EFFECT OF PAWPAW SEED MEAL SUPPLEMENTATION ON PRODUCTIVITY, MORTALITY AND CARCASS CHARACTERISTICS OF INDIGENOUS VENDA CHICKENS RAISED IN CLOSED CONFINEMENT

MASTER OF SCIENCE IN AGRICULTURE (ANIMAL PRODUCTION)

S. Y. MOSEHLANA

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BY

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SUPERVISOR : PROF. J. W. NG'AMBI
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DECLARATION

I declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Science in Agriculture (Animal Production) has not previously been submitted by me for a degree at this or any other University; that it is my own work in design and execution, and that all material contained herein has been duly acknowledged.

………………………………….. ……………………………

Mr S. Y. Mosehlana Date

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DEDICATION

This mini-dissertation is dedicated to my lovely parents Leroki A. and Ngwarekgotho E. Mosehlana for their understanding, caring, encouraging and financial support throughout the whole period of study and also to my late uncle Jackson and aunty Joyce Mokanzi.

ABSTRACT

A nutritional experiment was conducted to determine the effect of pawpaw seed meal supplementation on productivity, mortality and carcass characteristics of indigenous Venda chickens raised in closed confinement. Supplementation levels of 0, 50, 100, 150 and 200 g of pawpaw seed meal per kg DM feed were used in a completely randomised design having five replications with 10 birds per replication. Pawpaw seed meal supplementation had no effect ($P>0.05$) on growth rate, live weight, nitrogen retention and diet DM digestibility of Venda chickens aged one to seven weeks. Similarly, pawpaw seed meal supplementation had no effect ($P>0.05$) on feed intake, growth rate, live weight, diet DM digestibility, and carcass, breast, thigh, drumstick, wing, gizzard, liver, heart and fat pad weights and also on meat juiciness and flavour of female Venda chickens aged eight to 13 weeks. However, pawpaw seed meal supplementation improved ($P<0.05$) feed intake, feed conversion ratio and metabolisable energy of Venda chickens aged one to seven weeks. Similarly, pawpaw seed meal supplementation improved ($P<0.05$) feed conversion ratio, metabolisable energy, nitrogen retention and meat juiciness of female Venda chickens aged eight to 13 weeks. Mortality of indigenous Venda chickens fed diets supplemented with pawpaw seed meal was reduced from 20 to 0 % ($P<0.05$) as compared to those of chickens on diets without pawpaw seed meal supplementation.

Growth rate, live weight, metabolisable energy and nitrogen retention of indigenous Venda chickens aged one to seven weeks were optimized at different pawpaw seed meal supplementation levels of 133, 143, 101 and 133 g/kg DM feed, respectively. Similarly, growth rate, live weight, metabolisable energy and nitrogen retention of female Venda chickens aged eight to 13 weeks were optimized at different pawpaw seed meal supplementation levels of 54, 87, 69 and 177 g/kg DM feed, respectively.

Results of the present study showed no single dietary pawpaw seed meal supplementation level for all production variables. It is concluded that pawpaw seed meal supplementation can reduce mortality of indigenous Venda chickens.

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CHAPTER 1

INTRODUCTION

1.1 Background

Indigenous chickens are very important in South Africa and the world as a whole. These chickens are economically, nutritionally and socially important to rural people of South Africa. However, their productivity values are low (Singh, 1990). They have high feed conversion ratios, low growth rates and high mortality rates (Mupeta *et al.*, 2002). Poor health, nutrition and management have been contributory factors to low productivity values of these chickens. It is estimated that more than 50 % of the low productivity in indigenous chickens is attributable to poor nutrition (Kitalyi, 1997). There is evidence that pawpaw seed meal supplementation reduces mortality rates in chickens (Braunius, 1987; Hofstad, 1984; Reid, 1990; Reid and Mcdougald, 1991; Ruff and Allen, 1990). However, such information is not extensive and conclusive. Thus, there is need to ascertain the effect of pawpaw seed meal supplementation on productivity and mortality of indigenous Venda chickens. Indigenous Venda chickens are economically and nutritionally very important to rural people of Limpopo Province.

1.2 Problem statement

Indigenous Venda chickens are important to rural people of South Africa. However, these chickens have low growth and high mortality rates (Mtileni *et al*., 2010; Mbajiorgu *et al*., 2011; Adesola *et al*., 2012). Their low productivity results in poor nutrition and less income for rural people of South Africa.

1.3 Motivation

This study will determine the effect of dietary pawpaw seed meal supplementation level on feed intake, digestibility, feed conversion ratio, growth and carcass characteristics of indigenous Venda chickens. Results from this study will help in finding ways of improving productivity and reducing mortality rates of indigenous Venda chickens. Such information will enhance the economic, nutritional and social status of Venda chicken farmers.

1.4 Aim and objectives

The aim of this study was to improve productivity and reduce mortality rates of Venda chickens through supplementation of pawpaw seed meal to the diets. The objectives of this study were as follows:

i. To determine the effect of pawpaw seed meal supplementation on feed intake, digestibility, growth, mortality and carcass characteristics of indigenous Venda chickens kept in closed confinement.
ii. To determine pawpaw seed meal supplementation levels for optimal productivity, mortality and carcass characteristics of indigenous Venda chickens kept in closed confinement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Chickens are a dependable quick protein source and even a store of economic value in rural communities of developing countries (Annan-Prah, 2010). Approximately 80% of the chicken populations in Africa are reared in free scavenging systems (Gueye, 1998). Olori and Sonaiya (1998) reported that in most African countries, the rural chicken population accounts for more than 60% of the total national chicken. Wattanachant *et al.* (2005) reported that the meat from indigenous chickens has a unique taste and texture and is popular among consumers. Meat and eggs from indigenous chickens are tastier and preferred by most consumers to those obtained from commercial chicken breeds (Mbugua, 1990). The proportional contribution of poultry to the total animal protein production of the world by the year 2020 is estimated to increase to 40%, the major increase being expected in the developing world (Delgado *et al*., 1999). However, their productivity is low (Kondombo, 2005). They have low egg production, poor growth rates and high mortality rates (Tadelle *et al*., 2003). Teketel (1986) and Aberra (2000) also characterized the low productivity in terms of low egg production, production of small-sized eggs, slow growth rate, late maturity, small clutch size, an instinctive inclination to broodiness and high mortality of chicks. The most striking problem in village chickens is high mortality rate which could reach as high as 80–90% within the first few weeks after hatching, due to diseases and predation (Wilson *et al*., 1987). High mortality rates of indigenous chickens affect their sustainability and productivity (Kugonza *et al.*, 2008). Tadelle *et al.* (2003) found that mortality goes up to 49 % in village chickens in Ethiopia while Kugonza *et al*. (2008) reported that mortality goes up to 74 % in local chickens in Uganda. Feeding pawpaw seed meal tends to reduce mortality rates in broiler chickens (Ekanem *et al.,* 2004). However, such information is limited and inconclusive. In fact, no such research in indigenous Venda chickens was found. Therefore, there is need to ascertain the effects of pawpaw seed meal supplementation on productivity, mortality and carcass characteristics of indigenous Venda chickens.

2.2 Chemical composition of pawpaw seeds

Passera and Spettoli (1981) observed that pawpaw seeds have high percentage of ash (4.86 %), crude protein (16.86 %) and crude fibre (3.21 %) but are low in fat (11.16 %). Chinoy *et al*. (1994) and Passera and Spettoli (1981) reported that oleic (79.1 %), palmitic (16.6 %), stearic (4-5 %) and linoleic (2.5-3.5 %) acids are present in large amounts in pawpaw seeds. Pawpaw seed oil, also, contains high amounts of benzylisothiocyanate (0.56 %) and benzylglucosinolate (1 %) (Harvey *et al.,* 2006). Pawpaw is also a good source of fibre (21.8 %), which has been shown to lower high cholesterol levels of animals (Guruma, 2010). Hoernecke *et al.* (1993), Duskova and Wald (1999), Hofstad (1984) and Schwinger (1970) observed that pawpaw seeds contain high amounts of papain which assists in immune systems. Artschwager (1996) observed that pawpaw seeds contain high amounts of carbohydrates, carpasemine, benzyl senevol and a glucoside. Calam *et al.* (1985) reported that the main constituents of pawpaw latex are papain and chymopapain. According to Gwatkin (1964), Grag *et al.* (1970), Singh and Devi (1978) and Egbunike *et al*. (2000), all parts of the pawpaw tree contain whitish latex which is rich in papain, a proteolytic enzyme. Results of the study of Poulter and Caygill (1985) found that a pawpaw plant is the most natural source of papain, an effective natural digestive aid which breaks down protein and cleanses the digestive tract. The latex of *Carica papaya* is a rich source of the cysteine endopeptidases (digestive enzymes), including papain, glycyl endopeptidase, chymopapain and caricain, which constitute more than 80 % of the whole enzyme fraction (El Moussaoui *et al.*, 2001; Azarkan *et al.*, 2003). Rakhimov (2000) also reported that *Carica papaya* contains several unique protein-digesting enzymes including *papain* and *chymopapain*.

According to Harvey *et al.* (2006), pawpaw seed meal has a high crude protein content of about 40.0 %. Bolu *et al.* (2009) found that dried pawpaw seeds contain 30.08 % crude protein, 34.80 % ether extract, 1.67 % crude fibre and a nitrogen free extract of 23.67 %, with an ash content of 7.11 %, moisture content of 2.7 % and dry matter content of 97.27 %. Calcium and phosphorus occur in appreciable quantities of about 17 340 μ/g and 10 250 μ/g, respectively (Marfo *et al.,* 1986).

2.3 Effect of pawpaw seed meal supplementation on productivity of animals

Papain in pawpaw leaf meal aids in protein digestion, thus it enhances the release of free amino acids necessary to enhance growth (Onyimonyi and Onu, 2009). Poulter and Caygill (1985) observed that papain is an effective natural digestive aid which breaks down protein and cleanses the digestive tract of chickens. Cornell University (2008) observed that chymopapain and papain in pawpaw seeds improve feed digestibility in livestock. The increase of total protein in blood of rabbits fed pawpaw latex was associated with improvement of crude protein digestibility (El-Kholy *et al.*, 2008). Dry matter and protein digestibilities in buffaloes given diets supplemented with pawpaw leaf and seed meals are up to 49.9 % and 51.4 %, respectively (Babu *et al*., 2003). Papain also helps humans remove the extra fat from the bodies and accelerates their metabolism (Look Chemistry, 2008). Papain and vitamin C in pawpaw seeds improve the digestion in humans and remove toxins from the bodies (Look Chemistry, 2008). Penaflorida (1995) observed increased feed conversion ratio in *Penaeus monodon postlarvae* fed diets supplemented with unsoaked pawpaw leaf meal. Papain extracted from pawpaw seeds increased immune system functions in livestock (Hoernecke *et al.,* 1993; Duskova and Wald*,* 1999; Hofstad, 1984; Schwinger, 1970). The addition of *Carica papaya* latex to the growing New Zealand white rabbit diets improved immunity capabilities (El-Kholy *et al.*, 2008).

Pawpaw peels and leaf meals fed to giant West African snails gave the best results in feed intake increment with no adverse effects when compared to other tropical fruit by-products (mango, plantain and cocoyam) (Omole *et al*., 2004). Bolu *et al.* (2009) observed significant improvement in feed intake (63.56 %) and live weight gain (79.79 %) of broiler chickens when the diets were supplemented with pawpaw seed meal. Pawpaw leaf meal inclusion to the diets of broiler chickens improved their growth and live weight (Onyimonyi and Onu, 2009). Similarly, Lohiya *et al.* (2006) observed that rats given pawpaw seeds showed a slight increase in body weight. However, Udoh *et al.* (2005) observed mild hypertrophy and hyperplasia of muscles in rats given pawpaw seed meal. Udoh *et al.* (2004) reported pronounced hypertrophy and hyperplasia on thyrotrophs (TSH cells) of anterior pituitary and on thyroid glands of rats. Jegede *et al.*

(2008) observed that fish fed pawpaw seed meal diets showed a slight increase in interstitial cells. Udoh and Udoh (2005) observed that pawpaw seed meal supplementation resulted in some proliferation of hepatic cell cirrhosis in rats. Artschwager (1996) observed that papain supplementation tenderizes chicken meat. El-Kholy *et al.* (2008) observed improved growth and live weight of New Zealand white rabbits given diets supplemented with pawpaw latex. Weight gain of *Penaeus monodon postlarvae* fed diets supplemented with unsoaked pawpaw leaf meal was improved by (16 %) (Penaflorida, 1995). According to Carson *et al.* (2000), Cavieres *et al.* (2002) and Wang and Dey (2006) weight of rats administered with fermented pawpaw seed extracts increased. Jegede *et al*. (2008) observed a slight increase in intestinal cells of fish fed diets supplemented with pawpaw seed meal while Udoh *et al.* (2005) found improved body weight on albino rats supplemented with pawpaw seed meals. Rat foetuses treated with 100 mg of papain per kg body weight had significant increases in the implantation sites (Oderinde *et al*., 2002).

Negative effects of pawpaw seed meal supplementation on livestock productivity have also been reported. Asian sea bass given pawpaw leaf meal had lower growth rates than those on control diets (Eusebio *et al*., 2000). Indian prawns (*Fenneropenaeus indicus*) fed a soybean meal-based diet where pawpaw leaf meal replaced 9% of the protein had lower growth rates and weight gains than those fed the control diet (Eusebio *et al*., 1998). Abdulazeez *et al.* (2009) found no significant differences in litter size and litter body weight in rats dosed with the fermented extract of *Carica papaya* seeds compared to the control group. Chinoy *et al*. (1994) indicated that pawpaw extract did not promote body weight gain or water retention in obesed rats. Papain in trials with rats did not improve their body weights (Encyclopedia International, 2012). There was a significant reduction in the body weights of the fetuses in the group treated with 60 mg of the extract of *Carica papaya* leaf meal per kg body weight compared with the control (Ekong *et al.,* 2011). Oderinde *et al*. (2002) reported that aqueous extracts of *Carica papaya* seeds at an oral dose of 800 mg/kg body weight showed no significant differences in the total body weight of the rat fetuses exposed to these regimes. Rat fetuses treated with 100 mg/kg body weight significantly decreased. Raji *et al*. (2005)

reported significant litter reduction with no effect on the fetal weight and morphology with the seed extract, while Abdulazeez *et al*. (2009) reported that fermented seed extract did not affect rat litters nor their weights and morphometry.

The study conducted by Satrija *et al*. (1995) supports the results of other studies which indicate that pawpaw latex is effective against *Ascaridia galli* in chickens. Annan-Prah (2010) observed that giving pawpaw seeds to rural chickens alleviates coccidiosis. Cornell University (2008) observed that pawpaw seed meals could be used as dewormers in chickens. They observed that 6.25 % aquous extract of the seeds has the greatest anticoccidia oocyst production effect. Similarly, Naidoo *et al.* (2008) observed that extracts of pawpaw seeds reduced the number of protozoa that cause coccidiosis in chickens. Papain is used to treat digestion disorders (bloating and chronic indigestion), arthritis, intestinal worms, warts, corns and sinuses in humans. The milky juice of the unripe pawpaw fruit is a powerful anti-helminthic for roundworms, stomach disorders and enlargement of liver and spleen of humans (Gill, 1992). The seeds are also effective as a vermifuge and in the treatment of hypertension, diabetes mellitus and hypercholesterolemia in humans (Gill, 1992). In addition, pawpaw contains the digestive enzyme, papain, which is used like bromelain, a similar enzyme found in pineapple, to treat sports injuries, other causes of trauma, and allergies. Vitamin C and vitamin A, which are made in the body from the beta-carotene in pawpaw, are both needed for the proper function of a healthy immune system in humans (Guruma, 2010). Papain and chymopapain enzymes have been shown to help lower inflammation and to improve healing from burns in humans (Rakhimov, 2000). In addition, the antioxidant nutrients found in pawpaw, including vitamin C, vitamin E, and beta-carotene are also very good at reducing inflammation in humans (Jarvik *et al.,* 2002).

Consumption of pawpaw may cut risk of certain cancers in animals (Irwig, 2002). Various isothiocyanates are effective anti-cancer agents in experimental animals. Pawpaw is a good source of nutrients and some phyto-chemicals such as beta-cryptoxanthin and benzyl isothiocyanates. It is believed that these phytochemicals may offer benefits on certain chronic conditions such as cancers. Dietary tocopherols and carotenoids have been believed to cut risks of certain cancer and cardiovascular diseases (Irwig, 2002). Recently, Otsuki *et al.* (2009) showed that *Carica papaya* leaf extract mediated a Th1 type shift in human immune system; they believe it is an evidence that pawpaw leaf extract may benefit people at risk of cancer. Look Chemistry (2008) reported that pawpaw extracts can effectively treat intestinal and gastric inflammation and indigestion and prevent the cancerization of the digestive system. Guruma (2010) also reported that pawpaw latex is rich in anti-oxidants, the B vitamins, folate and pantothenic acid and the minerals (potassium and magnesium). Together, these nutrients promote the health of the cardiovascular system and also provide protection against colon cancer. Papain also decreases pain and inflammation associated with rheumatoid arthritis and helps in treating mouth sores and swallowing difficulty (Hoernecke *et al.,* 1993; Duskova and Wald*,* 1999; Hofstad, 1984; Schwinger, 1970).

