However, since birds were randomly allotted to treatment group, there was apparently no reasonable ground to consider such possibility as a serious interference.

4.2 Chemical composition of the feed ingredients and test feed

Table 7 shows the chemical composition of the ingredients for compounding the experimental ration and that of the compounded test feed. The CP value for the maize bran and cassava leaves were within expected ranges. However the fishmeal had an extremely low CP content. The test diet was compounded to contain 18% CP However the analysis shows that it was 2% units less.

Table 7: Chemical composition of feed ingredients and the test feed

Ingredients	DM%	CP%	CF%	EE%	NFE%	Ash%
Maize Bran	90.2	10.6	11.9	15.9	49.8	2.1
Fish meal	95.3	26.9	8.8	7.3	24.4	27.9
Cassava leaf	67.1	23.0	19.9	5.4	14.9	4.3
Test feed	89.0	16.2	10.5	10.3	37.2	15.0
Standard error	±0.2	±0.2	±0.1	±0.1	±0.3	±0.1

4.3 Intake and growth performance

4.3.1 Dry Matter feed Intake

Ducks in all treatments consumed all the feed that was offered for the day. Table 8 shows the average amount of test feed and farm diet consumed by the birds. Increasing the daily offer from 2.5%of the body weight to 5% body weight increased intake by over 400% among Pekins and nearly 600%in the Muscovies. However, both the Pekins and the Muscovies receiving the farm diet consumed about 1.5 to 2 times more feed than those given the highest offer.

Table 8: Performance of duckling offered different levels of test diet and basal diet

Treatment	Initial weight	Final weight	Average daily weight gained (g/day)	Average daily feed intake (g/day /bird)	FE (g feed/ g gain)	Feeding cost(Tsh/g of gain)
Pekin						
T I	180±40^{d}	760±52^{b}	10.4± 5.3^{b}	34.4±0.02a	3.3±0.1a	0.4 ±0.07^{a}
TII	79±49^{a}	950±86^{b}	15.6±5.7^{b}	58.9±0.03^{b}	3.8±0.1^{a}	0.5 ±0.09^{a,b}
T III	190±35^{c}	2140±120^{c}	34.8±3.5^{b}	154.4±0.35^{b}	4.4±0.32	0.5 ±0.01^{a}
Control	140±86^{c}	834±50^{d}	12.4±6.2^{b}	228.7±0.25^{b}	18.5±2.3^{b}	1.9 ±0.5^{c}
Muscovy						
T I	106±26^{c}	820±80^{e}	12.8±4.2^{b}	42.2±0.06^{a}	3.3±0.1^{a}	0.4 ±0.01^{a}
TII	120±65.6^{d}	740±78^{c}	11.1±3.4^{b}	42.2±0.05^{a}	3.8±0.2^{a}	0.5 ±0.1a
T III	140±35.2^{c}	1830±120^{c}	30.2±5.2^{b}	121.1±0.32^{b}	4.0±0.1^{a}	0.5±0.1^{a,b}
Control	90±47^{d}	500±89^{e}	7.3±3.4^{b}	164.1±0.52^{b}	22.4±4.2^{b}	2.2 ±0.69^{c}

a. b. c. d. e Means in columns with different superscripts are significantly different at ($p< .05$)

