GROWTH AND LAYING PERFORMANCE OF JAPANESE QUAILS (*Coturnix coturnix japonica*) FED GRADED LEVELS OF SWEET POTATO (*Ipomoea batatas)* AND SWEET POTATO PEEL MEALS

BY

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A DISSERTATION SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE,
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DECEMBER, 2017

DECLARATION

I hereby declare that the work in this dissertation entitled "Growth and laying performance of Japanese Quails (C*oturnix coturnix japonica*) fed graded levels of sweet potato (*Ipomoea batatas* and sweet potato peel meals", has been performed by me in the Department of Animal Science. The information derived from literatures has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another higher Degree or Diploma.

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Agbai Kalu Nnenna Date

CERTIFICATION

This dissertation entitled **"GROWTH AND LAYING PERFORMANCE OF JAPANESE QUAILS (*Coturnix coturnix japonica*) FED GRADED LEVELS OF SWEET POTATO (*Ipomoea batatas* AND SWEET POTATO PEEL MEALS"** by **Nnenna AGBAI KALU** meets the regulations governing the award of Masters Degree in Animal Science in Ahmadu Bello University Zaria and is approved for its contribution to knowledge and Literary presentation.

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DEDICATION

This dissertation is dedicated to Almighty God, the author and finisher of our faith; and to my loving parents **Chief and Mrs. Paul Agbai Kalu** and my siblings: Pastor. Agbai Kalu Pera, Honourable Agbai Kalu Johnson, Mr. Agbai Kalu Igbani, Mr. Agbai Kalu Ikwuagwu and Mr. Agbai Kalu Elechi.

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ABSTRACT

Two feeding trials were conducted to evaluate the effect of sweet potato and sweet potato peel meals on the growth and laying performance of Japanese quails (*Coturnix coturnix japonica*). One thousand Five hundred and six Japanese quails were used for the study. In experiment 1, three hundred mixed sexes of 2 weeks old Japanese quails (mean weight 32.00g) were fed the different diets of sweet potato meal for a period of 28 days for the grower phase and two hundred and twenty eight female 7 weeks old Japanese quail birds (mean weight 137.00g) were fed for 112 days for the laying phase. The birds were assigned to four dietary treatments each (0, 10, 20, 30%) of sweet potato meal consisting of 75 grower quails per treatment with three replicates of 25 birds at the grower phase and 57 hens per treatment with three replicates of 19 birds at laying phase. Water and feed were supplied *ad libitum*. During grower phase, higher final body weight (141.47g) of the Japanese quails was achieved in quail birds fed diets containing 10% sweet potato meal, this was followed by the quail birds fed 0% sweet potato meal (141.28g) while the least final body weight (134.80 g) was obtained in the quail birds fed 30% sweet potato diet. The feed conversion ratio showed no significant ($P < 0.05$) differences across the entire treatment groups for sweet potato meal. Higher carcass weight (101.52g) of the quails was achieved in birds fed diets containing 10% sweet potato meal. Quails fed diets containing 10% sweet potato meal had better apparent digestibility of nutrients compared to birds fed other diets. Feed cost analysis during grower phase revealed that birds fed diets containing 30% sweet potato meal ((₦ 304.67) had better feed cost than birds on other diets. The result on laying performance and egg characteristics showed significant ($P < 0.05$) differences in birds fed sweet potato meal. Hen-day egg production of quails fed 10% sweet potato meal diets (55.71) was significantly ($P < 0.05$) higher than those of birds fed the other diets. Peak egg production values of birds fed 10% sweet potato meal (83.33 days) was statistically the same with birds fed 0% sweet potato diets (82.31days). There was no mortality recorded during the grower and laying phase. In experiment 2, three hundred mixed sexes of 2 weeks old Japanese quails (mean weight 32.00g) were fed the different diets of sweet potato peels meal for a period of 28 days for the grower phase and two hundred and twenty eight female 7weeks old Japanese quail birds (mean weight 137.00g) were fed for 112 days for the laying phase. The birds were assigned to four dietary treatments each (0, 10, 20, 30%) of sweet potato peel meal consisting of 75 grower quails per treatment with three replicates of 25 birds at the grower phase and 57 hens per treatment with three replicates of 19 birds at laying phase. Water and feed were supplied *ad libitum*. At grower phase, higher final body weight (141.33g) of the Japanese quails was achieved in quail birds fed diets containing 10% sweet potato peel meal, this was followed by the quail birds fed 0% sweet potato peels meal (141.28g) while the least final body weight (132.32 g) was obtained in the quails fed diets containing 30% sweet potato peel meal. Quail birds fed 10% sweet potato peel meal performed significantly ($P < 0.05$) better in feed conversion ratio. Quails on 0% sweet potato peel meal (control) had higher carcass weight (98.80) compared to other dietary treatment ($P < 0.05$). Birds on 10% sweet potato peel meal performed better than birds on other diets on apparent crude protein digestibility. Feed cost analysis during grower phase revealed that birds fed 30% sweet potato peel meal had better feed cost (₦ 247.08) than birds fed other diets. The result on laying performance and egg characteristics showed significant ($P < 0.05$) differences in birds fed sweet potato peel meal. Hen-day egg production of quails fed 10% sweet potato peel meal diets (52.43) was significantly ($P < 0.05$) higher than those of birds on the other diets. Peak egg

production values of birds fed 10% sweet potato peel meal (82.31days) was statistically similar with birds fed 0% sweet potato diets (82.31). There was no mortality recorded during the grower and laying phase. Inclusion of sweet potato and sweet potato peel meals in the diets of Japanese quails did not result in any detrimental effect on overall performance. Thus substituting maize with sweet potato meal at 10% inclusion and sweet potato peel meal at 10% inclusion in Japanese quails diet resulted in enhanced growth and egg production performance at the least cost. At the growing phase, diets containing sweet potato meal at 10, 20 and 30% levels of inclusion reduced cost of production by 1.97%(₦ 0.62), 3.21% (₦ 1.01) and 5.35% (₦ 1.68) respectively while diets containing 10 and 30% sweet potato peel meal reduced the cost of production by 59.04% (₦ 18.55) and 66.58% (₦ 66.58) respectively.