Capaine from pawpaw seeds slows the heart rate in humans and thus reduces blood pressure (Artschwager, 1996). Eno *et al.* (2000) found that fruit juice of *Carica papaya* demonstrated blood pressure lowering activities via alpha-adrenoceptor route in a study of mice. Ekanem *et al.* (2004) observed that mortality of fish was reduced from 30 to 0 % in the group treated with 250 mg l^{-1} extract of pawpaw seeds. Beta-carotene, an anti-oxidant extracted from pawpaw parts can resist the free radicals which destroy the normal cells and accelerate the aging inside the human body (Look Chemistry, 2008). Recent ethnobotanical survey conducted by Adeneye *et al.* (2009) also revealed that *Carica papaya* seeds are used by Yoruba herbalists (Southwest Nigeria) in the treatment of poison related liver and renal diseases. Contrary, Eusebio *et al.* (1998) observed no effect on the survival rates of Indian prawns (*Fenneropenaeus indicus*) given pawpaw leaf meal diets as compared to those fed the control diet.

Bitto (2008) stated that cholesterol levels were significantly increased with increasing levels of pawpaw peel meal inclusion in the cerebral cortex and mid-brain of male rabbits. Onyimonyi and Onu (2009) observed increased performance of broiler chickens as levels of pawpaw leaf meal in the diets increased. They also reported that carcass quality increased in terms of nutrient profiles.

The significant general acceptability of meat of broiler chickens fed pawpaw leaf meal is a further confirmation that the eating quality of the meat of the birds on pawpaw leaf meal can be greatly improved (Onyimonyi and Onu, 2009). Dakare (2004) utilized pawpaw seeds as both flavour enhancers and nutritious non-meat protein in Nigerian rural communities.

There was a significant increase in tenderness of the meat of broiler chickens fed 2 % pawpaw leaf meal (Onyimonyi and Onu, 2009). Both green pawpaw fruit and the tree's latex are rich in papain which tenderizes meat and other proteins. Its ability to break down tough meat fibres was used for thousands of years by indigenous Americans (Echeverri *et al.*, 1997; Lohiya *et al.,* 2002). Babu *et al*. (2003) reported that unripe pawpaw fruit, as well as bark, leaves and seeds contain papain that is used to tenderize meat. In food biotechnology, papain is used in tenderizing meat (Morton, 1987). Irwig (2002) also indicated that papain is used as a meat tenderizer. It breaks down tough meat fibres.

2.4 Conclusion

Indigenous chickens are economically, nutritionally and socially important to rural people of South Africa. However, they have low productivity values and high mortality rates. There is some evidence that pawpaw seed meal supplementation improves productivity of chickens. Similarly, some evidence indicates that pawpaw seed meal supplementation reduces mortality rates in chickens. However, such information is limited and not conclusive. Therefore, there is need to ascertain such effects of pawpaw seed meal supplementation on productivity, mortality and carcass characteristics of indigenous Venda chickens.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study site

This experiment was conducted at the University of Limpopo Experimental farm, South Africa. The average rainfall of the area ranges between 440 and 450 mm, with summer rainfall occurring between October and March. The ambient summer temperatures range from 17 ºC to 32 ºC. The average winter temperatures range from 4.7 ºC to 19 ºC (Deloitte and Touche, 2003).

3.2 Preparation of the house

The experimental house was thoroughly cleaned with water, disinfected with formalin (that was obtained from NTK, Polokwane) and then left to dry for two weeks. The house was left open for two weeks after cleaning so as to break the life cycle of any disease causing organisms that were not killed by the disinfectant. The house was divided into 25 floor pens of equal size (1.5 m^2). Fresh sawdust was spread to a depth of seven centimetres. All equipment such as drinkers, feeders, separating wires, etc. were thoroughly cleaned and disinfected. The footbath was thoroughly cleaned and a new disinfectant was added daily.

3.3 Acquisition of materials and birds

All the required materials (medicines, vaccines and chemicals) for the experiment were purchased in advance prior to the commencement of the study. A grower diet was formulated. A total of 250 day-old chicks were collected from the University of Limpopo Experimental Farm and used in the experiment. The welfare of the chickens was well respected. The chickens were raised according to the standards set out by the University of Limpopo Ethics Committee.

3.4 Experimental design, treatments and procedures

The first part of the study determined dietary pawpaw seed meal supplementation levels for optimal feed intake, digestibility, growth, feed conversion and mortality rate of unsexed indigenous Venda chickens aged one to seven weeks. The day-old chicks were assigned to five treatments, in a completely randomized design. Each treatment group consisted of five replicates with 10 chickens per replicate. The chickens were on these treatments for seven weeks. Fresh water and feeds were given to chickens *ad libitum* on a daily basis. Lights were switched-on throughout the experiment. The two treatments were as follows:

PS_0 : Unsexed Venda chickens fed a grower diet (16 % CP) without pawpaw seed meal supplementation

PS_{50} : Unsexed Venda chickens fed a grower diet (16 % CP) supplemented with 50 g of pawpaw seed meal per kg DM feed

PS_{100} : Unsexed Venda chickens fed a grower diet (16 % CP) supplemented with 100 g of pawpaw seed meal per kg DM feed

PS_{150} : Unsexed Venda chickens fed a grower diet (16 % CP) supplemented with 150 g of pawpaw seed meal per kg DM feed

PS_{200} : Unsexed Venda chickens fed a grower diet (16 % CP) supplemented with 200 g of pawpaw seed meal per kg DM feed

The nutrient composition and feed composition of the diets for Venda chickens are presented in Tables 3.01 and 3.02, respectively.

Table 3.01 Nutrient composition of the Venda chicken grower diets (the units are in g/kg feed for dry matter, MJ/kg DM feed for energy, g/kg DM feed for crude protein, calcium and phosphorus)

	Treatment				
Variable	PS_0	PS_{50}	PS_{100}	PS_{150}	PS_{200}
Dry matter	923	923	923	923	923
Energy	16	16	16	16	16
Crude protein	16	16	16	16	16
Calcium	10.6	10.6	10.6	10.6	10.6
Phosphorus	5.5	5.5	5.5	5.5	5.5

Table 3.02 Diet composition of grower mash for Venda chickens

	Treatment				
Feed	PS0	PS50	PS100	PS150	PS200
Maize (%)	40.69	40.69	40.69	40.69	40.69
Wheat (%)	15	15	15	15	15
Lucerne meal (%)	5.8	4.8	3.8	2.8	1.8
Soya bean meal (%)	21.83	18	15.23	11.93	8.63
Fish meal (2-8% fat) (%)	5	5	5	5	5
Maize gluten meal (%)	3.47	3.40	3.33	3.26	3.19
Full fat (%)	2.19	2.18	2.18	2.18	2.18
Soya oil (%)	3	3	1.75	1.12	0.49
DI sodium phosphate (%)	0.11	0.11	0.11	0.11	0.11
Calcium carbonate (%)	0.86	0.86	0.86	0.86	0.86
Salt (%)	0.18	0.18	0.18	0.18	0.18
DI Calcium phosphate (%)	1.47	1.47	1.47	1.47	1.47
DL- Methionine (%)	0.20	0.20	0.20	0.20	0.20
L – Lysine (%)	0.20	0.20	0.20	0.20	0.20
Pawpaw seed meal (%)	0	5	10	15	20
Total	100	100	100	100	100
Nutrients					
Crude protein (%)	16	16	16	16	16
Energy (MJ/kg DM)	16	16	16	16	16

The second part of the study determined the effect of dietary pawpaw seed meal supplementation on feed intake, digestibility, growth rate, feed conversion ratio, mortality and carcass characteristics of female indigenous Venda chickens aged between eight and 13 weeks. Due to a limited number of male indigenous Venda chickens, only female indigenous Venda chickens were used for the second part of the experiment. A completely randomized design was used.

Each treatment consisted of three replicates with five chickens per replicate. The five treatments were as follows:

FPS_0 : Female Venda chickens fed a grower diet (16 % CP) without pawpaw seed meal supplementation

FPS_{50} : Female Venda chickens fed a grower diet (16 % CP) supplemented with 50 g of pawpaw seed meal per kg DM feed

FPS_{100} : Female Venda chickens fed a grower diet (16 % CP) supplemented with 100 g of pawpaw seed meal per kg DM feed

FPS_{150} : Female Venda chickens fed a grower diet (16 % CP) supplemented with 150 g of pawpaw seed meal per kg DM feed

FPS_{200} : Female Venda chickens fed a grower diet (16 % CP) supplemented with 200 g of pawpaw seed meal per kg DM feed

3.5 Data collection

An electronic weighing scale was used to weigh the chicks in each replicate within 24 hours after hatching. . The initial live weights were taken when the chicks were a day old and thereafter mean live weight per pen was measured at weekly intervals, by weighing the chickens in each pen and dividing the weight by the total number of birds in the pen. Voluntary feed intake was measured by subtracting the difference in weight between the leftovers from that offered per week, and the difference was divided by the total number of birds per pen. Thus, daily feed intake per bird was calculated from these values. Feed conversion ratio was calculated by dividing the average feed intake by the average weight gain in each pen. This was calculated as the amount of feed consumed divided by the total weight of live chickens plus those of dead or culled chickens minus initial weight of all the chickens in the pen. Apparent digestibility was carried out when the birds were seven and 13 weeks old. Apparent digestibility was conducted in specially designed metabolic cages having separated watering and feeding troughs. Two birds were randomly selected from each replicate and transferred to metabolic cages for measurement of apparent digestibility. A three day acclimatization period was allowed prior to a three-day collection period. Droppings voided by each bird were collected on a daily basis at nine hours. Care was taken to avoid contamination from feathers, scales, debris and feeds. Apparent digestibility (AD) of nutrients was calculated according to McDonald *et al.* (2002) as follows:

$$AD (\%) = \frac{\text{Amount of nutrient ingested} - \text{Amount of nutrient excreted}}{\text{Amount of nutrient ingested}} \times 100$$

Mortalities were recorded as they occurred per pen. At 13 weeks of age all the remaining Venda chickens per pen were weighed on an electronic weighing scale to obtain the live weight and then slaughtered. Thereafter, carcass weights of the chickens were measured. Dressing percentage was calculated by dividing carcass weight by the live weight times one hundred. Breast, thigh, drumstick, wing, gizzard, liver, heart and fat pad weights were determined. At the end of each slaughtering, meat samples from the breast part of the slaughtered chickens were dried in the oven for 24 hours at a temperature of 105 ºC and later analysed for nitrogen content.

3.6 Chemical analysis

Dry matter contents of feeds, feed refusals, faeces and meat were determined by drying the samples in the oven for 24 hours at a temperature of 105 ºC. Ash contents of the feeds, feed refusals, faeces and meat were analyzed by ashing a sample at 600 ºC in a muffle furnace for 24 hours (AOAC, 2000). Nitrogen contents of feeds, feed refusals, faeces and meat were determined by semi-micro Kjeldahl method (AOAC, 2000). Gross energy values were determined by using a bomb calorimeter (AOAC, 2000). Calcium and phosphorus in the feeds were determined with an inductively coupled plasma emission (ICP) Perkin-Elmer spectrometer (University of Limpopo Laboratory, South Africa). Cysteine protease activity of the chicken feed extracts was measured by a fluorometric method according to Rawlings *et al*. (1994). Z-L-arginyl-L-arginine-7-amido-4-methyl-coumarin (Z-Arg-Arg-AMC) was used as the synthetic peptide fluorescent substrate for cysteine proteases. Proteins were extracted by adding 1 ml of 50 mm sodium acetate, pH 6 buffer containing 10 mm L-cysteine to 200 mg of each of the chicken feed samples. The suspension was incubated overnight on a rotary shaker in the cold room. The suspension was then centrifuged for 10 minutes at 8 850 x g. The protein extract (10 µl) was added to 80 µl of 50 mm sodium acetate buffer containing 80 µm of the peptidyl substrate and 10 mm L-cysteine. The amount of amino-4-methyl-coumarin (NH_2AMC) released from hydrolysed substrates at excitation and emission wavelengths of 365 and 465 nm, respectively, was estimated by the increase in fluorescence in a Beckman Coulter DTX 800 Multimode Detector micro-plate reader over 350 seconds. Negative controls contained an equal volume of the buffer instead of enzyme solution and positive controls contained an equal volume of papain (200 mg/mL).

3.7 Statistical analysis

Effect of pawpaw seed meal supplementation on feed intake, digestibility, growth rate, mortality rate and carcass characteristics of Venda chickens were analyzed using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS, 2008). The means were separated using Duncan's multiple-range test procedures (Duncan, 1955). The responses in feed intake, feed conversion ratio, growth rate, live weight, carcass characteristics and meat quality to pawpaw seed meal supplementation were modelled using the following quadratic equation:

$$Y = a + b_1x + b_2x^2$$

Where Y = optimum feed intake, feed conversion ratio, growth rate, live weight, mortality rate and carcass characteristics; a = intercept; b_1 and b_2 = coefficients of quadratic equation; x = pawpaw seed meal inclusion level and $-b_1/2b_2$ = x value for optimum response. The quadratic model was fitted to the experimental data by means of NLIN procedure of SAS (SAS, 2008). The quadratic model was used because it gave the best fit.

The relationship between optimal responses in feed intake, feed conversion ratio, growth rate, live weight, carcass, dry matter digestibility, metabolisable energy, nitrogen retention and meat quality across the two experiments and pawpaw seed meal supplementation levels were modelled using a linear regression equation (SAS, 2008) of the form:

$$Y = a + bx$$

Where y = optimal feed intake, feed conversion ratio, growth rate, live weight, dry matter digestibility, metabolisable energy, nitrogen retention or meat quality; a = intercept; b = coefficient of the linear equation, x = dietary pawpaw seed meal supplementation level.

CHAPTER 4

RESULTS

Statistical analyses of cysteine protease activity of the chicken feeds were 2223442[e] (PS_0), 2442250[d] (PS_{50}), 2528438[c] (PS_{150}), 2554292[b] (PS_{100}) and 2685794[a] (PS_{200}) flourescence units, with the standard error (SE) of 40923.21. Cysteine protease activity of the chicken feed extracts increased (P<0.05) with an increase in pawpaw seed meal supplementation level. Thus, chicken feed without pawpaw seed meal supplementation showed lower (P<0.05) cysteine protease activity values than diets supplemented with pawpaw seed meal.

Results of the effect of pawpaw seed meal supplementation on intake, growth, feed conversion ratio, diet dry matter (DM) digestibility, apparent metabolisable energy, nitrogen retention and live weight of indigenous Venda chickens aged one to seven weeks are presented in Table 4.01. Pawpaw seed meal supplementation had no effect (P>0.05) on growth of Venda chickens aged one to seven weeks. Similarly, pawpaw seed meal supplementation had no effect (P>0.05) on live weight, nitrogen retention and diet DM digestibility of Venda chickens aged seven weeks. However, pawpaw seed meal supplementation had effect (P<0.05) on diet intake of Venda chickens. Indigenous Venda chickens fed diets supplemented with 200 g of pawpaw seed meal per kg DM feed had higher (P<0.05) intakes than those fed a diet without pawpaw seed meal supplementation and those on diets supplemented with 50 and 100 g of pawpaw seed meal per kg DM feed. Venda chickens fed diets supplemented with 150 or 200 g of pawpaw seed meal per kg DM feed had similar (P>0.05) feed intakes. Chickens fed a diet supplemented with 150 g of pawpaw seed meal per kg DM feed had higher (P<0.05) feed intakes than those on a diet supplemented with 50 g of pawpaw seed meal per kg DM feed and those on a diet without a pawpaw seed meal supplement. However, chickens fed diets supplemented with 100 or 150 g of pawpaw seed meal per kg DM feed had similar (P>0.05) feed intakes. Similarly, chickens fed diets supplemented with 50 or 100 g of pawpaw seed meal per kg DM feed had similar (P>0.05) feed intakes. Venda chickens fed a diet without a pawpaw seed meal supplement and those on a diet supplemented with 50 g of pawpaw seed meal per kg DM feed had similar (P>0.05) intakes.

Indigenous Venda chickens fed a diet without any pawpaw seed meal supplementation had a better ($P<0.05$) feed conversion ratio than those on a diet supplemented with 200 g of pawpaw seed meal per kg DM feed (Table 4.01). However, chickens fed a diet supplemented with 200 g of pawpaw seed meal per kg DM feed had similar ($P>0.05$) feed conversion ratio values with those on a diet supplemented with 150 g of pawpaw seed meal per kg DM feed. Venda chickens fed diets supplemented with 50, 100 or 150 g of pawpaw seed meal per kg DM feed had similar ($P>0.05$) feed conversion ratio values. Similarly, chickens fed a diet without a pawpaw seed meal supplement and those on a diet supplemented with 50 g of pawpaw seed meal per kg DM feed had same ($P>0.05$) feed conversion ratios.