1 US $ = 1230 Tsh

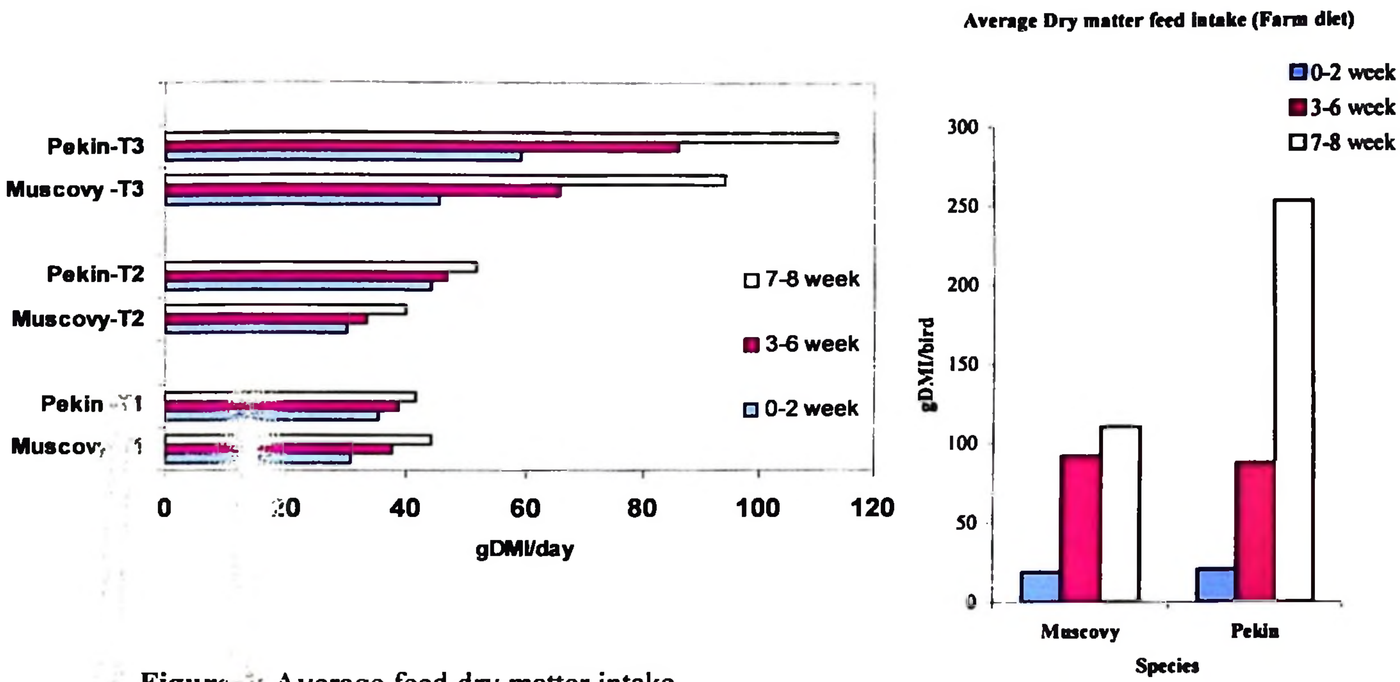

Figure : Average feed dry matter intake

4.3.2 Live weight gain

Table [illegible] shows initial weight and final weight of ducks and their corresponding average live weight gain. The weight gain in treatment III, were significantly higher in both species of ducks (P<0.05) compared to their contemporaries receiving lower offers. Ducks (Pekin and Muscovy) offered the farm ration had significantly inferior gains even when compared to those receiving lower rates of offer.

4.3.3 Feed Efficiency

Table 8. indicates that generally the feed efficiency (g Feed/g gain ratio) increased as the rate of offer was increased. This was true for both Pekin and Muscovy. The FCE was generally low for all level of offer. This was particularly so for the group receiving the Farm diet. The Muscovy and Pekin ducks fed on Farm diet needed between 4-5 times more feed per gram of gain when compared to those receiving T3 diet. This also translates to a difference of between 3-4 times better growth performances for ducks on experimental diet.

The unit cost of production, in terms of feed was higher in Pekin than Muscovy. The cost of production of ducks, increased as the rate offered increase.

As indicated in Table 9 the gross margin was higher in Pekin. It can be noted that the test diet at higher rate of offer (treatment III) had highest cost: benefit ratio. whereas the control diet had the least.

Pekin ducks in this study showed higher cost: benefit ratio, than the corresponding treatments for Muscovies. As similar trend was observed I gross margin.

Table 9: Gross margin analysis for Pekin and Muscovy ducks in the growth study at Ubena ranch.

Specie	Treatment	Total variable cost (Tsh / Duckling)				Gross return* (Tsh/Duck)	Benefit cost ratio
		Duckling	Feed	Medicine	Total cost		
	Treatment I	200	231.1	38.09	356.96	2455	6.8
Pekin	Treatment II	200	150.65	38.09	395.8	3119.2	7.9
	Treatment III	200	491.43	38.09	1034.9	6884	6.7
	Control	200	675.5	38.09	1280.7	1805	1.4
	Treatment I	100	67.75	38.09	283.6	1233.4	4.3
Muscovy	Treatment II	100	136.78	38.09	283.6	1085.4	3.8
	Treatment III	100	396.83	38.09	813.8	2571.7	3.2
	Control	100	413.73	38.09	1102.8	-1175.5	-0.1

Gross return* = Expected sale price at 2.7kg = Tsh. 10,000 approx . Tsh 3.7/g live weight for Pekins and Tsh. 5,000 (appr. Tsh 1.85/g live weight)
Test feed = 125/kg, Farm diet 100/kg.