TABLE OF CONTENTS

Contents **Page**

Cover page

Fly page

Title page……..i

Declaration……..ii

Certification…….……..iii

Dedication…….iv

Acknowledgements…….v

Abstract…….vii

Table of contents……..ix

List of tables…….xiv

CHAPTER ONE 1

1.0 INTRODUCTION 1

1.1 Background of the Study……..……. 1

1.2 Justification ……..……..4

1.3 Objectives of the study……...4

1.4 Hypotheses……..5

CHAPTER TWO……7

2.0 LITERATURE REVIEW……...7

2.1 Sweet Potato (*Ipomoea batatas*) ….……..7

2.2 Origin and Distribution of Sweet Potato ….……..7

2.3 Global situation of Sweet Potato production ……..8

2.4 Processing Techniques of Sweet potato ……..10

2.5 Chemical Composition of Sweet Potato ……....11

2.5.1 Carbohydrates in Sweet Potato…...……..11

2.5.2 Protein Content of Sweet Potato……...13

2.5.3 Lipid Content of Sweet Potato ……16

2.5.4 Vitamin Content of Sweet Potato.……17

2.5.5 Mineral Content of Sweet Potato……..19

2.6 Anti-nutritional Factors in Sweet Potato……..19

2.6.1. Trypsin Inhibitors in Sweet Potato…..……...22

2.6.2 Oxalate in Sweet Potato…..……...24

2.6.3 Chemical and Phytochemicals in Sweet Potato…….……..……..…….24

2.7 Uses of Sweet Potato in Poultry Feeding...…….…….27

2.8 Sweet Potato Peel As Source of Dietary Fibre …..……..31

2.9 Miscellaneous Uses of Potato Peels…….32

2.10 Japanese quail (C*oturnix coturnix*)……..…….33

2.10.1 History of Japanese Quails (*Coturnix coturnix*)……...33

2.10.2 Japanese quail coturnix grower……35

2.10.3 Nutritional Requirements of Japanese Quails……..36

2.10.3.1 Quail feeding……36

2.10.3.2 Protein…….……....37

2.10.3.3 Energy ……38

2.10.3.4 Vitamin ……...39

2.10.3.5 Minerals ……..…44

2.10.3.5.1 Calcium and Phosphorus ……..……45

2.10.3.5.2 Magnesium ...……..45

2.10.3.5.3 Manganese ……. ……46

2.10.3.5.4 Salt (Sodium Chloride) ……..……...48

2.10.3.5.5 Iron, Copper and Cobalt ……..……46

2.10.3.5.6 Selenium ……..……47

2.10.3.5.7 Zinc …..……48

2.10.4 Performance of Japanese Quails …… ……48

2.10.5 Haematological Indices of Quails ……49

2.10.6 Carcass Characteristics of Quails ….… ……...51

2.10.7 Effect of Processing of Ingredients on Carcass Characteristics of Quails…….… ……...51

CHAPTER THREE.……53

3.0 MATERIALS AND METHODS ….…….. ……..53

3.1 Experimental Site ……..……..53

3.2 Source of Experimental Birds ……...……...53

3.3 Source and Processing of Sweet Potato and Sweet Potato Peels…….53

3.4 Laboratory Analysis…… ……..…….54

3.5 Experiment 1a: Growth Performance of Japanese Quails Fed Diet Containing varying Levels of Sweet Potato Meal (2-6 weeks) …….. ……55

3.5.1 Experimental Diets for Grower Japanese Quails ……...……...55

3.5.2 Experimental Design and Management of Birds (2-6 weeks) …….……55

3.5.3 Determination of Haematological and Biochemical Parameters….. ……..….……57

3.5.4 Digestibility Trial…….57

3.5.5 Carcass Analysis ……..……58

3.5.6 Statistical Analysis ……. ……...59

3.5.7 Cost Benefit Analysis …… ……59

3.6 Experiment 1b: Laying Performance of Japanese Quails Fed Diet Containing Varying Levels of Sweet Potato Meal (7-20weeks) ….....……...…….59

3.6.1 Experimental Diets for Laying Japanese Quail Hens …...……...59

3.6.2 Determination of Proximate Composition of Experimental Diets ……...……60

3.6.3 Experimental Design and Management of Birds (7-16weeks) ……60

3.6.4 Determination of Egg Quality Parameters……..62

3.6.5 Statistical Analysis ……65

3.7 Experiment 2a: Growth Performance of Japanese Quails Fed Diet Containing varying Levels of Sweet Potato Peel Meal (2-6 weeks) … .…… ……65

3.7.1 Experimental Diets for Grower Japanese Quails ……..…….. .65

3.7.2 Determination of the Proximate Composition of Experimental Diets. …… ……..66

3.7.3 Experimental Design and Management of Birds (2-6weeks) ……..……66

3.7.4 Determination of Haematological and Biochemical Parameters…..……..…….....66

3.7.5 Digestibility Trial ……..……...66

3.7.6 Carcass Analysis ……..……66

3.7.7 Statistical Analysis ……...66

3.7.8 Cost Benefit Analysis ……...……66

3.8 Experiment 2b: Laying Performance of Japanese Quails Fed Diet Containing Varying Levels of Sweet Potato Meal Peel (7-20weeks) …..……...……68

3.8.1 Experimental Diets for Grower Japanese Quails ……...68

3.8.2 Determination of Proximate Composition of Experimental Diets.……68

3.8.3 Experimental Design and Management of Birds (2-6weeks) ……68

3.8.4 Determination of Egg Quality Parameter ……..68

3.8.5 Statistical Analysis ……68

CHAPTER FOUR ……...70

4.0 RESULTS…… 70

4.0 Proximate Composition of Sweet Potato Meal……...…70

4.2 Experiment 1a: Effect of Diets Containing Varying Levels of Sweet Potato Meal on Growth Performance, Digestibility, Haematological Parameters, Carcass Characteristics and Cost Benefits Analysis of Grower Japanese Quails …….……..……70

4.3 Experiment 1b: Effect of Diets Containing Varying Levels of Sweet Potato Meal on Laying Performance and Egg Quality Characteristics Japanese Quails……..…...78