Indigenous Venda chickens fed diets supplemented with 50 or 150 g of pawpaw seed meal per kg DM feed had higher ($P<0.05$) metabolisable energy values than chickens on diets supplemented with 10 or 200 g of pawpaw seed meal per kg DM feed and those on a diet without pawpaw seed meal supplementation. However, Venda chickens on diets supplemented with 100, 150 or 200 g of pawpaw seed meal per kg DM feed and those on a diet without pawpaw seed meal supplementation had similar ($P>0.05$) metabolisable energy values. Similarly, Venda chickens fed diets supplemented with 50 or 150 g of pawpaw seed meal per kg DM feed had same ($P>0.05$) metabolisable energy values. There were no deaths among the indigenous Venda chickens fed diets supplemented with pawpaw seed meal while 20 % of the chickens fed diets without pawpaw seed meal supplementation died. Thus, pawpaw seed meal supplementation reduced mortality rate from 20 % to 0 % ($P<0.05$).

A strong and positive relationship (r^2 = 0.976) was observed between pawpaw seed meal supplementation and feed intake of indigenous Venda chickens aged one to 49 days (Figure 4.01). There was, also, a strong and positive relationship (r^2 = 0.977) between pawpaw seed meal supplementation and feed conversion ratio of indigenous Venda chickens (Figure 4.02). Thus, supplementation with pawpaw seed meal resulted in poorer ($P<0.05$) feed conversion ratio. Growth rate, live weight, metabolisable energy and nitrogen retention of Venda chickens were optimized at pawpaw seed meal supplementation levels of 133 (r^2 = 0.075), 143 (r^2 = 0.667), 101 (r^2 = 0.463) and 133 (r^2 = 0.321) g/kg DM feed, respectively (Figures 4.03, 4.04, 4.05 and 4.06 and Table 4.02, respectively). There was a strong and negative relationship (r^2 = 0.725) between pawpaw seed meal supplementation and diet dry matter digestibility (Figure 4.07). Thus, pawpaw seed meal supplementation tended to reduce ($P<0.05$) diet dry matter digestibility of Venda chickens.

Results of the effect of dietary pawpaw seed meal supplementation on DM intake, growth, feed conversion ratio, diet DM digestibility, apparent metabolisable energy, nitrogen retention and live weight of female Venda chickens aged eight to 13 weeks are presented in Table 4.03. Pawpaw seed meal supplementation had no effect ($P>0.05$) on feed intake, growth rate, live weight and diet DM digestibility. However, female Venda chickens fed a diet without pawpaw seed meal supplementation had better ($P<0.05$) feed conversion ratio than those on a diet supplemented with 200 g of pawpaw seed meal per kg DM feed. Female Venda chickens fed a diet supplemented with 200 g of pawpaw seed meal per kg DM feed had similar ($P>0.05$) feed conversion ratios with those on diets supplemented with 50, 100 or 150 g of pawpaw seed meal per kg DM feed. Similarly, female chickens fed a diet without pawpaw seed meal supplementation and those on diets supplemented with 50, 100 or 150 g of pawpaw seed meal per kg DM feed had the same ($P>0.05$) feed conversion ratios.

Female Venda chickens fed a diet without pawpaw seed meal supplementation and those on diets supplemented with 50, 100 or 150 g of pawpaw seed meal per kg DM feed had higher ($P<0.05$) metabolisable energy values than chickens on a diet supplemented with 200 g of pawpaw seed meal per kg DM feed. However, metabolisable energy of female Venda chickens fed a diet without pawpaw seed meal supplementation was the same ($P>0.05$) as those of chickens on diets supplemented with 50, 100 or 150 g of pawpaw seed meal per kg DM feed. Female Venda chickens supplemented with 200 g of pawpaw seed meal per kg DM feed had higher ($P<0.05$) nitrogen retention values than those fed a diet without pawpaw seed meal and those on a diet supplemented with 50 g of pawpaw seed meal per kg DM feed. However, female

Venda chickens fed diets supplemented with 100, 150 or 200 g of pawpaw seed meal per kg DM feed had similar ($P>0.05$) nitrogen retention values. Female Venda chickens fed a diet without pawpaw seed meal supplementation had similar ($P<0.05$) nitrogen retention values with those on a diet supplemented with 50 g of pawpaw seed meal per kg DM feed.

Table 4.01 Effect of pawpaw seed meal supplementation on feed intake (g DM/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g DM feed/g weight gain/bird) and live weight (g/bird at 49 days old) of indigenous Venda chickens aged between one and 49 days, and apparent metabolisable energy (MJ ME/kg DM), nitrogen retention (g/bird/day) and dry matter digestibility (DMD) (%) of the aged seven weeks

	Treatment					
Variable	PS_0	PS_{50}	PS_{100}	PS_{150}	PS_{200}	SE
Intake	26.90^{d}	28.91^{cd}	29.44^{bc}	31.83^{ab}	33.16^{a}	0.648
Growth	10.57	10.53	10.53	10.67	10.50	0.027
FCR	2.54^{c}	2.75^{bc}	2.80^{b}	2.99^{ab}	3.16^{a}	0.062
Lwt	527	565	551	569	549	9.039
DMD	84.0	85.6	79.0	79.6	82.0	1.067
ME	13.3^{b}	14.9^{a}	14.0^{b}	14.2^{ab}	13.7^{b}	0.173
N-ret.	1.9	2.0	2.3	2.3	2.0	0.098

$^{a, b, c, d}$: Means with different superscripts within a row are significantly different ($P<0.05$)

SE : Standard error

Lwt : Live weight

ME : Metabolisable energy

N-ret. : Nitrogen retention

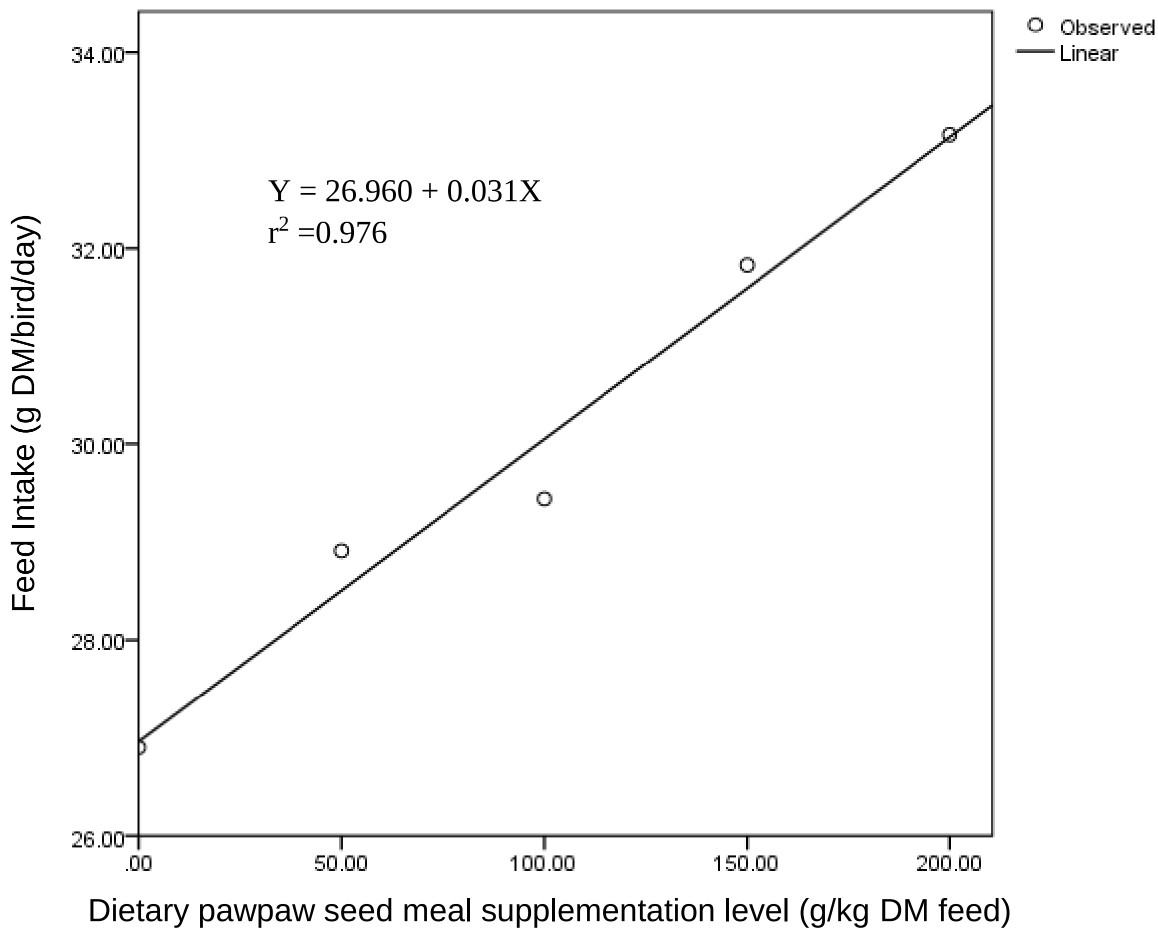

Figure 4.01 Relationship between dietary pawpaw seed meal supplementation and feed intake of indigenous Venda chickens aged one to 49 days

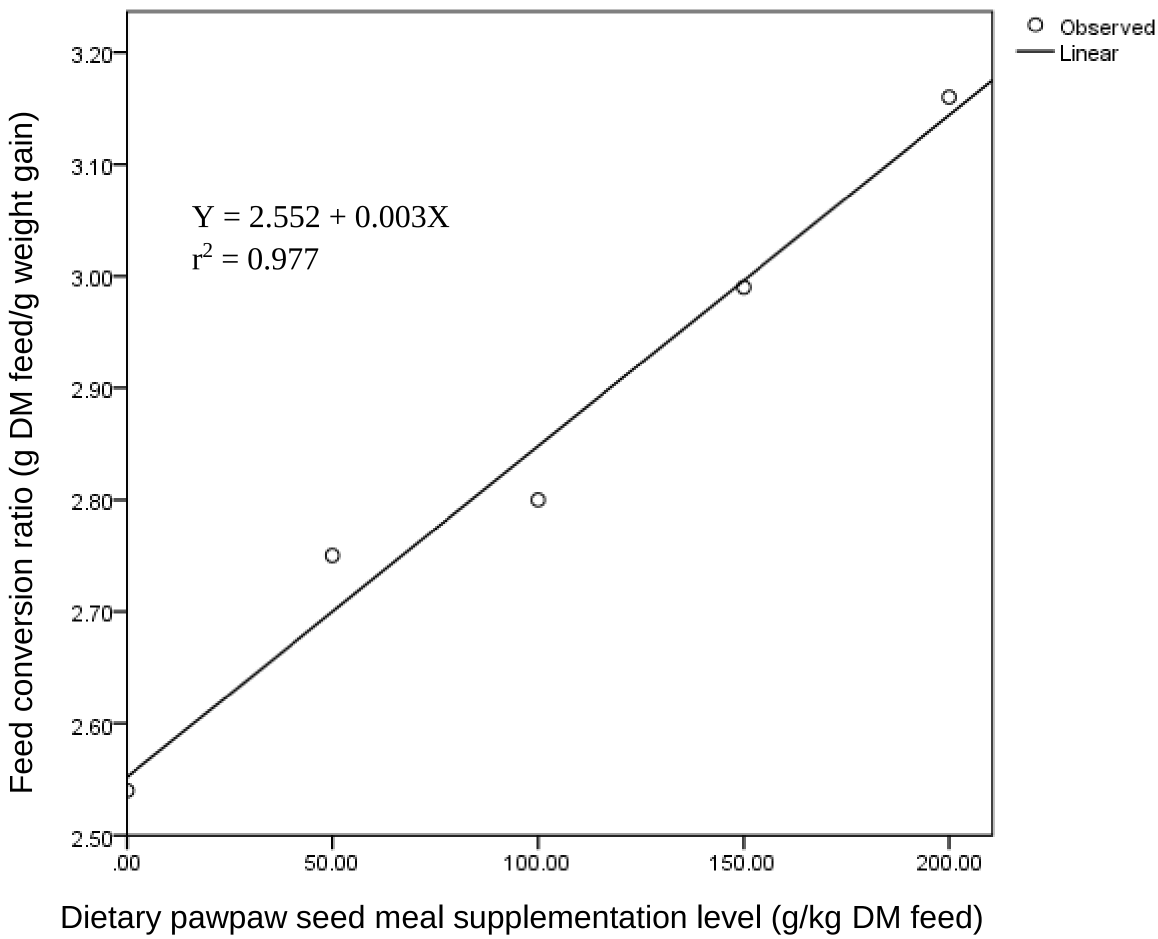

Figure 4.02 Relationship between dietary pawpaw seed meal supplementation and feed conversion ratio of indigenous Venda chickens aged one to 49 days

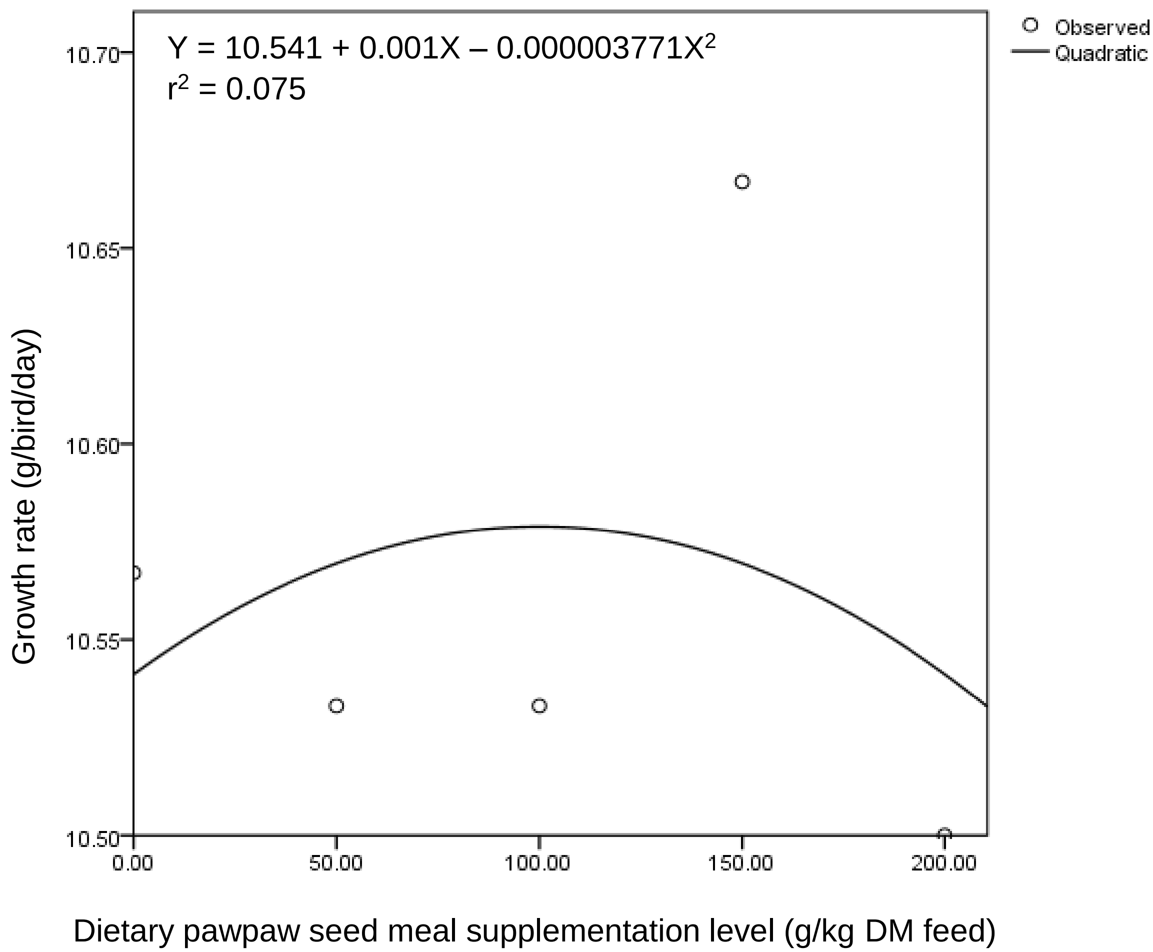

Figure 4.03 Effect of dietary pawpaw seed meal supplementation on growth of indigenous Venda chickens aged one to 49 days