4.4 Digestibility trial

The apparent DM, CP, Crude ether and Crude Fibre digestibility were not significantly affected by changing the rate of offer. However the CF digestibility improved as the rate of offer was increased. This was more so for Pekin than Muscovy as shown in Figure 3. Nevertheless the Muscovy had superior values of digestibility than the Pekin.

Table 10: Apparent nutrient digestibility of ducks

Parameter	T1		T2		T3		
	Pekin	Muscovy	Pekin	Muscovy	Pekin	Muscovy	Significance
DM Digestibility	0.77 ±0.02[a]	0.79 ±0.01[a]	0.77 ±0.01[a]	0.79 ± 0.01a	0.78 ±0.01[a]	0.79 ± 0.01[a]	Ns
CP Digestibility	0.75 ±0.03[a]	0.80 ±0.01[b]	0.77 ±0.02[a]	0.80 ±0.02[b]	0.83 ± 0.02[c]	0.81 ± 0.01[b]	Ns
EE Digestibility	0.81 ± 0.04a	0.72 ± 0.02b	0.87 ±0.09a	0.71 ±0.03b	0.85 ± 0.05a	0.62 ± 0.38ab	Ns
CF Digestibility	0.43 ± 0.28 [a]	0.56 ± 0.07 [a]	0.60 ±0.29[a]	0.66 ±0.04[b]	0.64 ±0.24[b]	0.75 ± 0.14 [c]	**

CHAPTER FIVE

5.0 DISCUSSION

5.1 Overview

With the exception of a few birds in Treatment I (who went off feed in 2nd week) all birds remained in a good health throughout the experimental period. Routine feeding was followed without problems and there was no shortage of feed materials throughout the experimental period.

5.2 Proximate chemical composition of feed ingredients and the test feed

Chemical analysis of the feed ingredients, that were used to compound the test feed, and the test feed itself showed that the range for most values were within expected values as reported by many local workers. (Doto *et al.*, 2004; Kaijage, 2003; Akinfala *et al.*, 2002 and Laswai *et al*, 2002). However the CP values for Fish Meal was far too low compared to the range commonly reported in the tropics. Further enquires revealed that the so-called fishmeal was made from the fish wastes arising from the fish processing industries around Lake Victoria. This material contains high content of skeletal structures left after filleting (Kjos, 2001; Katakweba, 2002). In additional the retailer informed the author of deliberate adulteration (adding sand and saw dust) made to increase weight. However the CP level of 16% in the test feed was enough to make it suitable for growers as recommended by Dean (1986).

The CF value recorded for CLM was slightly higher than the reported values by other workers around Morogoro (Doto *et al*, 2004). The deviation was within the acceptable limits for roughage materials collected at different stages of growth (Wanapat and Wachirapokorn, 1999). The Cassava leaf meal (CLM) was made from fairly mature stands of cassava. Ash content of the feed indicates high level of inorganic substances in the diet. In the test diet high ash content probably arises from fishmeal.

5.3 Dry matter intake

Ducks consumed all the feed that was being provided throughout the growth trial. This was true at all levels of offer of test diet, suggesting that the upper limit of appetite was not reached even at the highest rate of offer (i.e. 5%). Adult poultry normally consume 170 g – 230 g of feed per day (Payne, 1990). Pekin ducks on Farm diet group had the highest intake, consuming an average daily intake of 228.7± 0.25g/bird, whereas the Muscovy daily intake was164.1± 0.52 g/bird. These ranges are close to expected values as reported by Roy *et al*, (1994) working on White Pekin. Similar findings was observed by Dat and Yu, (2003) working on meat type Super M breed of duck. Average feed intake among treatment differed significantly; differences between species were noted, where Pekin ducks consumed more than Muscovy at all rates of offer. Similar result was reported by Bhuiyan *et al*, (2005), working on Pekin, Muscovy and Deshi white ducks from day old to 9 weeks, which showed Pekin to consume more. Provision of dry mash instead of wet mash could have caused some inaccuracies in the determination of voluntary intake. However the same procedure was applied to all treatments thus it was still possible to capture the treatment differences.