4.4 Proximate Composition of Sweet Potato Meal……...…84

4.5 Experiment 2a: Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Growth Performance, Digestibility, Haematological Parameters, Carcass Characteristics and Cost Benefits Analysis of Grower Japanese Quails …….……84

4.6 Experiment 2b: Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on

Laying Performance and Egg Quality Characteristics Japanese Quails…… ……..…...93

CHAPTER FIVE ……...100

5.0 DISCUSSION …….…….....100

5.1 Proximate Composition of Sweet Potato and Sweet Potato Peel Meals ….……....100

5.2 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Growth Performance, Cost Benefits Analysis, Nutrient Digestibility, Haematological Parameter and Carcass Characteristics of Grower Japanese Quails (2-6weeks) ...……....101

5.3 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Laying Performance and Egg Quality Characteristics of Japanese Quail Hens (7-20weeks).……..105

5.4 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Growth Performance, Cost Benefits Analysis, Nutrient Digestibility, Haematological Parameter and Carcass Characteristics of Grower Japanese Quails (2-6weeks) ...….……....108

5.5 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Laying Performance and Egg Quality Characteristics Japanese Quail Hens (7-20weeks)……..112

CHAPTER SIX……...116

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION …….....116

6.1 Summary……116

6.2 Conclusion .…….. 117

6.3 Recommendations…… 117

REFERENCES……...118

LIST OF TABLES

Table 2.1 Chemical Composition of Sweet Potato Roots (% Dry Matter)…… 12

Table 2.2 Proximate Composition of Major Root and Tuber Crops…… 14

Table 2.3 Amino Acids Content of Sweet Potato Roots and Vines (g/100g protein) …… 15

Table 2.4 Fatty Acid Analysis of the Total Neutral and Polar Lipid Fraction from Sweet Potato.. 18

Table 2.5 Mineral Contents of Sweet Potato …… 20

Table 2.6 Percentage Inhibition of Trypsin in Sweet Potato and Soybean …… 23

Table 3.1 Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal for Grower Japanese Quails (2-6weeks) ……...56

Table 3.2 Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal for Japanese Quail Hens (7-20weeks) ……..…...61

Table 3.3 Composition of Experimental Diets Containing Varying Levels of Sweet Potato Peel Meal for Grower Japanese Quails (2-6weeks) ……...……...67

Table 3.4 Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal Peel for Japanese Quail Hens (7-20weeks) ……..…...69

Table 4.1 Proximate Composition of Sweet Potato Meal…….…….. 71

Table 4.2 Proximate Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal for Grower Japanese Quails (2-6 weeks) …….....…….72

Table 4.3 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Growth Performance of Grower Japanese Quails ……...73

Table 4.4 Apparent Digestibility of Nutrients and Ash Retention of Grower Japanese Quails Fed Diets Containing Varying Levels of Sweet Potato Meal (2-6weeks) ……75

Table 4.5 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Some Biochemical Parameters of Grower Japanese Quails ……..76

Table 4.6 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Haematological Parameters of Grower Japanese Quails ……..……..77

Table 4.7 Carcass Characteristics of Grower Japanese Quails Fed Diets Containing Varying

Levels of Sweet Potato Meal (2-6weeks) ……..……..79

Table 4.8 Proximate Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal for Japanese Quail Hens (7-20weeks) .....…….....80

Table 4.9 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Performance of Japanese Quail Hens ……82

Table 4.10 Effect of Diets Containing Varying Levels of Sweet Potato Meal on External Egg Quality Characteristics of Japanese Quail Hens (7-20weeks) ……..83

Table 4.11 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Internal Egg Quality Characteristics of Japanese Quail Hens (7-20weeks) ……..85

Table 4.12 Proximate Composition of Sweet Potato Peel……...86

Table 4.13 Proximate Composition of Experimental Diets Containing Varying Levels of Sweet Potato Peel Meal for Grower Japanese Quails (2-6weeks)....……...87

Table 4.14 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Growth Performance of Grower Japanese Quails ……..88

Table 4.15 Apparent Digestibility of Nutrients and Ash Retention of Grower Japanese Quails Fed Diets Containing Varying Levels of Sweet Potato Peel Meal (2-6weeks) ……90

Table 4.16 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Some Biochemical Parameters of Grower Japanese Quails ……..91

Table 4.17 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Haematological Parameters of Grower Japanese Quails ..……..92

Table 4.18 Carcass Characteristics of Grower Japanese Quails Fed Diets Containing Varying Levels of Sweet Potato Peel Meal (2-6weeks) ……..……..94

Table 4.19 Proximate Composition of Experimental Diet Containing Varying Levels of Sweet Potato Peel Meal for Japanese Quail Hens (7-20weeks) .....……...95

Table 4.20 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Performance of Japanese Quail Hens ……. …….....96

Table 4.21 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on External Egg Quality Characteristics of Japanese Quail Hens (7-20weeks) …… 98

Table 4.22 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Internal Egg Quality Characteristics of Japanese Quail Hens (7-20weeks) ……100

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Poultry is an important source of protein to the ever-expanding human population. The cost of feed has been identified by farmers as the major constraint in poultry production (Munyawu *et al.*, 1998). The poultry producers have experienced a rise in the cost of production due to the increasing cost of feed. The cost of maize which makes 65 % of the current poultry feeds is very high (Scott, 1995; Mutetwa, 1996). Maize has a lot of industrial and domestic uses, such as bio-fuel, brewing, starch industries and for human food. However, inadequate production of this grain and the intense competition for maize between man, industries and livestock has made poultry rations to be expensive. This situation has forced poultry farms and feed millers to search for alternative feed ingredients which are available in large quantities, cheaper and can substitute for the scarce and expensive maize. Some of these feed alternatives are sweet potato (*Ipomoea batatas*) and their peels, which have great potentials as energy sources in poultry nutrition.