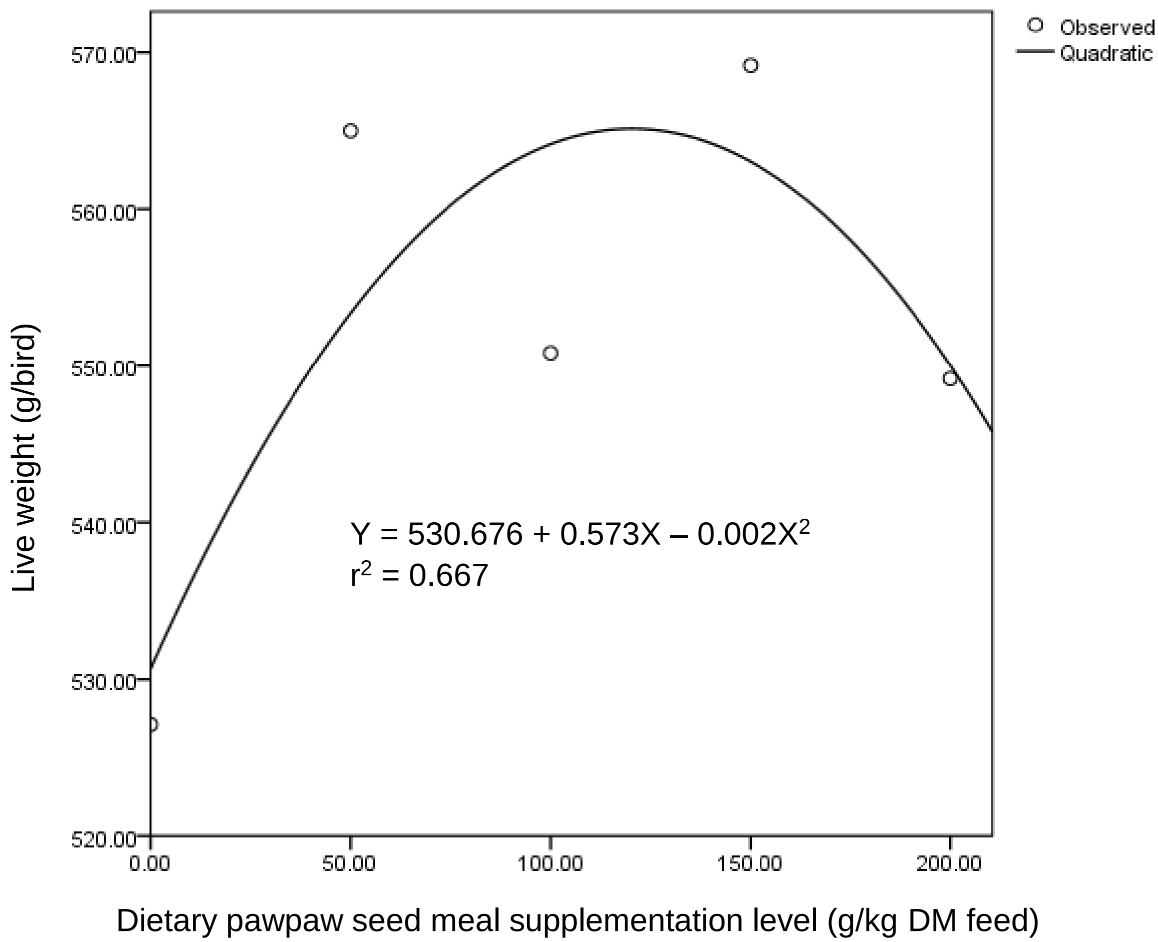

Figure 4.04 Effect of dietary pawpaw seed meal supplementation on live weight of indigenous Venda chickens aged 49 days

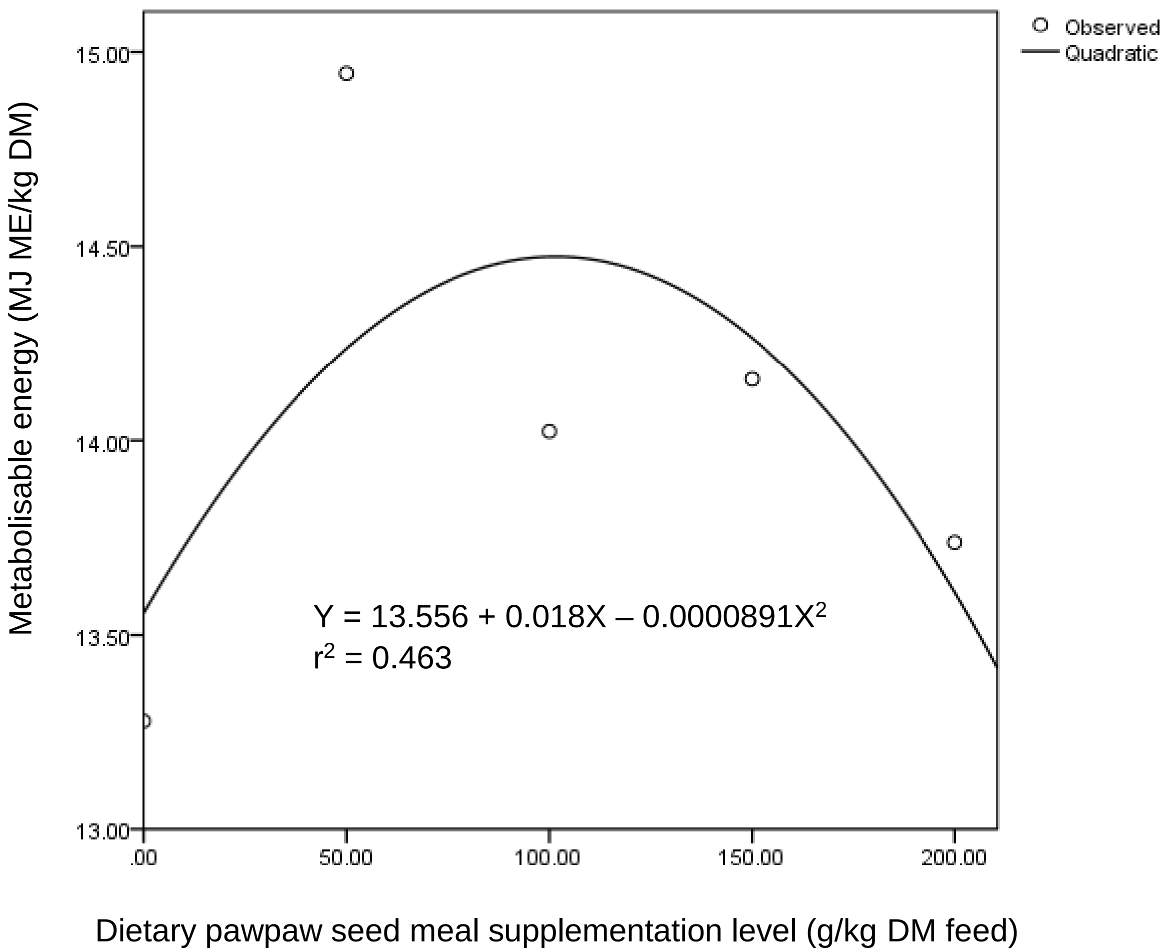

Figure 4.05 Effect of dietary pawpaw seed meal supplementation on metabolisable energy of indigenous Venda chickens aged seven weeks

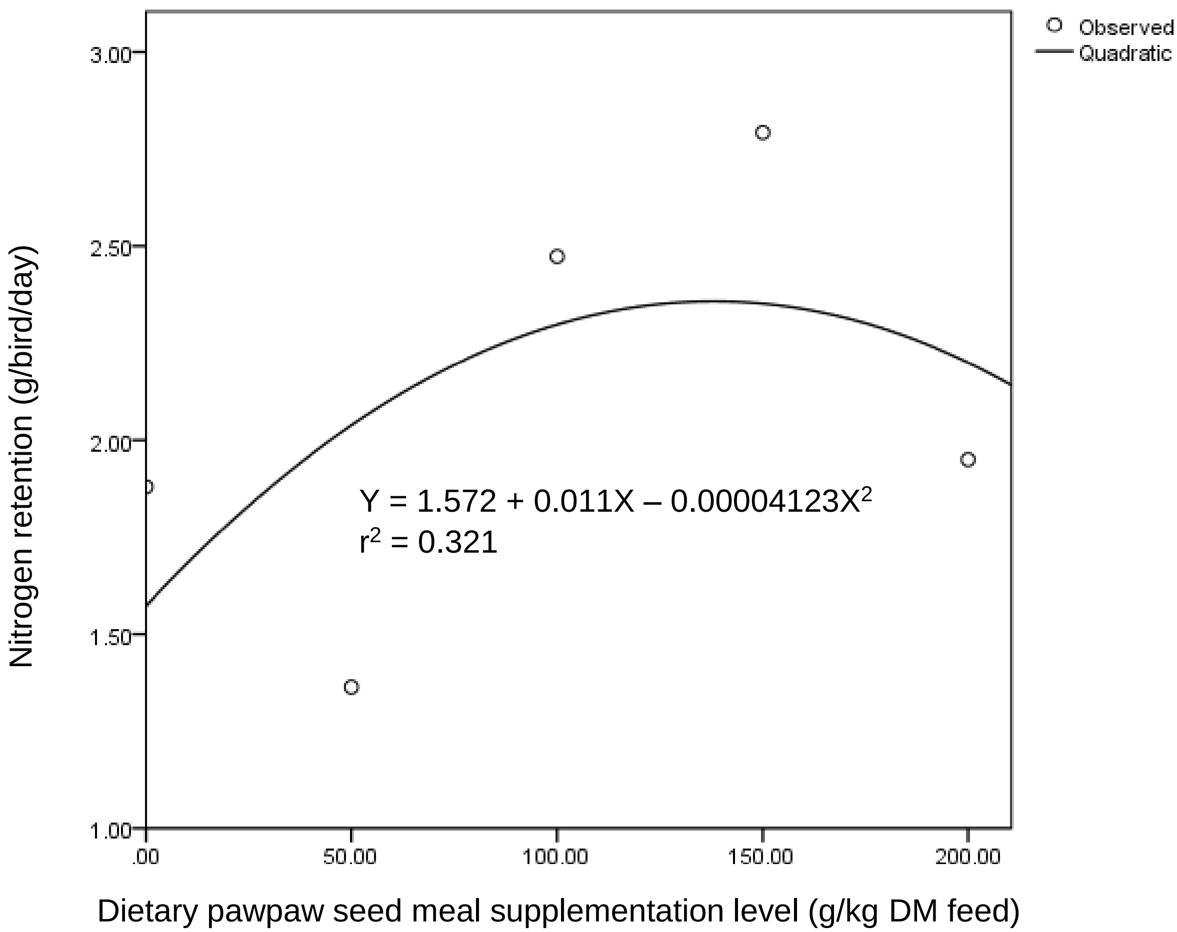

Figure 4.06 Effect of dietary pawpaw seed meal supplementation on nitrogen retention of indigenous Venda chickens aged seven weeks

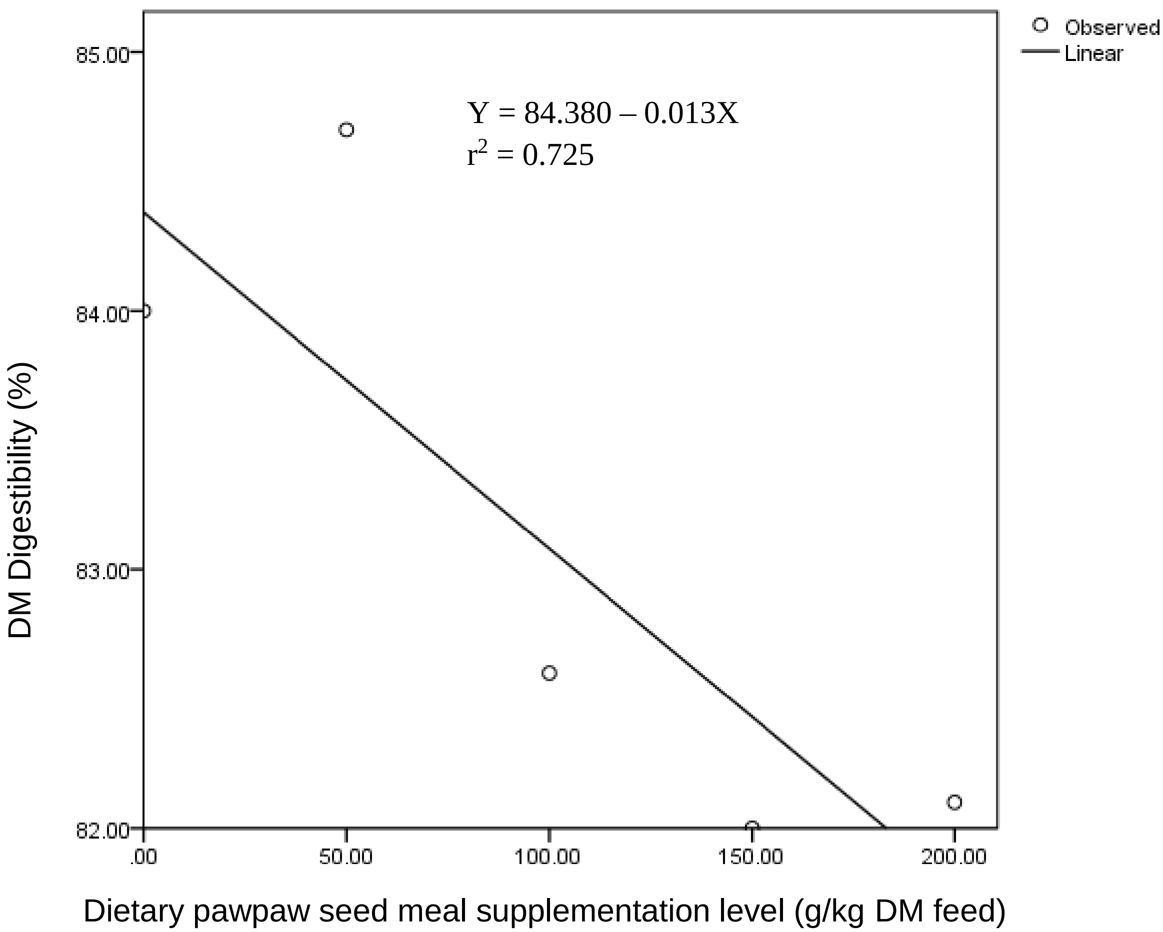

Figure 4.07 Relationship between dietary pawpaw seed meal supplementation and dry matter digestibility of indigenous Venda chickens aged seven weeks

Table 4.02 Effect of pawpaw seed meal supplementation level on optimal growth rate (g/bird/day), live weight (g/bird at 49 days old), apparent metabolisable energy (MJ ME/kg DM) and nitrogen retention (g/bird/day) of indigenous Venda chickens aged one to 49 days

Trait	Formula	PS	Y-Value	r^2	P
Growth	$Y= 10.541 + 0.001X – 0.000003771X^2$	133	10.607	0.075	0.925
Lwt	$Y= 530.676 + 0.573X – 0.002X^2$	143	571.717	0.667	0.333
ME	$Y = 13.556 + 0.018X – 0.00008911X^2$	101	14.465	0.463	0.537
N-Ret	$Y = 1.572 + 0.011X – 0.00004123X^2$	133	2.305	0.321	0.679

Lwt : Live weight
PS : Pawpaw seed supplementation level for optimal variable
Y-Value : Optimal Y-Value
r^2 : Regression coefficient
P : Probability
ME : Metabolisable energy
N-Ret : Nitrogen retention

A strong and positive relationship (r^2 = 0.972) was observed between pawpaw seed meal supplementation and feed intake of indigenous female Venda chickens aged between eight and 13 weeks (Figure 4.08). Thus, feed intake tended to increase ($P<0.05$) with an increase in pawpaw seed meal supplementation. Similarly, there was a strong and positive relationship (r^2 = 0.990) between pawpaw seed meal supplementation and feed conversion ratio of indigenous Venda chickens (Figure 4.09). Growth rate, live weight, metabolisable energy and nitrogen retention of female Venda chickens were optimized at different pawpaw seed meal supplementation levels of 54.3 (r^2 = 0.719), 86.5 (r^2 = 0.893), 69 (r^2 = 0.955) and 177 (r^2 = 0.960) g/kg DM feed, respectively (Figures 4.10, 4.11, 4.12 and 40.13 and Table 4.04, respectively). A strong and negative relationship (r^2 = 0.725) was observed between pawpaw seed meal supplementation and diet dry matter digestibility of indigenous female Venda chickens aged 13 weeks (Figure 4.14).

Results of the effect of dietary pawpaw seed meal supplementation on carcass weight and carcass parts of indigenous female Venda chickens aged 13 weeks are presented in Table 6. Pawpaw seed meal supplementation had no effect (P>0.05) on carcass, breast, thigh, drumstick, wing, gizzard, liver, heart and fat pad weights of indigenous female Venda chickens.