5.4 Effect of rate of offer on growth performance

There was a clear trend of improved growth performance for both Pekin and Muscovy as the rate of feed on offer was increased. The Pekin ducks had significantly superior rate of gain compared to the Muscovy. Similar observations have been reported by other workers. Bhuiyan *et al*, (2005) reported a higher growth rate in Pekin as compared to Muscovy and Deshi white ducks.

Birds on treatment III showed most impressive gain compared to those on other treatments. This phenomenon was true for both species. Increasing the rate of offer from 2.5% to 5.0% improved dry matter intake by a magnitude of 2.6 to 4.2 times depending on the stage of growth (the higher margin being noted during the 7th and 8th weeks). This improvement corresponds with the higher final weight (125%) in birds on treatment III. Such a trend would suggest that improving the Farm diet by inclusion of FM and CLM could help in reaching breedable weight (approximately 2.7 kg live-weight) earlier for both Pekin and Muscovy replacement ducklings. Under this experimental feeding regime both the Pekin and the Muscovy had attained respectively about 77% and 66.7%

of their expected breeding weight by the 8th week. This compares favourably against the rate of growth recorded for ducks receiving the Farm diet.

5.5 Feeding cost and margin return for Pekin and Muscovy production

Feed costs contribute 60 – 80% of total cost of production. To optimise production one would aim at improving feed efficiency. It was observed that FE was improved as the rate of offer was decreased. Birds on treatment III had 2 – 3 times higher gross margins than those in TI and TII. When compared to the traditional feeding (Farm diet) the benefits were 3.5- 4 times higher. This suggests that offering a good quality diet leads to better results despite the increase in total cost (Bhuiyan *et al*, 2005).

The gross margin obtained was higher in Pekin than in Muscovy ducks; findings that are similar to those of Ali and Muslim (1995) and Bhuiyan *et al*, (2005). This was particularly so for birds offered the higher rate of feeding (treatment III). The superior gross margin of the Pekin arises from the fact that they were larger in size than the Muscovy and because they normally fetch a better price. This observation is similar to reports by Bhuiyan *et al*, (2005) and suggests that it can be feasible to raise Pekin ducks commercially in Tanzania.

To improve the gross margins, cheap protein sources e.g. cassava leaf meal should be used. This study showed the inclusion of cassava leaf meal was equally acceptable as the fishmeal in the ration

Johnson and Raymond (1965), Wanapat *et al*, (2000[b]) and Nguyen and Preston, 2004) showed that proper sun drying is sufficient to reduce the level of cyanide. Inclusion of 30% of cassava leaf meal in the diet had no ill effect on ducks even when offered at a rate of 5% of body weight.

5.6 Effect of rate of offer on apparent nutrient digestibility

Apparent nutrient digestibility of feed was higher in Muscovy than in Pekin. Similar findings was reported by Borin *et al.* (2006), that indigenous breeds of ducks normally have higher digestibility than exotic breeds because they have adapted to the high fibre diets common in the tropics. However, in this study the difference for dry matter, crude protein and crude ether were not statistically significant.

The increase of rate of offer of feed had no effect on digestibility of nutrient; this is at variance with many other studies. Bond (1987), Payne (1990) and Borin *et al.* (2006) reported on decrease in digestibility as the rate of feed offer increases.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATION.

6.1 Conclusions

Result from this study shows that ducks can perform reasonably well on a diet of 16 % CP offered at a rate of 5% of their body weight. However, more feed can be provided to ducks since the upper limit of appetite was not reached.

Feeding at 5% was both efficient and cost effective. Farmers keeping Muscovy and Pekin ducks may benefit from this feeding regime, as ducks rationed at 5% of body weight attained over 2.0 live weight by the 9^{th} week. It is suggested that ducks should be marketed sooner than is traditionally done in Tanzania.

To improve the gross margin, inclusion of cassava leaves at 30% of the diet proved to be cost effective and had no detrimental effect on intake and health of ducks, suggesting that it may be feasibly used to replace fish meal, hence reduce fed cost.

Ducks are more resistant to diseases, are able to digest higher fibre diets, and are well adapted to tropical environments. They can be kept in backyards and on marginal land, so can be utilized to produce cheap animal protein using locally available materials.