Prices of poultry products, especially eggs keep rising as a result of the rise in the costs of feed, which constitute between 60-80% of the total production costs (Nuhu *et al*., 2008). The conventional energy feed sources constitute between 40-65% of formulated poultry diets and have high price tags as a result of their numerous alternative uses (Afolayan, 2010). Among these sources, maize is the most widely employed for poultry feed formulation (Vantsawa, 2001; Afolayan *et al*., 2012). In order to step down the problem of high and unstable price situation and save the poultry industry from collapse, there is need to broaden the energy

source base by assessing unconventional feedstuffs (Afolayan *et al*., 2012). Maize and sweet potato have comparable metabolizable energy values of 14.5 and 14.8 Kcal respectively (Woolfe, 1992). The digestibility of sweet potato carbohydrate fraction is reported to be above 90% (Ravindran, 1995). However, the level of starch decreases with period of storage and instead the level of reducing sugars, total sugars and total dextrins increase (Woolfe, 1992). Sweet potatoes have also been reported to exhibit trypsin inhibitor activity ranging from 20 to 90 % inhibition (Woolfe, 1992). However, Ravindran (1995) reported that trypsin inhibitor levels present in sweet potato tubers are low and should not be a cause for concern under practical situations. A study carried out in Nigeria recommended 27 and 30 % levels of sweet potato in the starter and finisher diets of poultry, respectively (Agwunobi, 1999). However, Woolfe (1992) reported having replaced 50 to 75% of maize in poultry feed with dried sweet potato flour without adverse effects on the growth of broilers.

The pollution caused by the potato peels as waste product has become an environmental concern. It poses a lot of problems for disposal especially during the wet season as it decays easily and pollutes the environment. Potato is processed into value added products by fast food industries. Sweet Potato is usually peeled during processing either by steam, lye or abrasive peeling methods depending on the type of products desired. However, large quantities of peels are generated which represent a severe disposal problem with increasing awareness and aims of minimizing environmental impact and sustainability (Schieber *et al.*, 2009). Potato peels contain some nutritionally and pharmacologically interesting compounds such as polyphenols and glycoalkaloids which may serve as natural antioxidants and precursors for steroid hormones (Schieber *et al.*, 2009). Potatoes are good sources of energy due to their high carbohydrate content. They also contain some protein and are rich in organic micronutrient such as Vitamin C, B vitamins and an appreciable level of minerals. Sweet potatoes are also a

very valuable source of feed for all classes of livestock (Woolfe, 1992). The tubers are relished by pigs and cattle. In 2007, half of the sweet potato tuber production went into animal feeding in United State of America (USA) and United Kingdom (Lebot, 2009; Chittaranjan, 2007). Sweet potatoes can be used on-farm or as an ingredient in commercial compound feeds (Scott, 1992; Gupta *et al*., 2009). The peels, which are the major portion of processing waste, represent a severe disposal problem to the industry since wet peels are prone to rapid microbial spoilage. Potato peels though a waste product of the food industry is a source of high value compounds (Schieber *et al*, 2001).

Japanese quails (*Coturnix coturnix japonica*) are small-sized, early maturing, hardy and prolific birds (Robbins, 1981). They come into egg production between the 5th and 6th week of life, but adult plumage is not attained until the 12th week of age (Martins *et al*., 1998). The eggs are small, mottled and weigh between 10 and 13g each (Edache *et al*., 2003a; Musa *et al*., 2008) with egg fertility and hatchability levels of 90% and 65% respectively (Edache *et al*., 2003b). The meat and eggs are low in body fat and cholesterol (Schwartz and Allen, 1981) which is of public health significance. Persons prone to high blood pressure and related diseases could consume these products with less risk. Crude protein diet content of 20% has been recommended for optimum egg production in Japanese quails (Edache *et al*., 2003a; Akpa *et al*., 2008). The usual high inclusion of maize in poultry diets translates into high cost of feed because of seasonality of production and competition for maize by man (Agbede *et al*., 2002). According to Bamgbose *et al*. (2004) maize accounts for about 45 to 55% of poultry feed. This necessitates the need to replace maize either partially or totally in poultry diets to reduce overall cost. Increasing use of alternatives to maize has been recommended (Ani, 2007; Ani and Omeje, 2007; Obikaonu and Udedibie, 2007).

Currently, very few information exist on the use of sweet potato and the peels in Japanese quail

diets in Nigeria.

1.2 Justification

The Nigerian poultry industry is faced with a lot of problems that have resulted to a gross shortage of meat to meet the population challenge in the country and there is acute shortage of animal protein in the diet of an average Nigerian (FAO, 2006). This is due to the high cost of conventional protein and energy concentrates, increasing competition between man, industries and livestock for the available grains, price fluctuations and unavailability of the feed ingredients for the formulation of animal feeds (Duru and Dafwang, 2010). Profit maximization cannot be attained unless the birds are fed diets at lowest costs. There is need to search for non-conventional feed resources that are cost-effective, non-toxic and readily available and alternative sources of energy concentrate. Sweet potato and the peels can be a good alternative source of energy in poultry ration.

The main aim of this research is to evaluate the effect of Sweet potato and its peels as alternative energy sources on the growth and laying performance of Japanese quails.

1.3 Objectives of the study

The objectives of the study are to investigate: The effect of:

i. diets containing varying levels of Sweet Potato and Sweet Potato Peel Meals on growth performance of Japanese quails.
ii. diets containing varying levels of Sweet Potato and Sweet Potato Peel Meals on nutrient digestibility, carcass characteristics, haematological and biochemical parameters of Japanese quails.
iii. diets containing varying levels of Sweet Potato and Sweet Potato Peel Meals on laying performance of Japanese quails.

iv. diets containing varying levels of Sweet Potato and Sweet Potato Peel Meals on the external and internal egg quality characteristics of Japanese quails.

v. Using varying levels of Sweet Potato and Sweet Potato Peel Meals in Japanese quail rations on the economics of Japanese quail production.

1.4 HYPOTHESES

Experiment 1

Null Hypothesis (H_o): Diets containing varying levels of Sweet Potato Meal have no effect on growth performance, Carcass characteristics, Nutrient digestibility, Haematological and Biochemical parameters of Japanese quails.

Diets containing varying levels of Sweet Potato Meal have no effect on laying performance of Japanese quails.

Diets containing varying levels of Sweet Potato Meal have no effect on the external and internal egg quality characteristics of Japanese quail eggs.

Alternative Hypothesis (H_A): Diets containing varying levels of Sweet Potato Meal have effect on growth performance, Carcass characteristics, Nutrient digestibility, Haematological and Biochemical parameters of Japanese quails.