Results of the effect of dietary pawpaw seed meal supplementation on female Venda chicken meat flavour, tenderness and juiciness are presented in Table 4.06. Pawpaw seed meal supplementation had no effect (P>0.05) on juiciness and flavour of the meat of indigenous female Venda chickens aged 91 days. However, pawpaw seed meal supplementation had effect (P<0.05) on tenderness of the meat of indigenous female Venda chickens. Female Venda chickens fed a diet supplemented with150 g of pawpaw seed meal per kg DM feed produced meat that was more tender (P<0.05) than that from chickens fed a diet without pawpaw seed meal supplements. However, indigenous female Venda chickens fed a diet without pawpaw seed meal supplements produced meat with similar (P>0.05) tenderness values with those of the meat produced by chickens fed diets supplemented with 50, 100 or 200 g of pawpaw seed meal per kg DM feed. Female Venda chickens fed diets supplemented with 50, 100, 150 or 200 g of pawpaw seed meal per kg DM feed produced meat with similar (P>0.05) tenderness values.

Female Venda chicken meat tenderness and juiciness were optimized at pawpaw seed meal supplementation levels of 205.90 (r^2 = 0.885) and 79.55 (r^2 = 0.440) g/kg DM feed, respectively (Figures 4.15 and 4.16, respectively). A positive relationship (r^2 = 0.746) was observed between pawpaw seed meal supplementation and flavour of the meat of female Venda chickens (Figure 4.17).

Table 4.03 Effect of dietary pawpaw seed meal supplementation level on feed intake (g DM/bird/day), growth rate (g/bird/day), feed conversion ratio (FCR) (g DM feed/g weight gain/bird) and live weight (g/bird at 13 weeks of age) of female Venda chickens aged between eight and 13 weeks, and apparent metabolisable energy (MJ ME/kg DM), nitrogen retention (g/bird/day) and diet dry matter digestibility (DMD) (%) of the chickens aged 13 weeks

	Treatment					
Variable	PS_0	PS_{50}	PS_{100}	PS_{150}	PS_{200}	SE
Intake	48.94	52.25	55.41	60.74	61.72	1.883
Growth	11.93	11.93	11.97	11.80	11.27	0.115
FCR	4.11^{b}	4.38^{ab}	4.62^{ab}	5.14^{ab}	5.50^{a}	0.179
Lwt	1163	1168	1172	1177	1171	23.799
DMD	83.8	83.9	79.4	79.7	76.7	1.126
ME	14.0^{a}	14.2^{a}	14.5^{a}	14.1^{a}	13.1^{b}	0.135
N-ret.	1.9^{c}	2.1^{c}	2.5^{ab}	2.5^{ab}	2.7^{a}	0.086

$^{a, b, c, d}$: Means with different superscripts within a row are significantly different ($P<0.05$)

SE : Standard error

Lwt : Live weight

ME : Metabolisable energy

N-ret. : Nitrogen retention

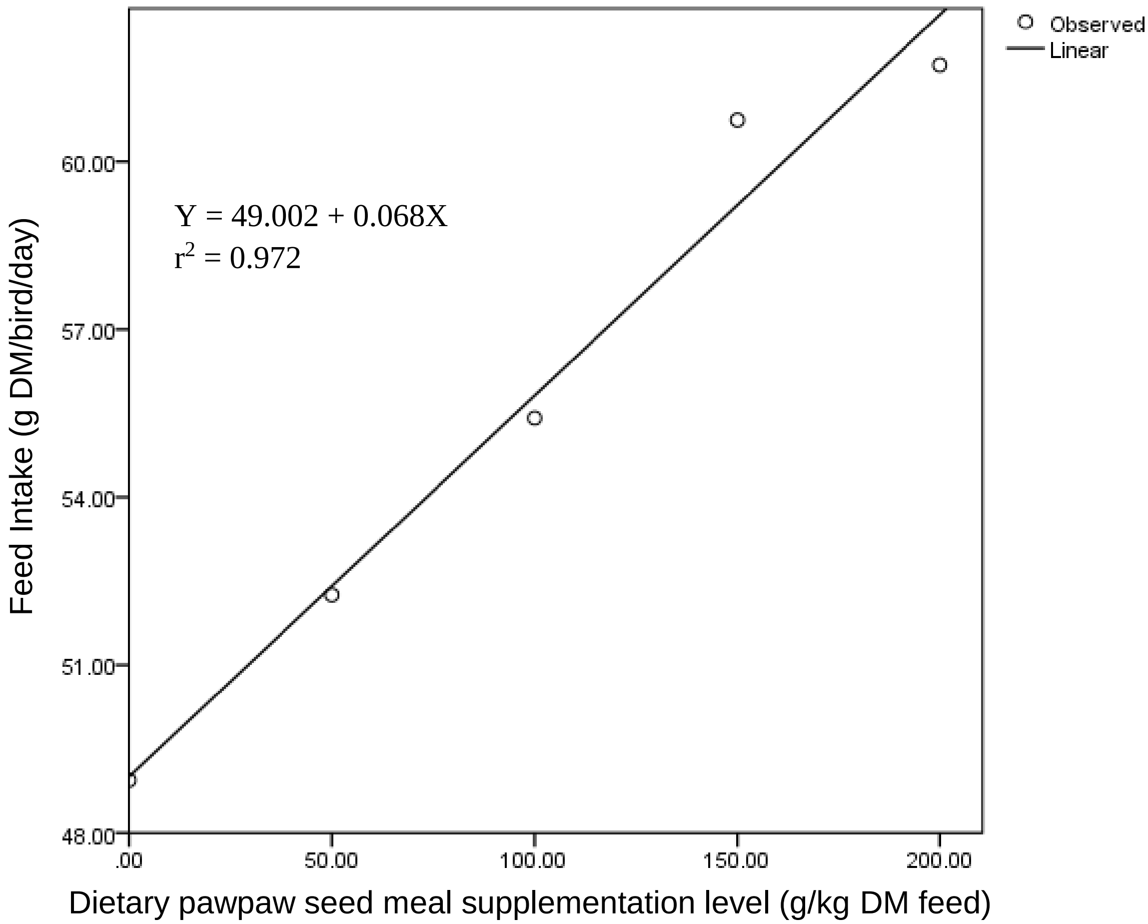

Figure 4.08 Relationship between dietary pawpaw seed meal supplementation and feed intake of female Venda chickens aged between eight and 13 weeks

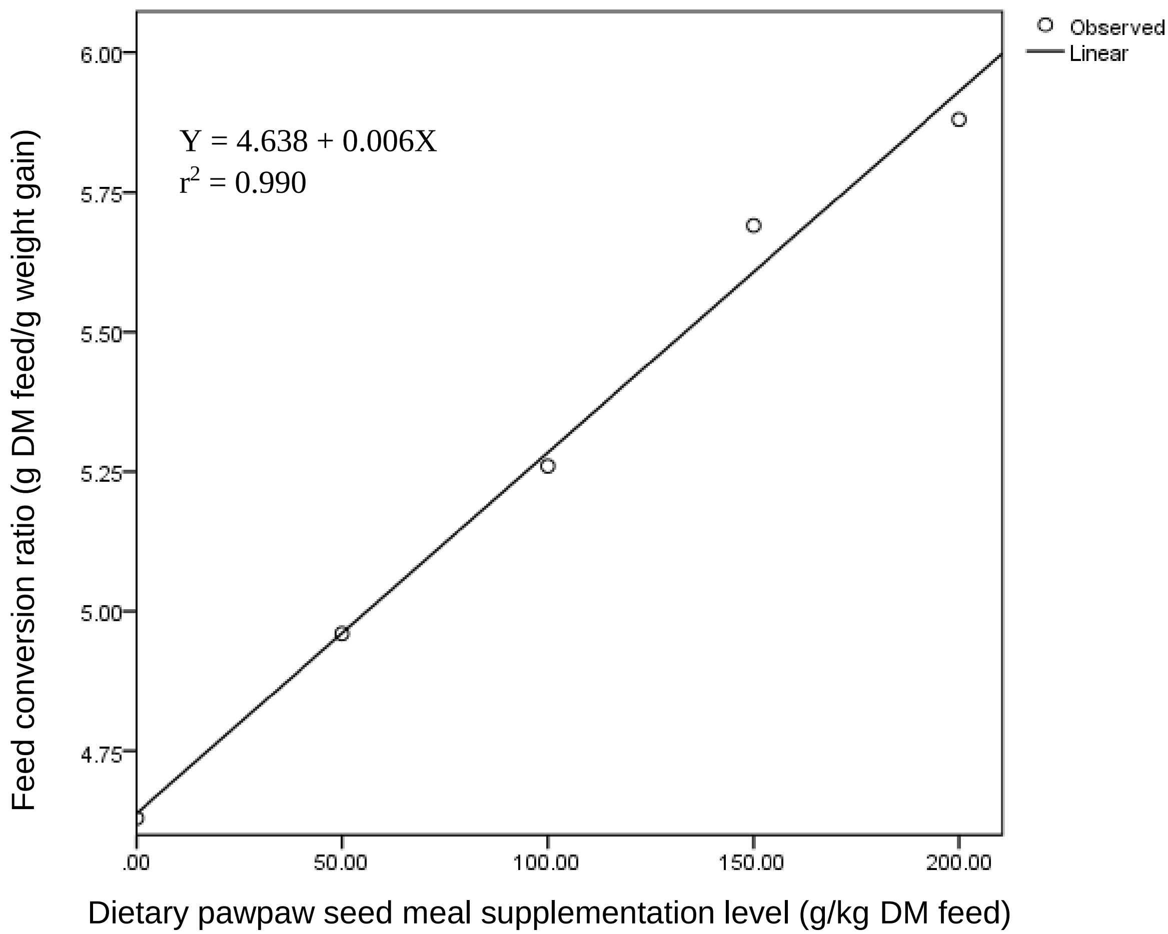

Figure 4.09 Relationship between dietary pawpaw seed meal supplementation and feed conversion ratio of female Venda chickens aged between eight and 13 weeks

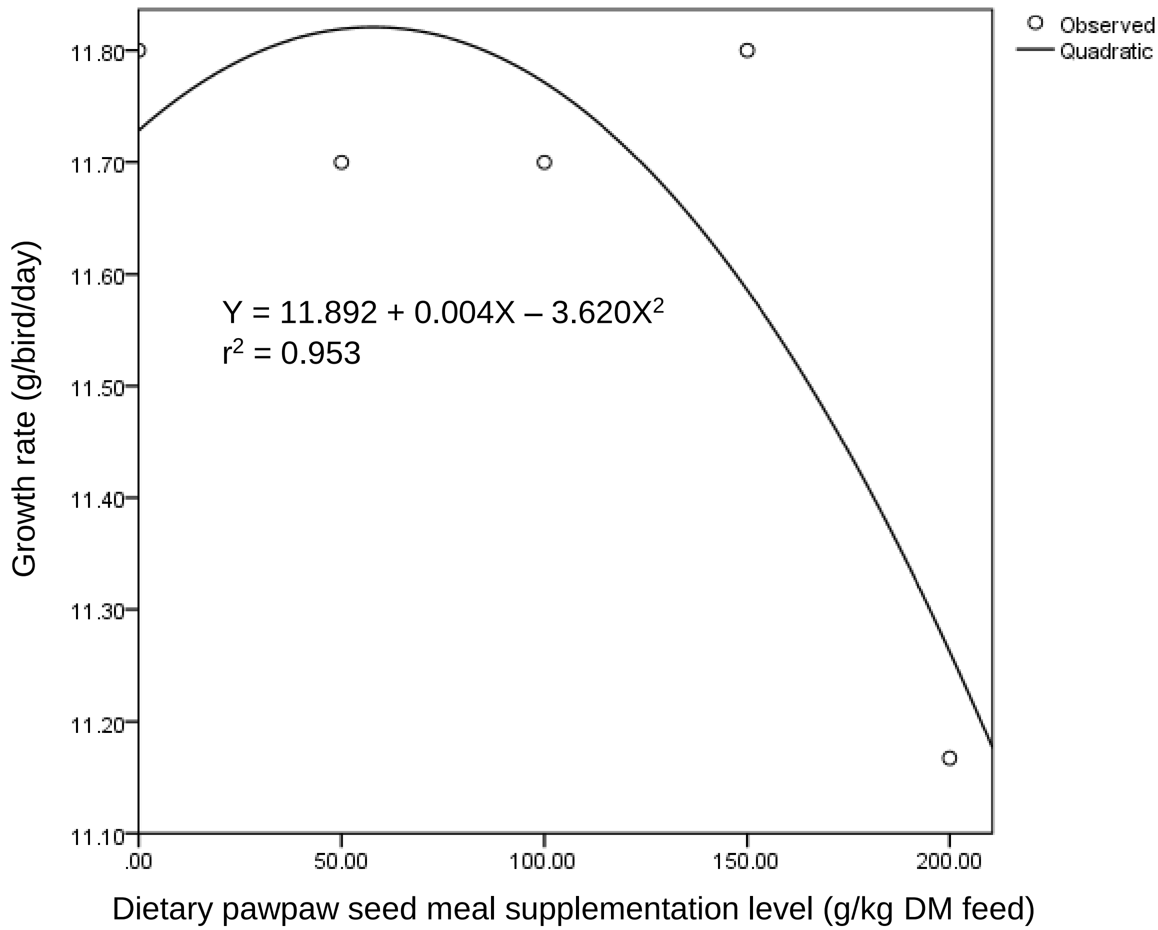

Figure 4.10 Effect of dietary pawpaw seed meal supplementation on growth rate of female Venda chickens aged eight to 13 weeks

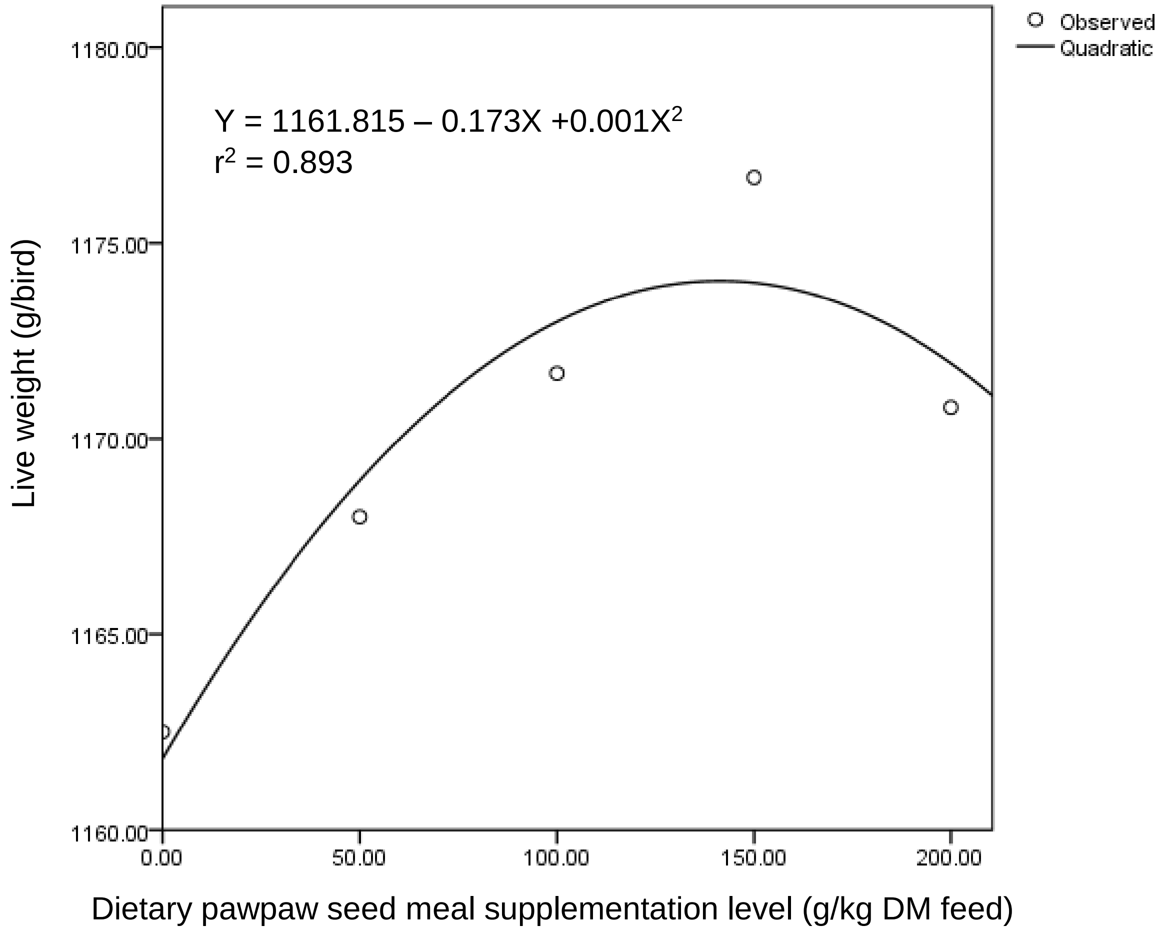

Figure 4.11 Effect of dietary pawpaw seed meal supplementation on live weight of female Venda chickens aged 91 days