6.2 Recommendations

i) The Study did not exhaust the whole range of information on performance parameters like egg production. egg quality and hatchability. and carcass quality was not evaluated due to lack of resources and time.

ii) Promotion and marketing of ducks is the major constraint facing the duck production in Tanzania. There is no hatchery for a day old ducklings (DOD). Most farmers depend on home grown parent stock for replacement. The diets shown in this trial suffice to meet the requirements for breeder stocks as on-farm replacements. It is suggested that Tanzania follows the example of South-East Asia countries where the duck industry is well established and helps to diversify resource utilization.

iii) Feeding of dry mash as adopted in this experiment may have limited the intake or exaggerated the spillage. It is recommended that feeds should be offered as wet mash to encourage higher intake.

iv) Further studies are required to establish proper feeding practice of ducks up to breeding age for both males and females.

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8.0 APPENDICIES

Appendix 1: Proximate analysis results for feed ingredients and test diet

		Dm%	Ash%	CF%	EE%	CP%
	Replicate1	95.320	27.810	8.790	7.332	26.945
	Replicate2	94.32	28.06	8.68	7.45	26.96
Fish Meal	Replicate3	96.21	27.72	8.84	7.23	27.18
	Replicate4	95.22	27.82	8.88	7.32	26.67
	Replicate1	90.200	2.060	11.860	15.874	10.605
	Replicate2	89.98	2.16	11.85	15.98	10.62
Maize Bran	Replicate3	90.25	2.05	11.82	15.86	10.55
	Replicate4	90.38	1.98	11.91	15.76	10.62
	Replicate1	89.040	15.010	10.520	10.314	15.972
Test Diet	Replicate2	89.21	15.14	10.54	10.35	15.67
	Replicate3	89	14.97	10.57	10.3	16.33
	Replicate4	88.91	14.92	10.46	10.29	15.92
	Replicate1	67.500	4.320	19.880	5.431	22.961
Cassava leaf	Replicate2	67.45	4.56	19.87	5.61	22.82
	Replicate3	67.52	4.24	20.14	5.32	23.84
	Replicate4	67.54	4.21	19.64	5.36	22.21

Appendix 2: Weight, feed intake, feed conversion efficiency and cost feeding cost.

S/no	Bird	Specie	Treatment	Rooms	Weight	Feed/day(g)	Total weekly intake	Average total feed	Average total weight change	FCE	Feeding cost
1	1.0	Muscovy	Control	I	0.5	186.0	1302.0	5530.0	380.0	0.1	1.5
2	2.0	Muscovy	Control	I	0.6	70.0	490.0	2303.0	484.0	0.2	0.5
3	3.0	Muscovy	Control	I	0.4	72.8	509.6	2430.4	376.0	0.2	0.6
4	4.0	Muscovy	Control	I	0.5	236.0	1652.0	6286.0	320.0	0.1	2.0
5	5.0	Pekin	Control	I	0.4	218.0	1526.0	6468.0	318.0	0.0	2.0
6	6.0	Pekin	Control	I	0.6	240.0	1680.0	7308.0	516.0	0.1	1.4
7	7.0	Pekin	Control	I	0.9	238.0	1666.0	7406.0	784.0	0.1	0.9
8	8.0	Pekin	Control	I	0.9	218.0	1526.0	7420.0	782.0	0.1	0.9
9	9.0	Pekin	Control	I	0.9	244.0	1708.0	7728.0	748.0	0.1	1.0
10	10.0	Pekin	Control	I	1.1	214.0	1498.0	7140.0	1042.0	0.1	0.7
11	11.0	Muscovy	Control	I	1.3	172.0	1204.0	7266.0	1222.0	0.2	0.6
12	12.0	Muscovy	Control	I	1.5	248.0	1736.0	3304.0	420.0	0.1	0.8
13	1.0	Muscovy	Level2	A	0.6	16.3	114.0	554.9	506.0	0.9	0.1
14	2.0	Muscovy	Level2	A	0.6	16.3	114.0	570.2	516.0	0.9	0.1
15	3.0	Muscovy	Level2	A	0.7	19.1	133.7	367.7	310.0	0.8	0.1
16	4.0	Muscovy	Level2	A	0.8	21.9	153.4	711.8	540.0	0.8	0.2
17	5.0	Muscovy	Level2	A	0.8	22.5	157.3	738.5	706.0	1.0	0.1
18	6.0	Pekin	Level2	A	0.7	20.8	145.5	670.5	650.0	1.0	0.1
19	7.0	Pekin	Level2	A	1.0	28.7	200.6	751.1	740.0	1.0	0.1
20	8.0	Muscovy	Level2	B	0.7	19.1	133.7	617.0	602.0	1.0	0.1
21	9.0	Muscovy	Level2	B	0.8	21.4	149.4	601.7	480.0	0.8	0.2
22	10.0	Pekin	Level2	B	0.7	18.5	129.8	428.7	400.0	0.9	0.1
23	11.0	Pekin	Level2	B	0.9	24.7	173.0	818.0	620.0	0.8	0.2
24	12.0	Pekin	Level2	B	1.0	27.0	188.8	825.8	780.0	0.9	0.1