Diets containing varying levels of Sweet Potato Meal have no effect on laying performance of Japanese quails.

Diets containing varying levels of Sweet Potato Meal have effect on the external and internal egg quality characteristics of Japanese quail eggs.

Experiment 2

Null Hypothesis (H_o): Diets containing varying levels of Sweet Potato Peel Meal have no effect on growth performance, Carcass characteristics, Nutrient digestibility, Haematological and Biochemical parameters of Japanese quails.

Diets containing varying levels of Sweet Potato Peel Meal have no effect on laying performance of Japanese quails.

Diets containing varying levels of Sweet Potato Peel Meal have effect on the external and internal egg quality characteristics of Japanese quail eggs.

Alternative Hypothesis (H_A): Diets containing varying levels of Sweet Potato Peel Meal have effect on growth performance, Carcass characteristics, Nutrient digestibility, Haematological and Biochemical parameters of Japanese quails.

Diets containing varying levels of Sweet Potato Peel Meal have effect on laying performance of Japanese quails.

Diets containing varying levels of Sweet Potato Peel Meal have effect on the external and internal egg quality characteristics of Japanese quail eggs.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Sweet Potato (*Ipomoea batatas*)

Sweet Potato (*Ipomoea batatas*) is a tuberous-rooted perennial mainly grown as an annual. The roots are adventitious, mostly located within the top 25 cm of the soil. Some of the roots produce elongated starchy tubers. Tuber flesh colours can be white, yellow, orange and purple, while skin colour can be red, purple, brown or white. The stems are creeping slender vines, up to 4m long. The leaves are green or purplish, cordate, palmately veined, born on long petioles. Sweet Potato flowers are white or pale violet, axillary, sympetalous, solitary or in cymes. (Duke, 1983; Ecocrop, 2010).

Sweet potato is cultivated for food in more than 100 countries. The area under cultivation was estimated to be 8.5 million Ha in 2009 with a worldwide tuber yield of 12648 kg/ha (FA0, 2010). The main sweet potato producers are China, Indonesia, Vietnam, India, Philippines and Japan in Asia, Brazil and the USA in the Americas and Nigeria, Uganda, Tanzania, Rwanda, Burundi, Madagascar, Angola and Mozambique in Africa (FAO, 2010).

2.2 Origin and Distribution of Sweet potato

The centre of origin is thought to be between the Yucatan Peninsula of Mexico and the mouth of the Orinoco River, in Venezuela. Sweet potato is said to be as old as 8000 years since when first found in Peru. It is now widely cultivated between 400N and 320S up to 2000 M (and up to 2800 M in equatorial regions) (Ecocrop, 2010; Paneque, 1992). Sweet Potato is cultivated wherever there is sufficient water to support their growth; optimal annual rainfalls for growth range between 750 – 2000 mm. When rainfall is below 850 mm irrigation may be necessary but it should be stopped before harvest in order to prevent the tubers from rotting, sweet potato

is a warm – season annual, requiring 20-25^{0}C average temperature and full sunlight for optimal development. Sweet potato thrives in well-drained loamy soils with high humus content that provides warm and moist environment to the roots. Optimal soil pH is between 5 and 7 (Ecocrop, 2010; Ecoport, 2010; Paneque, 1992). Sweet potato is mildly drought–tolerant and can survive dry spells during the summer. However, low humidity impairs crop quality even if the plant resumes growth after a water stress (Paneque, 1992; Ecoport, 2010).

In Nigeria, there has been a gradual increase in the production of sweet potato; particularly in the northern part of the country where it is available in the markets all year round. (Afolayan, 2010).

2.3 Global Situation of Sweet Potato Production

United Nation's Food and Agriculture Organization (FAO, 1990; FAO, 2011) reported that sweet potato (*Ipomea batatas*) is a very important crop in the developing world and a traditional, but less important crop in some parts of the developed world. According to FAO (2011), sweet potato is one of the seven crops in the world which produce over 105 hundred million metric tons of edible food products in the world annually. Only potato and cassava, among the root and tuber crops, produce more. China alone produced 80 to 85% of the total sweet potato production in the world while the remaining countries in Asia have the next highest production and then, followed by Africa and Latin America (Centro International de la Papa, 2009). In another report, sweet potato was placed among the world's most important and under-exploited food crops (Scott and Maldonado, 1999; Grant, 2003). With more than 133 million metric tons in annual production, sweet potato currently ranks as the fifth most important food crop on a fresh-weight basis in developing countries after rice, wheat, maize, and cassava (Scott and Maldonado, 1999; Grant, 2003). Despite the fact that sweet potato

commonly categorized as a subsistence, “food security” or “famine relief” crop, its uses have diversified considerably in developing countries over the last four decades (Grant, 2003).

The major producing countries are China, Russian Federation, India, Ukraine and the USA with the annual world production of potatoes in 2009 of about 329,581 million tons (FAO, 2011). Wheat which is suitable for bread-making cannot be grown satisfactorily in many countries, therefore, the FAO statistics has demonstrated that the importance of sweet potato in the area where wheat production is often disadvantaged due to climatic restraints, and utilization of indigenous crops could lead to reduction in importation of wheat or wheaten flour (Katan and De Roos, 2004). Sweet potato is a very efficient food crop and produces more dry matter, protein and minerals per unit area in comparison to cereals (Woolfe, 1992).

Research have reported that sweet potatoes being the staple food in the developed countries account for 130 kcal of energy per person per day against 41 kcal in the developing countries where it is still considered as vegetable. Apart from being a rich source of starch, sweet potatoes contain good quantity of secondary metabolites and small molecules which play an important role in a number of processes (Friedman, 1997). Many of the compounds present in sweet potato are important because of their beneficial effects on health, therefore, are highly desirable in the human diet and functions as a functional food (Katan and De Roos, 2004). The global situation of sweet potato as a commodity is that it is widely grown throughout the world. However, only about one percent of production enters world trade with Canada, the United Kingdom, France and the Netherlands being the major importing countries (Katan and De Roos, 2004). The USA is the largest exporter of sweet potato accounting for 35% of world trade. The other exporters are China (12%), Israel (9%), France (7%), Indonesia (6%) and Netherlands/France (5%). The last two are also involved in re-exporting. Most of the product is used for table consumption with a small percentage going into industrial uses and animal feed.