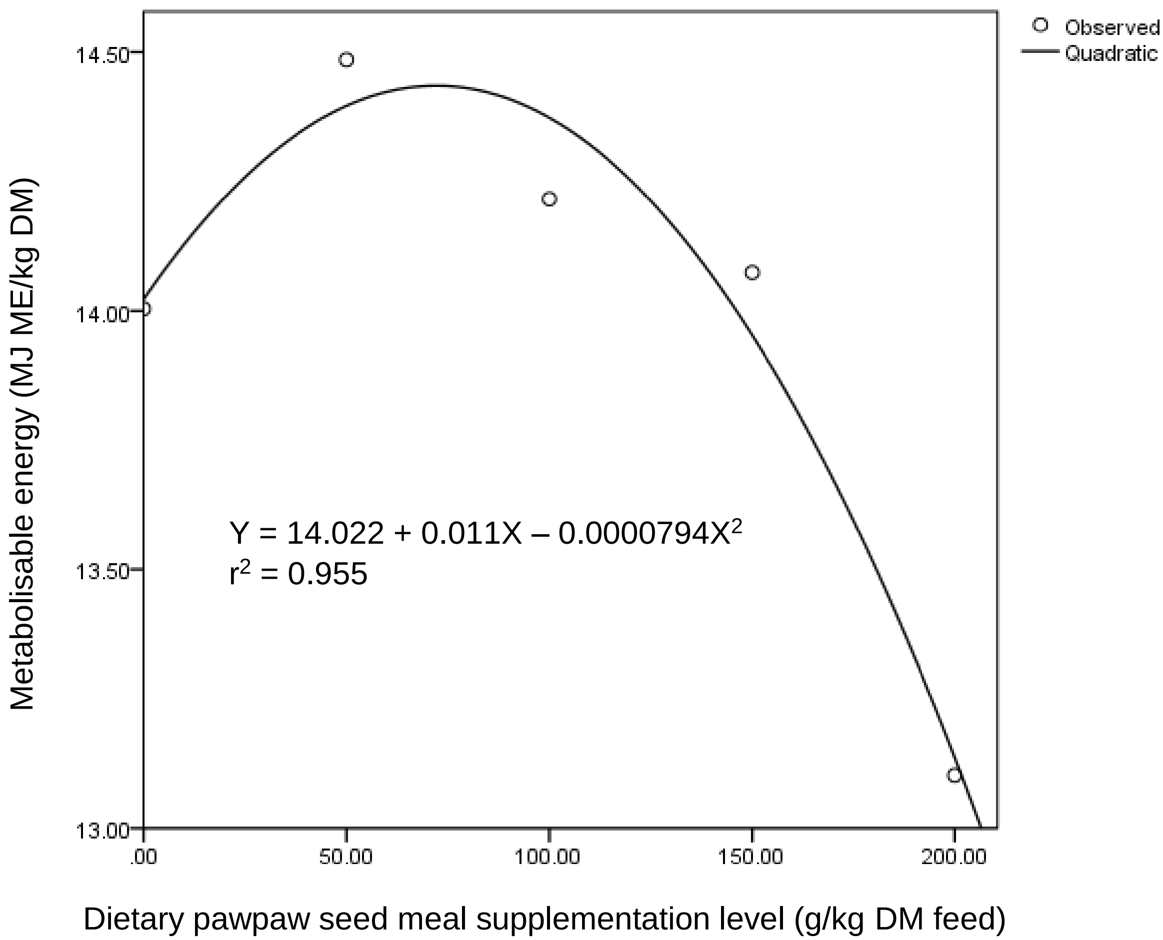

Figure 4.12 Effect of dietary pawpaw seed meal supplementation on metabolisable energy of female Venda chickens aged 13 weeks

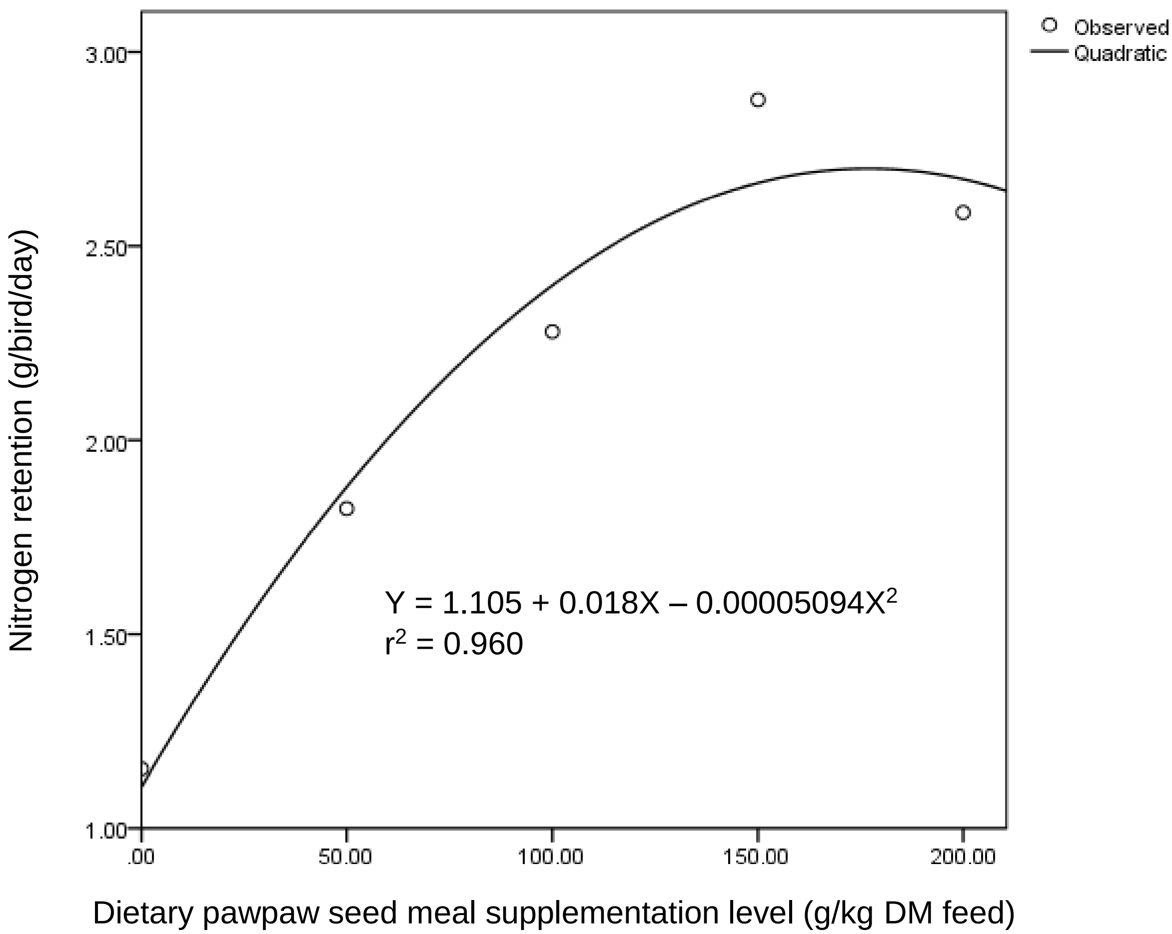

Figure 4.13 Effect of dietary pawpaw seed meal supplementation on nitrogen retention of female Venda chickens aged 13 weeks

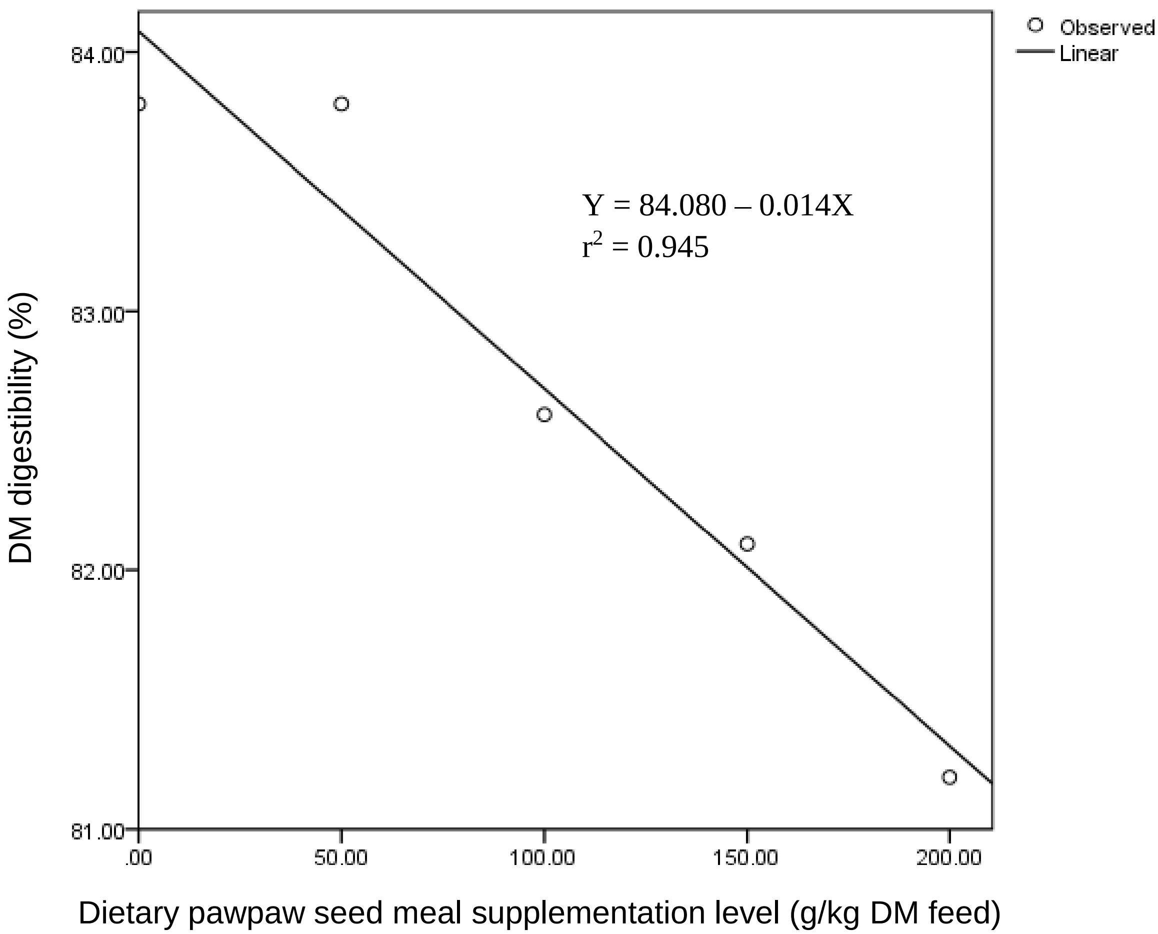

Figure 4.14 Relationship between dietary pawpaw seed meal supplementation and diet DM digestibility of female Venda chickens aged 13 weeks

Table 4.04 Effect of pawpaw seed meal supplementation level on optimal growth rate (g/bird/day), live weight (g/bird at 13 weeks of age), apparent metabolisable energy (MJ ME/kg DM) and nitrogen retention (g/bird/day) of female Venda chickens aged eight to 13 weeks

Trait	Formula	PS	Y-value	r^2	P
Growth	$Y = 11.729 + 0.003X – 0.00002760X^2$	54	11.810	0.719	0.281
Lwt	$Y = 1161.815 + 0.173X – 0.001X^2$	87	1169.298	0.893	0.107
ME	$Y = 14.022 + 0.011X – 0.0000794X^2$	69	14.403	0.955	0.045
N-Ret	$Y = 1.105 + 0.018X - 0.00005094X^2$	177	2.695	0.960	0.040

Lwt : Live weight
PS : Pawpaw seed meal supplementation level for optimal variable
Y-Value : Optimal Y-Value
r^2 : Regression coefficient
P : Probability
ME : Metabolisable energy
N-Ret : Nitrogen retention

Table 4.05 Effect of dietary pawpaw seed meal supplementation on carcass weight (g) and carcass parts (g) of female Venda chickens aged 91 days

	Treatment					
Variable	PS_0	PS_{50}	PS_{100}	PS_{150}	PS_{200}	SE
Carcass	737	767	790	820	825	19.99
Breast	197	204	205	215	197	5.13
Thigh	57	61	62	65	66	1.80
Drumstick	58	60	60	61	62	0.67
Wing	45	46	48	46	53	1.32
Gizzard	40	29	44	38	41	2.46
Liver	18	19	19	19	19	0.78
Heart	5	5	5	5	5	0.20
Fat pad	15.5	19.5	6.7	29.4	14.3	3.10

SE : Standard error

Table 4.06 Effect of dietary pawpaw seed meal supplementation on tenderness, juiciness and flavour of meat of female Venda chickens aged 91 days

Variable	Treatment					SE
	PS_0	PS_{50}	PS_{100}	PS_{150}	PS_{200}	
Tenderness	2.44[b]	2.56[ab]	3.33[ab]	3.56[a]	3.44[ab]	0.176
Juiciness	2.67	3.44	2.78	3.00	2.56	0.200
Flavour	2.00	2.44	2.22	3.00	2.89	0.178

a, b : Means with different superscripts within a row are significantly different (P<0.05)

SE : Standard error

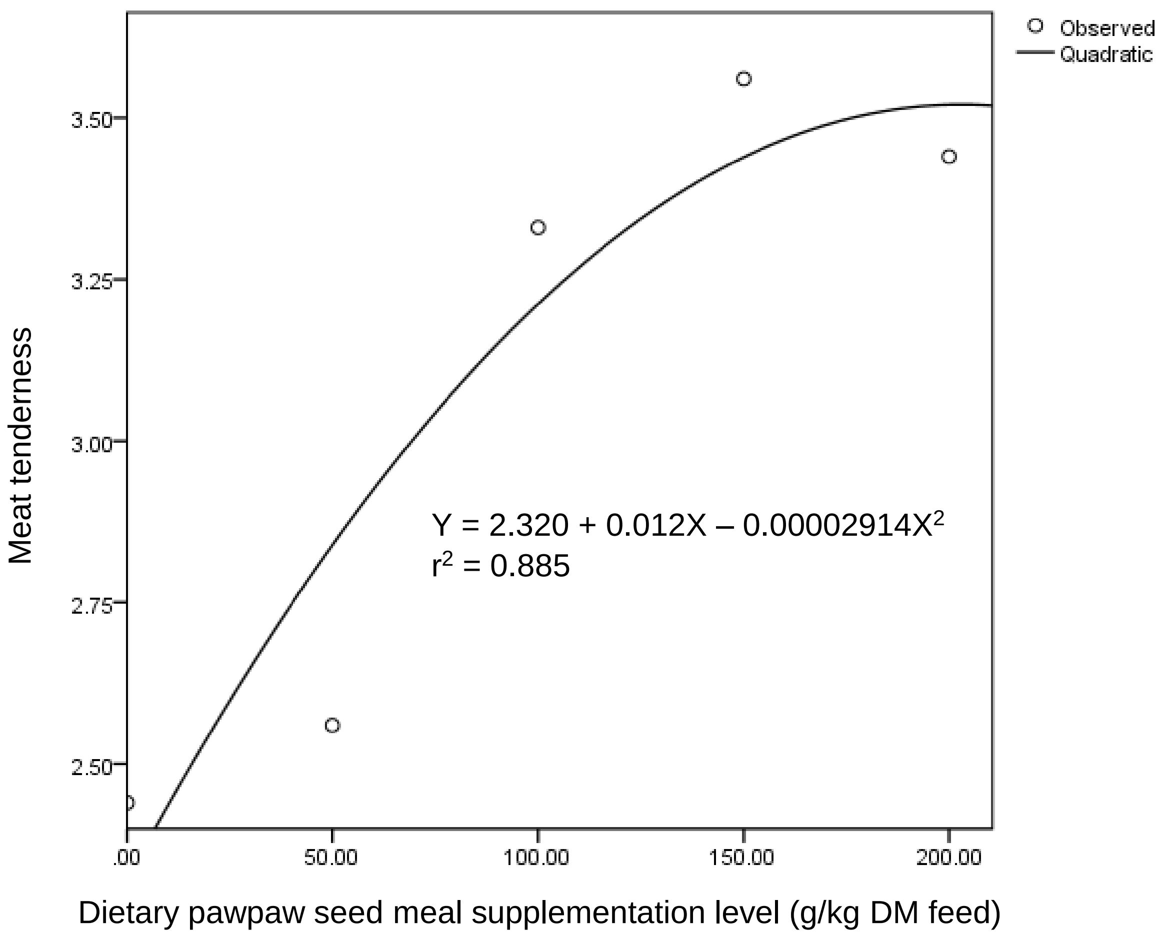

Figure 4.15 Effect of dietary pawpaw seed meal supplementation on tenderness of meat of female Venda chickens aged 91 days