25	13.0	Pekin	Level2	B	1.0	28.1	196.6	707.9	680.0	1.0	0.1
26	14.0	Pekin	Level2	C	1.4	39.9	279.2	1152.3	640.0	0.6	0.2
27	15.0	Pekin	Level2	C	1.6	45.5	318.5	1803.9	1526.0	0.8	0.1
28	16.0	Pekin	Level2	C	2.0	57.3	401.1	1852.3	1060.0	0.6	0.2
29	17.0	Muscovy	Level2	C	0.9	33.8	236.7	776.3	620.0	0.8	0.2
30	18.0	Muscovy	Level2	C	0.5	21.2	148.7	562.7	476.0	0.8	0.1
31	1.0	Muscovy	Level3	D	0.7	29.1	203.7	810.4	476.0	0.6	0.2
32	2.0	Muscovy	Level3	D	0.8	30.7	214.7	814.8	400.0	0.5	0.3
33	3.0	Muscovy	Level3	D	0.9	33.8	236.7	1095.1	782.0	0.7	0.2
34	4.0	Muscovy	Level3	D	0.9	36.2	253.3	1172.2	842.0	0.7	0.2
35	5.0	Pekin	Level3	D	0.9	36.2	253.3	1176.6	846.0	0.7	0.2
36	6.0	Pekin	Level3	D	1.0	40.9	286.3	1420.5	420.0	0.3	0.4
37	7.0	Pekin	Level3	D	1.1	41.7	291.8	1013.0	300.0	0.3	0.4
38	8.0	Pekin	Level3	D	1.1	44.0	308.3	1592.8	1034.0	0.6	0.2
39	9.0	Pekin	Level3	D	1.1	44.8	313.8	1414.9	860.0	0.6	0.2
40	10.0	Pekin	Level3	D	1.3	51.9	363.4	1233.3	480.0	0.4	0.3
41	11.0	Muscovy	Level3	E	0.9	36.2	253.3	2274.4	852.0	0.4	0.3
42	12.0	Muscovy	Level3	E	1.0	38.5	269.8	2230.9	916.0	0.4	0.3
43	13.0	Pekin	Level3	E	1.1	42.5	297.3	1222.3	360.0	0.3	0.4
44	14.0	Muscovy	Level3	E	1.0	39.3	275.3	1158.4	932.0	0.8	0.2
45	15.0	Pekin	Level3	E	1.1	41.7	291.8	1484.9	986.0	0.7	0.2
46	16.0	Muscovy	Level3	E	1.0	40.1	280.8	1372.0	956.0	0.7	0.2
47	17.0	Pekin	Level3	E	1.1	44.0	308.3	1414.9	680.0	0.5	0.3
48	18.0	Muscovy	Level3	E	1.0	40.9	286.3	1257.5	972.0	0.8	0.2
49	1.0	Muscovy	Level5	F	1.2	45.6	319.3	1568.0	1084.0	0.7	0.2
50	2.0	Muscovy	Level5	F	1.5	82.0	574.2	1753.9	1220.0	0.7	0.2
51	3.0	Muscovy	Level5	F	1.9	105.6	739.3	5166.6	1804.0	0.3	0.4
52	4.0	Muscovy	Level5	F	1.9	107.9	755.1	6346.4	1852.0	0.3	0.4
53	5.0	Pekin	Level5	F	2.2	122.5	857.3	3813.8	2082.0	0.5	0.2
54	6.0	Muscovy	Level5	F	2.3	127.0	888.8	3637.6	2174.0	0.6	0.2
55	7.0	Muscovy	Level5	G	2.4	136.0	951.7	4468.2	2298.0	0.5	0.2
56	8.0	Muscovy	Level5	G	1.9	106.2	743.3	3551.9	1794.0	0.5	0.2
57	9.0	Pekin	Level5	G	2.7	151.7	1061.8	5033.7	2580.0	0.5	0.2