Sweet potatoes are grown throughout the world and are consumed in large quantities. One of the global health goals is to increase the availability of nutrients to a large population of the world. A reasonable and sensible approach to achieve this goal would be to increase the nutritional content of highly consumed crops (Katan and De Roos, 2004). Sweet potato can, and does, play important roles in the human diets being either supplemental or a luxury food besides being a staple crop for some parts of the world (Papua New Guinea, some parts of Philippines, Tonga and Solomon Islands) (Sosinski *et al*., 2001). In Asian countries, sweet potato uses range from supplementary food of little status (Thailand) to a very important supplementary food (Ryukyu Islands, Japan) to rice and other root and tuber crops (Wanda, 1987). Sosinski *et al.* (2001) reported that in the United States and other developed countries, the role of sweet potato is strictly as a luxury food and in other parts of the world such as in Japan, where it plays its role as novel plant products or nutriceuticals.

2.4 Processing Techniques of Sweet Potato

It was reported by Fellows (2000) that food processing entails combined procedures to achieve intended changes to the raw material and the processing technologies in the food industry. The processing is subdivided into two main groups, viz:

(i) Processing of foods with non-thermal methods (Lebovka *et al.*, 2004; 2007) such as high pressure processing, pulsed electric field (PEF), electronic beams, and

(ii) Processing of foods with the application of heat (Yadav *et al.*, 2006; Leeratanarak *et al*., 2006; Ahmed *et al.*, 2010; Fernando *et al.*, 2011; Singh and Pandey, 2012) such as blanching, pasteurization, sterilization, evaporation or concentration, drying or dehydration, microwave and infra-red heating.

2.5 Chemical Composition of Sweet Potato

The main nutritional importance of sweet potato has been its starch content. However, it can also be a source of other nutritionally important dietary factors, such as vitamin A, ascorbic acid, thiamin, riboflavin and niacin. However, sweet potato has low protein and fat levels, but the high nitrogen free extract fraction in this tuber is indicative of their main potential value as an energy source. Vines have lower carbohydrate content but are higher in fibre and protein and so their principal nutritive value is as a source of vitamins and protein (Dominguez, 1990 and Noblet, *et al.* 1990).

2.5.1 Carbohydrates in Sweet Potato

The principal constituent of edible carbohydrate is starch together with some sugars. Starches are made up of two main polymers, a straight chain glucose polymer called amylose, which usually constitute about 10-30 percent of the total, and the branched chain glucose polymer, amylopectin, which makes up the rest.

The proportion depends on the specie of root crop (Afolayan, 2010). In addition to starch together with some sugars, root crops also contain some non-starch polysaccharides; including cellulose, pectins and hemicelluloses; as well as other associated structural proteins and lignins, which are collectively referred to as dietary fibre. Sweet potato is a significant source of dietary fibre as its pectin content can be as high as 5 percent of the fresh weight or 20 percent of the dry matter at harvest (Collins and Walter, 1982). Fresh sweet potato tuber contains approximately 20% starch and 5% simple sugars (Ayuk, 2004). The structure of sweet potato starch does not differ from that of cereals and mandioca. (Szylit *et al*., 1978), the difficulty with its digestion could very well relate to the larger size of the starch molecule (25μm), compared to the latter (12 μm). The carbohydrates content

Table 2.1 Chemical Compositions of Sweet Potato Roots (% Dry natter)

	Noblet *et al*. (1990)	Dominguez (1990)
Dry matter	ND	29.2
N x 6.25	4.4	6.4
Ash	3.1	5.3
ADF	4.2	5.5
NDF	6.9	ND
Lignin	0.7	ND
Ether extract	0.6	ND
Gross energy (MJ/ Kg)	17.1	16

ND: Not determined

of sweet potato tubers consist of starch, sugars and small amount of pectins, hemicelluloses and cellulose (Lebot, 2009). Sugar content can be extremely variable, usually between 1 and 12% DM, but some US cultivars contained as much as 38% DM of sugars. The sugar composition of a cultivar, especially the sucrose values gives a reliable indication of its sweetness (Lebot, 2009).

The proximate composition of major root and tuber crops is shown in Table 2.2. Maize and sweet potato were reported to have comparable metabolizable energy value of 14.5 and 14.8 MJ/kg respectively (Woolfe, 1992). Fetuga and Oluyemi (1976) reported that dehydrated sweet potato roots are superior energy sources compared with dehydrated cocoyam, yam and plantain meals. The digestibility of sweet potato carbohydrate fraction was reported to be above 90% inspite of the cellulose, hemicellulose and insoluble pectin amounting to 3.26, 4.95 and 0.6 percent respectively (Ravindran, 1995). However, Woolfe (1992) reported that its starch decreased with the period of storage, while the levels of its reducing sugars, total sugars and total dextrins increased.

2.5.2 Protein Content of Sweet Potato

Sweet potato is low in protein. Dominguez (1990) and Noblet *et al*. (1990) reported that Sweet Potato contains 6.4% and 4.4 crude protein as shown in Table 2.3. These values are in agreement with the 5.0% recorded by Eka (1990), and 5.36% recorded by Afolayan (2010). However, several environmental factors such as growing season (Bouwkamp *et al*., 1985 and Lin, 1989), accumulated rainfall (Lin, 1989), location (Bradbury *et al*., 1985) genotype (Purcell *et al*., 1982), Edmond and Ammerman, (1971), nitrogen fertilization (Purcell *et al*. 1982 and Zhang *et al*. 1998) as well as cultural management and growth duration have been reported to influence protein content in sweet potatoes (Purcell *et al*. 1976).