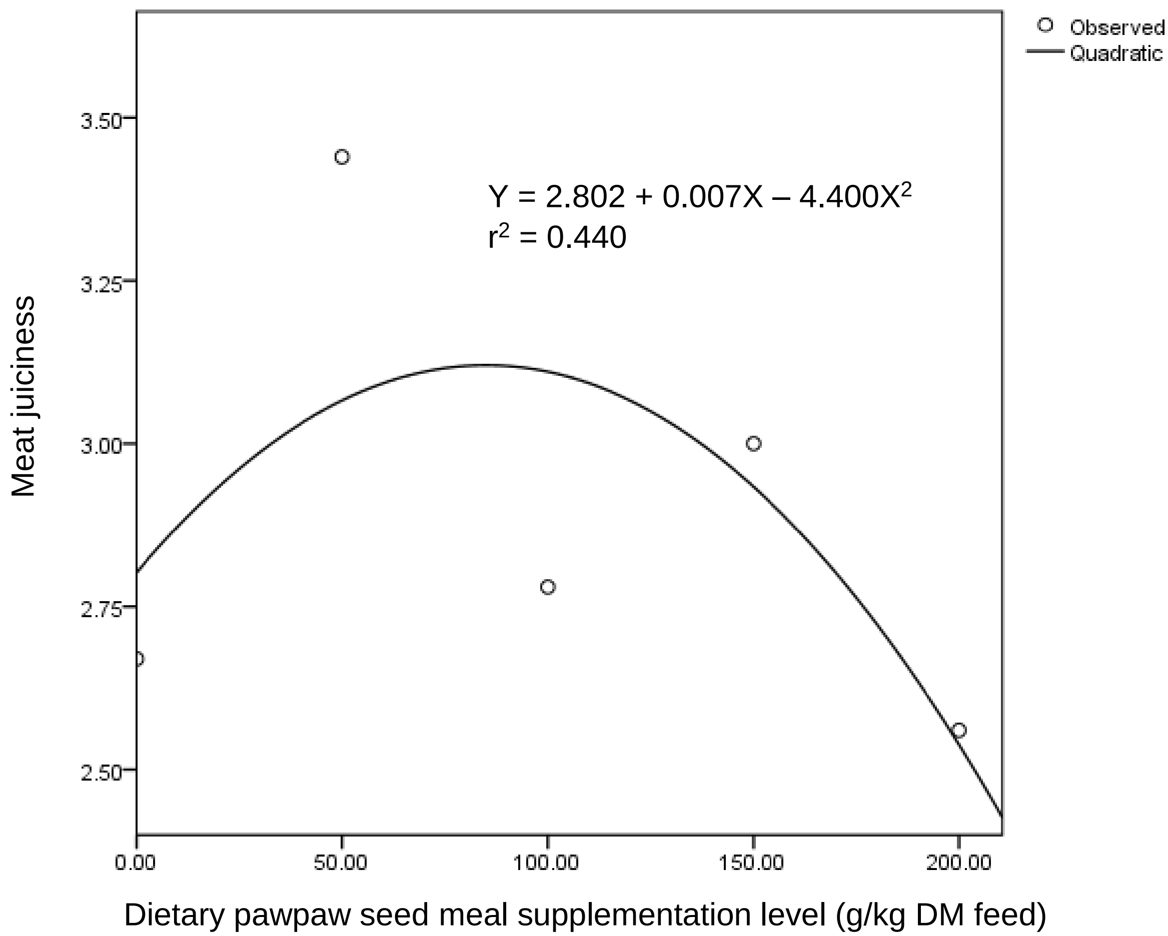

Figure 4.16 Effect of dietary pawpaw seed meal supplementation on juiciness of meat of female Venda chickens aged 91 days

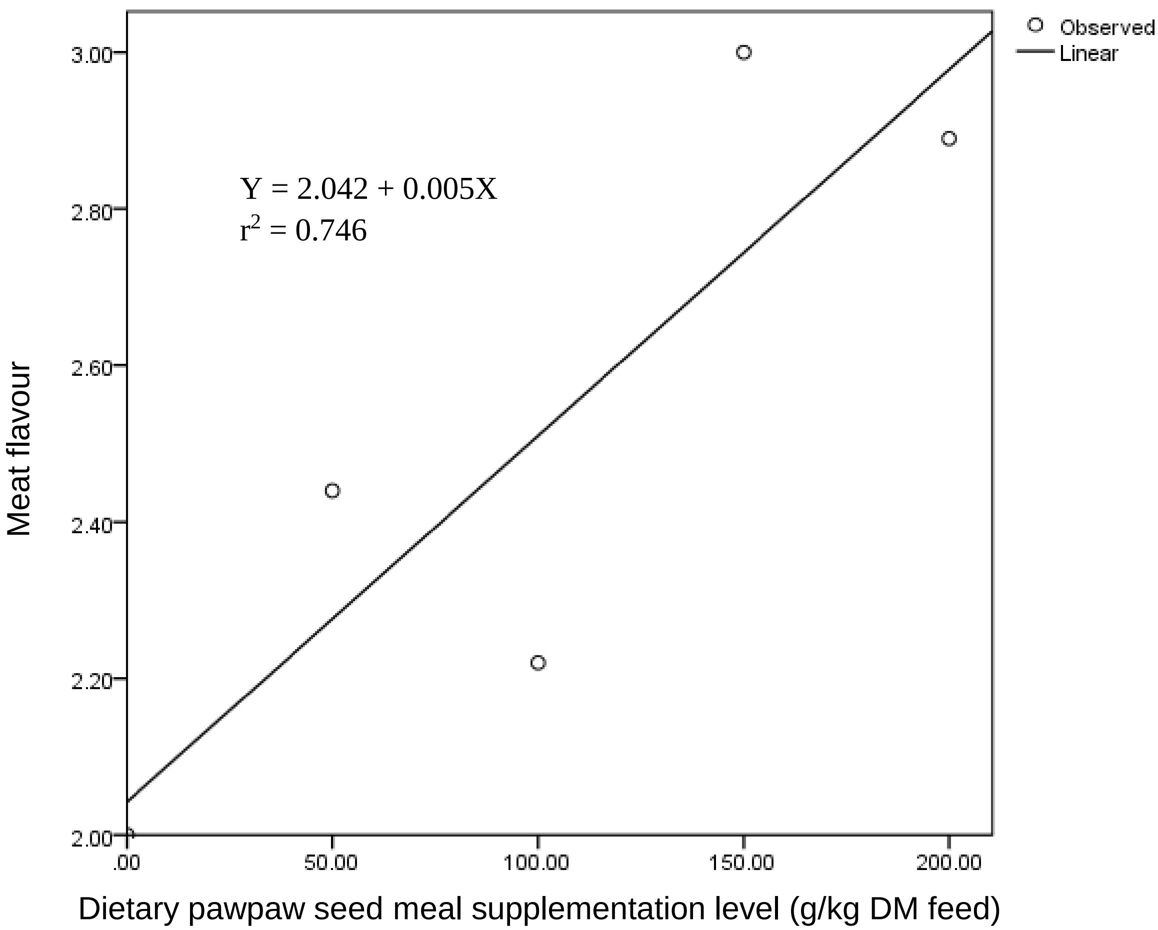

Figure 4.17 Relationship between dietary pawpaw seed meal supplementation and meat flavour of female Venda chickens aged 91 days

CHAPTER 5
DISCUSSION

Pawpaw seed meal supplementation in the diets of indigenous Venda chickens aged one to seven weeks improved feed intake as compared to those on diets without pawpaw seed meal supplementation. There were no studies found on the performance of indigenous Venda chickens fed diets supplemented with pawpaw seed meal. However, Bolu *et al.* (2009) observed similar improvements in feed intake of broiler chickens when the diets were supplemented with pawpaw seed meal. Taiwo *et al*. (2005) also observed increased feed intakes on rabbits given diets supplemented with pawpaw leaf meal. Similarly, Omole *et al*. (2004) reported increased feed intakes in snails given diets supplemented with pawpaw peel and leaf meals. The latex of papaya plants is rich in enzymes, collectively known as cysteine proteinases, which are used widely for protein digestion functions in the food and pharmaceutical industries (Villegas, 1997). Cysteine proteases are enzymes that break down chains of amino acids that make up proteins known as polypeptides (Lee and Joseph, 2012). The observation of the current study may indicate that cysteine protease activity increased as pawpaw seed meal supplementation levels increased. Thus, the actions of these enzymes may have improved feed intake of indigenous Venda chickens.

Live weight of indigenous Venda chickens fed diets supplemented with pawpaw seed meal did not improve, despite the fact that feed intake and metabolisable energy of chickens on diets supplemented with pawpaw seed meal improved. This may be due to poor feed conversion ratio of chickens fed diets supplemented with pawpaw seed meal. Abdulazeez *et al.* (2009) also observed no significant differences in litter body weight in rats supplemented with germinated pawpaw seeds as compared to the control group. In contradiction with the current study, Penaflorida (1995) reported that diets of *Penaeus monodon postlarvae* supplemented with pawpaw leaf meal improved feed conversion ratio. The results of the current study also contradict with the findings of Bolu *et al.* (2009) who observed live weight improvements of broiler chickens fed diets supplemented with pawpaw seed meal. El-Kholy *et al.* (2008) observed digestibility and live weight improvements of New Zealand White Rabbits given diets supplemented with pawpaw seed meal. Lohiya *et al.* (2006) observed similar results on rats given pawpaw seeds.

Growth rate, live weight, metabolisable energy and nitrogen retention were optimized at different pawpaw seed meal supplementation levels of 133, 143, 101 and 133 g/kg DM feed, respectively. Thus, there was no single dietary pawpaw seed meal supplementation level that optimized all production variables.

Pawpaw seed meal supplementation in the diets of indigenous Venda chickens aged one to seven weeks reduced mortality from 20 % to 0 %. Hoernecke *et al.* (1993), Duskova and Wald (1999), Hofstad (1984) and Schwinger (1970) reported that papain, a cysteine protease enzyme, extracted from pawpaw seeds increased immune system functions in livestock. This may have reduced mortality of Venda chickens. This is similar to the findings of Ekanem *et al.* (2004) who reported that mortality of broiler chickens and fish fed diets supplemented with pawpaw seed meal reduced from 30 % in the control to 0 %.

Pawpaw seed meal supplementation to the diets of indigenous Venda chickens aged eight to 13 weeks had no effect on feed intake, dry matter digestibility, growth rate, live weight, carcass characteristics, meat juiciness and meat flavour. There were no studies found on the performance of indigenous chickens supplemented with dietary pawpaw seed meal. Contrary to the present findings, Bolu *et al.* (2009) found improved performance variables of broiler chickens given diets supplemented with pawpaw seed meal. Similarly, Chen *et al*. (2009) reported increases in performance variables of rats on diets supplemented with pawpaw seed meal. El-Kholy *et al.* (2008) and Taiwo *et al*. (2005) also observed increased productivity responses in rabbits fed diets supplemented with pawpaw seed meal. Omole *et al*. (2004) also observed improved productivity responses in snails on diets supplemented with pawpaw peel and leaf meals. Babu *et al*. (2003) also found improved productivity responses in buffaloes given diets supplemented with pawpaw bark, leaf and seed meals. These results are in contradiction with the results of Okeniyi *et al.* (2007) who observed reductions in performance variables of rats on dietary pawpaw seed meal.

Dietary pawpaw seed meal supplementation did not improve feed conversion ratio of indigenous Venda chickens aged between eight and 13 weeks. This could be explained in terms of poor utilization of supplemented diets. Contrary to the findings of the current study, Penaflorida (1995) reported improved feed conversion ratio of *Penaeus monodon postlarvae* given diets supplemented with pawpaw leaf meal.

The present study indicates that pawpaw seed meal supplementation in the diets of indigenous Venda chickens at 13 weeks old improved meat tenderness and nitrogen retention, but poor metabolisable energy values of chickens were observed. Improved nitrogen retention could be explained in terms of cysteine protease enzymes (papain, chymopapain, etc.) activity in digestion of proteins. These results are similar to the findings of Babu *et al*. (2003) who reported that pawpaw seed meal supplementation in the diets of chickens improved meat tenderness. Onyimonyi and Onu (2009) also found similar results on broiler chickens fed pawpaw seeds. However, there were no improvements in meat juiciness and meat flavour of indigenous Venda chickens fed diets supplemented with pawpaw seed meal. The results of this study are in contradiction with those of Onyimonyi and Onu (2009) who observed increased carcass quality of broiler chickens fed diets supplemented with pawpaw leaf meal.

The present study showed that optimal responses in growth rate, live weight, metabolisable energy and nitrogen retention of indigenous Venda chickens aged eight to 13 weeks were achieved at different dietary pawpaw seed meal supplementation levels. Thus, growth rate, live weight, metabolisable energy and nitrogen retention were optimized at different pawpaw seed meal supplementation levels to the diets of chickens of 54, 87, 69 and 177 g/kg DM feed, respectively. Results of the present study showed no single dietary pawpaw seed meal supplementation level for all production variables. Pawpaw seed meal supplementation level for optimum production of a particular variable may have been influenced by nutrient requirements of female Venda chickens for that variable.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The present study demonstrated that pawpaw seed meal supplementation to the diets of indigenous Venda chickens aged one to seven weeks improved feed intake and diet dry matter digestibility. Dietary levels of pawpaw seed meal supplementation of 133, 143, 101 and 133 g per kg DM feed optimized growth rate, live weights, metabolisable energy and nitrogen retention of chickens, respectively. The present study also demonstrated that pawpaw seed meal supplementation to the diets of female Venda chickens aged eight to 13 weeks improved nitrogen retention. Growth rate, live weight, metabolisable energy, nitrogen retention, meat tenderness and juiciness of chickens aged eight to 13 weeks were optimized at different dietary pawpaw seed meal supplementation levels of 54, 87, 69, 177, 205.90 and 79.55 g per kg DM feed, respectively. It was observed that pawpaw seed meal supplementation in the diets of indigenous Venda chickens reduced mortality to 0 % as compared to that of 20 % in the control. It is, therefore, concluded that pawpaw seed meal supplementation was important in the diets of indigenous Venda chickens.

6.2 Recommendations

More research is required to explore biological reasons for increased feed intake, feed conversion ratio, growth rate, live weight, diet dry matter digestibility, metabolisable energy, nitrogen retention and breast meat nitrogen content of indigenous Venda chickens with pawpaw seed meal supplementation. Similarly, more research is required to explore reasons for improved meat tenderness of indigenous Venda chickens supplemented with pawpaw seed meal. It is, also, important to explore biological reasons for a reduction in mortality of the chickens with pawpaw seed meal supplementation.

CHAPTER 7

REFERENCES

Abdulazeez, M. A., Ameh A. D., Ibrahim, S., Ayo, J. O. and S. F. Ambali. 2009. Effect of fermented seed extracts of *Carica papaya* on litters of female Wistar rats (*Rattus norvegicus*). *African Journal of Biotechnology* 8: 854-857.

Aberra, M. 2000. Comparative studies on performance and physiological responses of Ethiopian indigenous (‘*Angete-melata’)* chicken and their F1 crosses to long term heat stress. PhD thesis. Martin-Luther University, Halle-Wittenberg, Berlin, Germany. pp 182.

Adeneye, A. A., Olagunju, J. A., Banjo, A. A. F., Abdul, S. F., Sanusi, O. A., Sanni O. O., Osarodion, B. A. and O. E. Shonoiki. 2009. The Aqueous Seed Extract of *Carica papaya* Linn. Prevents carbon tetrachloride induced hepatotoxicity in rats. *International Journal of Applied Research in Natural Products* 2: 19-32.

Adesola, A. A., Ng’ambi, J. W. and D. Norris. 2012. Effect of ascorbic acid supplementation level to the diets of indigenous Venda hens on egg production, hatchability and subsequent productivity of chicks. *African Journal of Biotechnology* 11: 12606-12611.

Annan-Prah, A. 2010. A study of the potential of using aqueous extracts of pawpaw (*Carica papaya*) roots, leaves and seeds as anticoccidia agents in chicken. http://www.idhaa.org/Art/483/377/A-study-of-the-potential-of-using-aqueous-extracts-of-pawpaw-Carica-papaya-roots-leaves-and-seeds-as-anticoccidia-agents-in-chicken.html.

AOAC. 2000. Official Methods of Analysis. 17th Edition. Association of Official Analytical Chemists, Washington DC.

Artschwager, M. 1996. Healing with plants in the American and Mexican West. The University of Arizona Press.

Azarkan, M., Moussaoui, A. E., Van Wuytswinkel, D., Dehon, G. and Y. Looze. 2003. Fractionation and purification of the enzymes stored in the latex of Carica papaya. *Journal of Chromatography* 790: 229-38.

Babu, A. R., Rao, D. S. and M. Parthasarathy. 2003. In sacco dry matter and protein degradability of papaya (*Carica papaya*) pomace in buffaloes. *Buffalo Bulletin* 22: 12-15.

Bitto, I. I. 2008. Total protein and cholesterol concentrations in brain regions of male rabbits fed pawpaw peel meal based diets. *African Journal of Biomedical Research* 11: 73 – 78.