58	10.0	Muscovy	Level5	G	1.4	77.5	542.7	1956.9	1304.0	0.7	0.2
59	11.0	Muscovy	Level5	G	1.5	86.5	605.6	2555.4	1474.0	0.6	0.2
60	12.0	Pekin	Level5	G	2.2	122.5	857.3	4142.6	2086.0	0.5	0.2
61	13.0	Pekin	Level5	H	2.4	133.7	936.0	4317.2	2282.0	0.5	0.2
62	14.0	Pekin	Level5	H	2.4	137.1	959.6	4473.7	2344.0	0.5	0.2
63	15.0	Pekin	Level5	H	2.5	139.3	975.3	4671.9	2360.0	0.5	0.2
64	16.0	Pekin	Level5	H	2.4	133.7	936.0	4317.2	2282.0	0.5	0.2
65	17.0	Pekin	Level5	H	2.4	137.1	959.6	4473.7	2344.0	0.5	0.2
66	18.0	Pekin	Level5	H	2.5	139.3	975.3	4671.9	2360.0	0.5	0.2

Appendix 3: Feed intake, weight gain, and nutrient digestibility in digestibility trials

MUSCOVY

				Excreta										
Cage No	Weight	Treatment	Amount Feed /day	1	2	3	4	5	Feed/day	ApDM dig	ApCF dig	ApAshdig	ApEEdig	ApCpdig
1	1228	I	61.4	159	160	158	145	164	61.4	0.79	0.56	0.56	0.71	0.8
2	1867	I	93.36	230	212	320	219	202	93.36	0.8	0.48	0.32	0.71	0.8
3	1217	I	60.86	147	147	154	230	181	60.86	0.79	0.65	0.37	0.74	0.81
4	1325	II	92.76	213	238	255	219	261	92.76	0.79	0.39	0.45	0.69	0.82
5	1322	II	92.56	232	201	252	205	253	92.56	0.79	0.33	0.43	0.75	0.81
6	1632	II	114.24	282	283	286	285	244	114.24	0.8	0.41	0.3	0.69	0.77
7	1299	III	129.9	305	296	307	289	352	129.9	0.8	0.94	0.52	0.76	0.83
8	1557	III	151.7	353	336	343	315	374	151.7	0.78	0.81	0.45	0	0.8
9	1512	III	151.2	306	293	271	268	371	151.2	0.79	0.7	0.54	0.74	0.8
10	1876	III	187.6	550	481	472	432	368	187.6	0.78	0.56	0.47	0.99	0.81

PEKIN

Cage No	weight	Treatment	Amount Feed /day	Excreta 1	2	3	4	5	Feed/day	ApDM dig	ApCF dig	ApAshdig	ApEEdig	ApCpdig
1	1382	I	69.5	100	121	150	135	143	69.5	0.78	0.15	0.47	0.81	0.78
2	1829	I	91.46	165	215	184	264	179	91.46	0.75	0.35	0.34	0.86	0.75
3	1888	I	94.4	155	200	214	208	256	94.4	0.79	0.79	0.44	0.76	0.72
4	1934	II	135.38	205	225	307	275	268	135.38	0.77	0.93	0.34	0.77	0.76
5	1236	II	86.52	167	197	189	181	198	86.52	0.79	0.81	0.42	0.97	0.79
6	1952	II	136.64	227	238	266	262	261	136.64	0.76	0.28	0.45	0.86	0.76
7	1981	III	198.1	286	416	396	440	436	198.1	0.78	0.87	0.4	0.8	0.84
8	1969	III	196.9	330	321	373	362	434	196.9	0.77	0.41	0.45	0.9	0.81

Appendix 4: ANOVA Feed intake, weight, FCE, and feeding cost.