Table 2.2 Proximate Composition of Major Root and Tuber crops

CROPS	DM	CP	EE	CF	ASH	NFE	ME(cal/kg)
Cassava (*M esculenta*)[3]	36	2.5	0.6	2.9	3.8	90	3.2
Potatoes (*S. tuberosum*)[1]	21	12.1	0.9	3.9	5.0	78	3.6
Sweet Potatoes (*I. batatas*)[3]	28	5.4	0.5	0.3	3.2	89	3.2
Taro (*C. esculenta*)2	24	3.4	0.7	3.3	3.2	89	3.3
Water Yam (*D. alata*)[3]	34	5.2	0.8	2.6	5.2	83	3.2
White Yam (*D. rotundata*)[3]	31	6.4	0.4	2.7	4.3	86	3.7
Chinese Yam (*D. esculent*)[1]	20	8.9	0.6	3.5	4.3	83	3.3
Cocoyam (*Xanthosoma Sp*)[1]	41	5.9	0.8	2.6	1.7	89	3.6

Sources: [1] Khajarem *et al* (1979), Sources: [2] Harris *et al* (1982), Sources: [3] Oyenuga and Fetuga (1975).

Table 2.3 Amino Acid Content of Sweet Potato Roots and Vines (g/100g protein)

	Purcell *et al.* (1972)		Li (1982)	Walter *et al.* (1978)
Essential amino acids	Ideal Protein	Roots	Vines	
Isoleucine	3.8	4.2 – 10.1	3.9 – 5.1	4.9
Leucine	7.0	7.8 – 9.2	6.2 – 7.9	9.6
Phenylalamine[3]	6.7	11.9 – 13.6	7.2 – 10.1	10.6
Methionine and Cysteine	3.5	2.8 – 3.8	3.0 – 3.9	2.8
Threonine	4.2	5.5 – 6.3	5.1 – 6.1	5.3
Tryptophan	1.0	0.8 – 1.2	ND	ND
Valine	4.9	6.8 – 8.3	4.9 – 8.2	6.3
Lysine	7.0	4.2 – 7.2	4.3 – 4.9	6.2
Chemical score	100	80 – 109	85 – 110	80

Phenylalanine+ tyrosline. Source: Fuller and Chamberlain, (1982). ND: Not determined

Yang (1982) reported that protein content of sweet potato varies between 2.0–7.5%, depending on the cultivar and treatment. A range of 1.27% to 10.05% with the mean of 4.5% crude protein was reported by Li (1982). In another experiment with American cultivars, Dickey *et al*. (1984) reported 4.38% to 8.98% with a mean of 6.29% crude protein. However, Purcell *et al*. (1972) reported crude protein content range from 1.7% to 11.8% (dry weight basis). It is believed that nitrogen fertilizer increases the protein content of sweet potato but decreases the lysine, while aspartic acid and free amino acids increases. Also leafy growth increases at the expense of tuber production (Afolayan, 2010). Eka (1990) reported that, the proteins of sweet potato are of high biological value, containing many of the essential amino acids.

The protein of sweet potato is of acceptable nutritive value, with a chemical score of 82 and sulphur amino-acids (methionine and cysteine) as the major limiting amino acids (Purcell *et al*., 1972) as shown in Table 2.3. The quality of protein depends on the severity of heat treatment during the processing of sweet potato products (Walter *et al*., 1983). When unheated sweet potato flour was added to wheat in the diet of rats at 30 percent level, the biological value of the diet was increased from 72 to 80 owing to the improved protein value (Walter *et al*., 1983). A similar result was obtained when sweet potato flour replaced rice (Yang, 1982). Afolayan, (2010) reported that Sweet Potato Meal (SPM) contains 92.76% DM, 5.36% CP, 2.93% Total ash, 0.71% ether extract, 9.22% CF, 81.78% NFE, 3050 ME(Kcal./kg), 8.90mg/100g Trypsin inhibitor activities (TIA), 0.67 mg/100g Hydrogen cyanide (HCN) and 0.082g/100g Phytic acid.

2.5.3 Lipid Content of Sweet Potato

Sweet potato like other root crops has low lipid content (Afolayan, 2010). Monday and Mueller (1977) put the sweet potato lipid content at about 2.7 percent. These are mainly lipids of the

cell membrane, which enhance cellular integrity, offer resistance to bruising and help to reduce enzymic browning. Most of the lipids contain equal amounts of unsaturated fatty acids, linoleic and linolenic acids and the saturated fatty acids stearic and palmitic acids. This statement was supported by the fatty acid analysis carried out by Osagie and Opute (1981) as shown in Table 2.4 above.

2.5.4 Vitamin Content of Sweet Potato

Most roots and tubers contain only negligible amounts of beta carotenes (Vitamin A precursors) with the exception of selected varieties of sweet potato. Deep coloured varieties are richer in carotenes than white cultivars. Afolayan, (2010) and Dominguez, (1990) reported that, sweet potato is a source of important dietary factors, such as ascorbic acid, thiamin, riboflavin and niacin. One of the nutritional advantages of sweet potato is that sufficient and regular ingestion of sweet potato leaves, together with the tubers of high beta-carotene varieties can meet the consumer's daily requirement of vitamin A, and hence prevent the dreadful disease known as xerophthalmia, which is responsible for nutritional blindness in many sub-Saharan countries and in Asia (szylit *et al.,* 1978). The dessert type of sweet potato is even higher in beta-carotene and it has been estimated that an intake of 13g/day will be sufficient to meet the vitamin A requirement of humans. Most of the root crops contain small amount of the vitamin B group sufficient to supplement normal dietary sources for humans. The B group of vitamins acts as a co-factor in enzyme systems involved in the oxidation of food and the production of energy.

Villareal *et al*. (1985) estimated that a hectare of land planted with sweet potato will provide about eight times as much vitamin B_{12} (riboflavin) as a hectare planted with rice. Ananzonwu–Bello (1977) estimated vitamin B content of raw sweet potato and reported 127, 23 and

Table 2.4 Fatty Acid Analysis of the Total Neutral and Polar Lipid Fractions from Sweet Potato

	Lipids				% Fatty Acid		
Classes	14.0	16.0	18.0	18.1	18.2	18.3	20.0
Total lipids	T	21.7	4.6	0.6	58.2	12.2	1.6
Nonpolar lipids	T	35.2	2.1	0.4	46.6	12.9	1.3
Glycolipids	T	23.4	1.7	0.3	58.8	12.7	1.1
Phospholipids	T	34.3	3.8	1.3	50.0	8.0	T

T = not estimated . Source: Osagie and Opute (1981)

0.63 mg/100g thiamine, riboflavin and niacin respectively. The values reported for the cooked sweet potato were however lower for thiamin (117mg/100g) and niacin (0.57mg/100g) but higher for riboflavin (29mg/100g). However, vitamin C occurs in appreciable amounts in several root crops, sweet potato inclusive. There is a report of the occurrence of some vitamin E, up to 4mg per 100g in sweet potato (Afolayan, 2010).