Bolu, S. A. O., Sola-Ojo, F. E., Olorunsanya, O. A. and K. Idris. 2009. Effect of graded levels of dried pawpaw (*Carica papaya*) seed on the performance, haematology, serum biochemistry and carcass evaluation of chicken broilers. *Journal of Poultry Science* 8: 905-909.

Braunius, W. W. 1987. Some Aspects of Epidemiology and Control of Coccidiosis in Chicken. PhD thesis. Faculty of Veterinary Medicine. Utrecht, Netherland.

Carson, D. D., Bagchi, I., Dey, S. K., Enders, A. C., Fazleabas, A. T., Lessey, B. A. and K. Yoshinaga. 2000. Embryo implantation. *Developmental Biology* 223: 217-237.

Calam, D. H., Davidson, J. and R. Harris. 1985. High performance liquid chromatographic investigation on some enzymes of papaya latex. *Journal of Chromatography* 326: 103–111.

Cavieres, F. M., Jaeger, J. and W. Porter. 2002. Developmental toxicity of a commercial herbicide mixture in mice: Effects on embryo implantation and litter size. *Environmental Health Perspectives* 110: 1081-1085.

Chen J., Liu J., Jiang Y., Xu H. and M. Xu. 2009. Effect of Pawpaw on Reproductive Performance and Lactation Performance of New Zealand White Rabbit. *Chinese Journal of Rabbit Farming.* http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZGYT200905005.htm.

Chinoy, N. J., D'souza, J. M. and P. Padman. 1994. Effects of crude aqueous extract of *Carica papaya* seeds in male albino mice. *Reproduction Texicology* 8: 75-79.

Cornell University. 2008. Medicinal Plants for Livestock. *Carica papaya.* http://www.ansci.cornell.edu/plants/medicinal/papaya.html.

Dakare, M. 2004. Fermentation of *Carica papaya* seeds to be used as "daddawa". Master of Science thesis. Department of Biochemistry. A. B. U. Zaria.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S. and C. Courbois. 1999. Livestock to 2020: The next food revolution. Food, Agriculture and the Environment Discussion Paper 28. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp 72.

Deloitte and Touche. 2003. Study of Agricultural Industry – Waterberg Report. Polokwane, Republic of South Africa.

Duncan, D. B. 1955. Multiple ranges and multiple F-test. *Biometrics* 11: 1-42.

Duskova, M. and M. Wald. 1999. Orally administered proteases in aesthetic surgery. *Aesthetic Plastic Surgery* 23: 41-44.

Echeverri, F., Torres, F., Quinones, W., Cardona, G., Archbold, R., Roldan, J., Brito, I., Luis, J. G. and E. H. LahlouU. 1997. Danielone is a phytoalexin found in the papaya fruit. *Phytochemistry* 44: 255-256.

Egbunike, G. N., Sadiku, M. O. and O. E. Okebiorun. 2000. Sperm production and related phenomenon in rats fed diets containing pawpaw peels seed and leaves. *Tropical Journal of Animal Science* 3: 77-84.

Ekanem, A. P., Obiekezie, A., Kloas, W. and K. Knopf. 2004. Effects of crude extracts of *Mucuna pruriens* (Fabaceae) and *Carica papaya* (Caricaceae) against the protozoan fish parasite. *Ichthyophthirius multifiliis* 92: 361-366.

Ekong, M. B., Akpan, M. U., Ekanem, T. B. and M. I. Akpaso. 2011. Morphometric Malformations In Fetal Rats Following Treatment With Aqueous Leaf Extract Of Carica Papaya. *Asian Journal of Medical Sciences* 2: 18-22.

El-Kholy, K. H., Zeedan, K. I., El-Neney, A. M. B., Zeedan, I. O. and A. S. A. El-Hakim. 2008. Study on the Optimal Crude Papaya Latex Content of Growing Rabbit Diet under Summer Conditions: Effects on Growth Performance and Immune Status. *International Journal of Poultry Science* 7: 978-983.

El Moussaoui, A., Nijs, M., Paul, C., Wintjens, R., Vincentelli, J., Looze, Y. and M. Azarkan. 2001. Revisiting the enzymes stored in the laticifers of Carica papaya in the context of their possible participation in the plant defence mechanism. *Cell and Molecular Life Science* 58: 556-570.

Encyclopedia International. 2012. What makes you should eat papaya? Papain in papaya. http://verdilaurent.blogspot.com/2012/06/what-makes-you-should-eat-papaya.html.

Eno, A. E., Owo, O. I., Itam, E. H. and R. S. Konya. 2000. Blood pressure depression by the fruit juice of Carica papaya in renal and DOCA-induced hypertension in the rat. *Phytotherapy Research* 14:235-239.

Eusebio, P. S. and R. M. Coloso. 1998. Evaluation of leguminous seed meals and leaf meals as plant protein sources in diets for juvenile *Penaeus indicus*. *Israeli Journal of Aquaculture* 50: 47-54.

Eusebio, P. S. and R. M. Coloso. 2000. Nutritional evaluation of various plant protein sources in diets for Asian sea bass *Lates calcarifer*. *Journal of Applied Ichthyology* 16: 56-60.

Gill, L. S. 1992. *Carica papaya.* In: Ethnomedicinal uses of plants in Nigeria.

Grag, S. K., Saksena, S. K. and R. R. Chaudhury. 1970. Antifertility screening of plant parts. Effect of five indigenous plants on early pregnancy in albino rats. *Indian Journal of Medical Research* 58: 1258.

Gueye, E. F. 1998. Village egg and fowl meat production in Africa. *World's Poultry Science Journal* 54:73–86.

Guruma, A. 2010. Pawpaw (*Carica Papaya*) fruit. A Powerhouse of Nutrients! http://www.gurumaa.com/content/papaya-a-powerhouse-of-nutrients.html.

Gwatkin, R. B. L. 1964. Effects of enzymes and acidity on the zona pellucida of the mouse egg before and after fertilization. *Journal of Reproductive Fertilisation* 7:99.

Harvey, T., Chan, J. R., Heu, R. A., Tang, C. S., Okazaki, E. N. and S. M. Ishizaki. 2006. Composition of papaya seeds. *Journal of Food Science* 43: 255-256.

Hoernecke, R. and A. Doenicke. 1993. Perioperative enzyme therapy. A significant supplement to postoperative pain therapy. *Anaesthesist* 42: 856-861.

Hofstad, M. S. 1984. Diseases of Poultry. Iowa State University Press. Ames. IAP, pp. 236.

Irwig, M. S. 2002. Frequent intake of tropical fruits that are rich in beta-cryptoxanthin is associated with higher plasma beta-cryptoxanthin concentrations in Costa Rican adolescents. *Journal of Nutrition* 132: 3161-7.

Jarvik, G. P., Tsai, N. T., McKinstry, L. A., Wani, R., Brophy, V. H., Richter, R. J., Schellenberg, G. D., Heagerty, P. J., Hatsukami, T. S. and C. E. Furlong. 2002. Vitamin C and E intake is associated with increased paraoxonase activity. *Arteriosclerosis, Thrombosis and Vascular Biology* 22:1329-1333.

Jegede, T. and O. Fagbenro. 2008. Histology of gonads in *Oreochromis niloticus* (trewavas) fed pawpaw (*Carica papaya*) seed meal diets. http://ag.arizona.edu/azaqua/ista/ISTA8/FinalPapers/12/2%20Fish%20Heakth%20Management/PDF%20files/10%20FAGBE.pdf.

Kitalyi, A. J. 1997. Village Chicken Production Systems in Developing Countries: What Does the Future Hold? http://www.fao.org/docrep/w6437t/w6437t07.htm.

Kondombo, S. R. 2005. Improvement of village chicken production in a mixed (chicken–ram) farming system in Burkina Faso. PhD thesis. Wageningen Institute of Animal Sciences, Animal Nutrition Group, Wageningen University, The Netherlands. pp 208.

Kugonza, D. R., Kyarisiima, C. C. and A. Iisa. 2008 Indigenous chicken flocks of Eastern Uganda: I. Productivity, management and strategies for better performance. *Livestock Research for Rural Development.* http://www.lrrd.org/lrrd20/9/kugo20137.htm.

Lee, H. and A. Joseph. 2012. Wise geek. What is cysteine protease inhibitor? http://www.wisegeek.com/what-is-a-cysteine-protease-inhibitor.htm.

Lohiya, N. K., Manivanna, B., Mishra, P. K., Pathak, N., Sriram, S., Bhande, S. S. and S. Panneerdoss. 2002. Chloroform extract of *Carica papaya* seeds induce long-term reversible azoospermia in Langur monkey. *Asian Journal of Andrology* 4: 17-26.

Lohiya, N. K., Manivannan, B. and G. Shipra. 2006. Toxicological investigations on the methanol sub-fraction of the seeds of *Carica papaya* as a male contraceptive in albino rats. *Reproductive Toxicology* 22: 461-468.

Look Chemistry. 2008. Pawpaw fruit. The Important Functions of Pawpaw. http://www.lookchem.com/Chempedia/Health-and-Chemical/15151.html.

Marfo, E. K. O., Oke, L. and O. A. Afolabi. 1986. Chemical composition of papaya (*Carica papaya*) seeds. *Journal of Food Chemistry* 22: 259-266.

Mbagiorgu, C. A., Ng'ambi, J. W. and D. Norris. 2011effect of varying dietary energy to protein ratio level on growth and productivity of indigenous Venda chickens. *Asian Journal of Veterinary Animal Advances* 6: 334-352.

Mbugua, P. N. 1990. Rural smallholder poultry production in Kenya. In: CTA Seminar Proceedings, Volume 2, Smallholder poultry production, 9-13 October, 1990. Thessaloniki, Greece, pp 119-131.

Mcdonald, P., Edwards, R. A. Greenhalgh, J. F. D. and Morgan, C. A. 2002. Animal Nutrition, 4th Edition. Longman Scientific and Technical publishers, New York. USA. pp 200–216.

Morton, J. F. 1987. Papaya *Caria Papaya* Latex. In: Fruits of Warm Climate. Creative Resources Inc., Winterville. pp 336-346.

Mtileni, B. J., Muchadeyi, F. C., Mwaiwashe, A., Phitsane, P. M., Halimani, T. E. and K. Chimonyo. Characterisation of production systems for indigenous chicken genetic resources in South Africa. 2010. *Journal of Applied Animal Husbandry in Rural Development* 2: 18-22.

Mupeta, B., Wood, J., Mandonga, F. and J. Mhlanga. 2002. Mupeta Poultry Paper. A comparison of the performance of village chickens, under improved feed management, with the performance of hybrid chickens in tropical Zimbabwe. http://www.smallstock.info/research/reports/R7524/R7524-02.pdf.

Naidoo, V., McGawa, L. J., Bisschop, S. P. R., Duncan, N., and J. N. Eloff. 2008. The value of plant extracts with antioxidant activity in attenuating coccidiosis in broiler chickens. *Veterinary Parasitology* 153: 214-219.

Okeniyi, J., Ogunlese, T., Oyelami, O. and L. Adeyemi. 2007. Effectiveness of dried *Carica papaya* seeds against human intestinal parasitosis. A pilot study. *Journal of Medicinal food* 10: 194-196.

Oderinde, O., Noronha, C., Oremosu, A., Kusemiju, T. and O. A. Okanlawon. 2002. Abortificient properties of aqueous extract of Carica papaya (Linn) seeds on female Sprague-Dawley rats. *Nigerian Postgraduate Medicine Journal* 9: 95-98.

Olori, V. E. and E. B. Sonaiya. 1998. Village chicken production in South-Western Nigeria. In: *Proceedings of an international workshop on rural poultry development in Africa.* Iie-Ife, Nigeria. pp. 243–247.

Omole, A. J., Ayodeji, I. O. and M. A. Raji. 2004. The potential of mango, plantain, cocoyam and pawpaw as diets for growing snails (*Archachatina marginata*). *Livestock Research for Rural Development* 16: 102. http://www.cipav.org.co/lrrd/lrrd16/12/omol16102.htm.

Onyimonyi, E. A. and E. Onu. 2009. An assessment of pawpaw leaf meal as protein ingredient for finishing broiler*. International Journal of Poultry Science* 8: 995-998.

Otsuki, N., Dang, N. H., Kumagai, E., Kondo, A., Iwata, S. and C. Morimoto. 2009. Aqueous extract of Carica papaya leaves exhibits anti-tumor activity and immunomodulatory effects. *Journal of Ethnopharmacology* 127: 760-767.

Passera, C. and P. Spettoli. 1981. Chemical composition of papaya seed plant foods for human nutrition. *Chemistry and Materials Science* 31: 77-83.

Penaflorida, V. D. 1995. Effect of papaya leaf meal on the Penaeus monodon post larvae. *Israeli Journal of Aquaculture Bamidgeh* 47: 25–33.

Poulter, N. H. and J. C. Caygill. 1985. Production and utilization of papain-a proteolytic enzyme from *Carica papaya*. *Tropical Journal of Animal Science* 25: 123-137.

Raji, Y., Morakinyo, A. O., Oloyo, A. K., Akinsomisoye, O. S., Olufadekemi, T. and T. Kunle-Alabi. 2005. Impart of the chloroform extract of *Carica papaya* seed on oestrous cycle and fertility in female albino rats. *Journal of Medical Science* 5: 337-343.

Rakhimov, M. R. 2000. Pharmacological study of papain from the papaya plant cultivated in Uzbekistan (Article in Russian). *Eksp Klin Farmakol* 63: 55-57.

Rawlings, N. D., Tolle, D. P. and A. J. Barrett. 2004. MEROPS: The peptidase database. *Nucleic Acids Research* 32: 160-164.

Reid, W. W. 1990. The history of avian medicine in the United States. Control of coccidiosis. *Avian Diseases* 34: 509-525.

Reid, W. and L. R. Mcdougald. 1991. Diseases of Poultry: Coccidiosis. Iowa State University Press, Ames, pp. 780 -797.

Ruff, M. D. and P. G. Allen. 1990. Coccidiosis of Man and Domestic Animals: Pathophysiology. P. L. Long CRC Press, Boca Raton, pp.263-280.

SAS. 2008. Propriety Software release 9.2. Series Statistical Analysis System Institute, Inc., Cary, North Caroline, USA.

Satrija, F., Nansen, P., Murtini, S. and S. He. 1995. Anthelmintic activity of papaya latex against patent *Heligmosomoides polygyrus* infections in mice. *Journal of Ethnopharmacology* 48: 161-164.

Schwinger, O. 1970. Results of oral enzyme therapy in wounds of muscles, tendons and bones after accidents. *Wien Med Wochenschr* 120: 603-605.

Singh, R. A. 1990. Poultry Production. 3rd edition. Kalyani publishers, New Delhi, India.

Singh, S. and S. Devi. 1980. Effect of papain on foetal chodrogenesis: Result male of material administration of the enzyme in the rat. *Indian Journal of Experimental Biology* 18: 953-957.

Tadelle, D., Million, T., Alemu, Y. and K. J. Peters. 2003. Village chicken production systems in Ethiopia: 1. Flock characteristics and performance; *Livestock Research for Rural Development.* http://www.lrrd.org/lrrd15/1/tadea151.htm.

Taiwo, A. A., Adejuyigbe, A. D., Adebowale, E. A., Oshotan, J. S. and O. O. David. 2005. Performance and nutrient digestibility of weaned rabbits fed forages supplemented with concentrate. *Nigerian Journal of Animal Production* 32: 74-78.

Teketel, F. 1986. Studies on the Meat Production Potentials of Some Local Strains of Chickens in Ethiopia. Ph.D. Thesis, J. L. University Giessen, Germany.

Udoh, P., Nju, R. and F. Udoh. 2004. Effect of *Carica papaya* (pawpaw) seeds ethanolic extract on the pituitary, thyroid and parathyroid glands of male wistar rats. *Global Journal of Pure and Applied Sciences* 10: 515–517.

Udoh, F. V. *and* P. B. Udoh. 2005. Hepatotoxicity of the methanol extract of C*arica papaya* (pawpaw) seeds in wistar rats. *Pharmaceutical Biology* 43: 349-352.

Udoh, P., Essien, I. and F. Udoh. 2005. Effects of Carica papaya (paw paw) seeds extract on the morphology of pituitary-gonadal axis of wistar rats. *Phytotherapy Research* 19:1065-1068.

Villegas, V. N. (1997). Edible fruits and nuts - *Carica papaya* L. In EWM Verheij, RE Coronel, eds, volume 2. Wageningen University, the Netherlands.

Wang, H. and S. K. Dey. 2006. Roadmap to embryo implantation: clues from mouse models. *National Genetics* 7: 185-199.

Wattanachant, S., Benjakul, S. and D. A. Ledward. 2005. Microstructure and thermal characteristics of Thai indigenous and broiler chicken muscles. *Poultry Science* 84: 328–336.

Wilson, R. T., Traore, A., Kuit, H. G. and M. Slingerland. 1987. Livestock production in central Mali: Reproduction, growth and mortality of domestic fowl under traditional management. *Tropical Animal Health and Production* 19: 229–236.