The GLM Procedure

Class Level Information

Class	Levels	Values
spec	2	Muscovy Pekin
treat	4	Control Level2 Level3 Level5

Number of observations 63

Appendix 4a: ANOVA for Total feed intake

Dependent Variable: Total feed

Source	DF	Type III SS	Mean Square	F Value	Pr > F
spec	1	13271695.4	13271695.4	15.66	0.0002
treat	3	187928722.4	62642907.5	73.89	<.0001
spec*treat	3	11826092.4	3942030.8	4.65	0.0057

R-Square	Coeff Var	Root MSE	tfeed Mean
0.846513	36.80775	920.7314	2501.460

Appendix 4b: ANOVA for weight gain

Dependent Variable: Total amount weight

Source	DF	Type III SS	Mean Square	F Value	Pr > F
spec	1	1264409.73	1264409.73	18.54	<.0001
treat	3	18868005.46	6289335.15	92.21	<.0001
spec*treat	3	976330.22	325443.41	4.77	0.0050

R-Square	Coeff Var	Root MSE	tweight Mean
0.843855	26.93902	261.1631	969.4603

Appendix 4c: ANOVA for Feed conversion efficiency

Dependent Variable: fce

Source	DF	Type III SS	Mean Square	F Value	Pr > F
spec	1	0.04444640	0.04444640	2.06	0.1567
treat	3	3.51489647	1.17163216	54.35	<.0001
spec*treat	3	0.07256496	0.02418832	1.12	0.3481

R-Square	Coeff Var	Root MSE	fce Mean
0.775137	24.93153	0.146819	0.588889

Appendix 4d: ANOVA for feeding cost

Dependent Variable: Feeding cost

Source	DF	Type III SS	Mean Square	F Value	Pr > F
spec	1	0.00051484	0.00051484	0.01	0.9249
treat	3	7.08845809	2.36281936	41.15	<.0001
spec*treat	3	0.04209325	0.01403108	0.24	0.8650

R-Square	Coeff Var	Root MSE	cost Mean
0.709362	65.52435	0.239632	0.365714

Appendix 5: ANOVA for feed intake, and nutrient digestibility

Appendix 5a: ANOVA for Apparent digestibility of dry matter

Dependent Variable: ApDMdig

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Spec	1	0.00515802	0.00515802	49.52	<.0001
Treat	3	0.00047167	0.00015722	1.51	0.2183
Spec*Treat	3	0.00024500	0.00008167	0.78	0.5062

R-Square	Coeff Var	Root MSE	ApDMdig Mean
0.466146	1.302920	0.010206	0.783333

Appendix 5b: ANOVA for Apparent digestibility of dry Crude protein

Dependent Variable: ApCFdig

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Spec	1	0.08000079	0.08000079	2.49	0.1184
Treat	3	1.23937500	0.41312500	12.86	<.0001
Spec*Treat	3	1.22209500	0.40736500	12.68	<.0001

R-Square	Coeff Var	Root MSE	ApCFdig Mean
0.473391	30.96059	0.179227	0.578889

Appendix 5c: ANOVA for Apparent digestibility of Ash

Dependent Variable: ApAshdig

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Spec	1	0.00011321	0.00011321	0.03	0.8609
Treat	3	0.09294667	0.03098222	8.46	<.0001
Spec*Treat	3	0.03532000	0.01177333	3.21	0.0271

R-Square	Coeff Var	Root MSE	ApAshdig Mean
0.345339	14.11271	0.060528	0.428889

Appendix 5d: ANOVA for Apparent digestibility of Crude ether

Dependent Variable: ApEEdig

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Spec	1	0.34766116	0.34766116	9.70	0.0025
Treat	3	0.04004167	0.01334722	0.37	0.7731
Spec*Treat	3	0.06918833	0.02306278	0.64	0.5892

R-Square	Coeff Var	Root MSE	ApEEdig Mean
0.197616	25.22252	0.189309	0.750556

Appendix 5e: ANOVA for Apparent digestibility of Crude Protein

Dependent Variable: ApCpdig

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Spec	1	0.01369811	0.01369811	64.19	<.0001
Treat	3	0.02353000	0.00784333	36.75	<.0001
Spec*Treat	3	0.01897000	0.00632333	29.63	<.0001

R-Square	Coeff Var	Root MSE	ApCpdig Mean
0.777228	1.844018	0.014609	0.792222