2.5.5 Mineral Content of Sweet Potato

Sweet potato tuber is rich in minerals such as Ca, P, K, Na, Cl, Fe, Cu, and Mn. (Table 2.5). The table shows that potassium is the major mineral in sweet potato while sodium tends to be low. This makes some root crops particularly valuable in the diet of patients with high blood pressure, who have to restrict their sodium intake. In such cases the high potassium to sodium ratio may be an additional benefit (Meenely and Battarblee, 1976). However, high potassium foods are usually omitted in the diet of people with renal failure (McCay *et al*., 1975). As root crops are low in phytic acid relative to cereals, those minerals liable to inactivation by dietary phytic acid are more available than in cereals (McCay *et al*., 1975).

2.6 Anti-nutritional Factors in Sweet Potato

There are substances present in root and tuber crops, which limit their wider use. Some of these substances are either potentially toxic or may adversely affect the feed intake and bioavailability of nutrients. Compounds which act to reduce nutrient utilization and or feed intake are often referred to as anti-nutritional factors (ANF). These substances may be grouped into cyanogenic-glycosides, proteinase inhibitors, oxalates, phytates, tannins, alkaloids/steroids and acridity factors. Some of them are sensitive to normal processing temperatures, while others are resistant to these temperatures. (Afolayan, 2010).

Table 2.5 Mineral Content of Sweet Potato

Minerals	Amount
Ca (mg/ 100g)	25.0
P (mg/ 100g)	28.0
K (mg/ 100g)	508.0
Na (mg/ 100g)	54.0
Fe (µg/ kg)	64.0
Cu (µg/ Kg)	62.0
Mn (µg/ Kg)	9.3
Cl (µg/ Kg)	26.0

Source: Ananzonwu-Bello (1977)

Compositional analysis is part of the safety assessment of crops in general and commonly includes a range that can be measured in roots and leaves. Unlike many major nutrients, anti-nutrients are important secondary metabolites that can be measured in roots and leaves. Sweet potato contains a number of anti-nutrient compounds that have been well described, including oxalic acid, trypsin inhibitor, and furanoterpenoid compounds (Woolfe, 1992; Shireen *et al.*, 2001). Oxalic acid is an organic acid that can form complexes with minerals during intestinal passage and may, therefore, alter their bioavailability. Stress conditions have been reported to lead to increased levels of oxalic acid in sweet potato roots (Woolfe, 1992).

Trypsin inhibitors in sweet potato, also designated sporamin, make up a large proportion of the soluble proteins (60% to 80% depending on the variety). The number of different molecules and their characteristics (for example, susceptibility to heat and pH) differ among sweet potato cultivars (Scott and Symes, 1996). Heating, such as during cooking, removes some, but not all trypsin inhibitor activity (Woolfe, 1992; Sasi and Padmaja, 2003). Testing for anti-nutrients is not routinely done in variety testing, which focuses on productive traits such as yield and dry matter. However, measurement of anti-nutrient levels is both common and important in the comparative safety assessment of novel crops.

Shireen *et al.* (2001) analyzed the composition of sweet potato, specifically macro nutrients, amino acids, and trypsin inhibitor, as part of a nutritional study in hamsters. Levels of secondary metabolites such as furanoterpenoids (for example, ipomeamarone) may be negligible in non-diseased sweet potato, but elevated levels can be found in sweet potato plants suffering from insect or mold infestation. Ipomeamarone and related compounds cause liver toxicity in experimental animals (Wilson *et* al., 1970). Furthermore, molds growing on diseased sweet potato convert these furanoterpenoids to compounds, such as ipomeanol, that exert cytochrome-P450-mediated toxicity on lungs, kidney, liver, and other organs of various

animals, and on liver of humans (Woolfe, 1992; Lakhanpal *et al.*, 2001). However, there are no reports of adverse reactions to sweet potato in humans, probably because most diseased sweet potato is discarded due to the bitter taste of furanoterpenoids, and because the levels of these compounds are decreased by cooking or baking (Woolfe, 1992).

2.6.1 Trypsin Inhibitors in Sweet Potato

The presence of trypsin inhibitors in the raw sweet potato tubers could decrease the protein digestibility in mixed feed. Sweet potatoes contain trypsin inhibitors which may reduce the ability to utilize the protein if eaten raw (Wanda, 1995). The vines do not produce this effect because they do not contain great quantities of inhibitors. Very small amounts of proteinase inhibitors, trypsin and chymotrypsin inhibitors have been reported by Sumathai and Pattabiraman (1975); Bradbury and Hollway (1988). Various levels of trypsin inhibitor activity (TIA) in sweet potato cultivars have been reported (Lin and Chen, 1980; Dickey *et al*. 1984; Bradbury *et al*. 1985; Dominguez, 1990 and Afolayan, 2010). The trypsin inhibitors can be destroyed or reduced to minimum by preheating the raw sweet potato roots. Moist heat treatment at temperatures above 80^0C is effective in eliminating trypsin inhibitor activity in sweet potatoes Ravindran, (1995) and Dominguez, (1992) reported that cooking improves the feeding value of the tubers since it reduces trypsin inhibitors and improves starch digestibility. The authors however reported that trypsin inhibitor content is very variable between varieties (2.6 to 32.0) Tui/g (Trypsin inhibitor unit). Cooking sweet potato is therefore necessary on account of two factors; to increase its starch digestibility and reduce presence of trypsin inhibitors as shown in Table 2.6 above (Dominguez, 1990). There is a significant correlation between the trypsin inhibitor content and the protein content of sweet potato varieties. Lawrence and Walker (1976) have implicated TIA in sweet potato as a contributory factor in the disease Enteritis necroticas. Trypsin inhibitors are of no consequence in cooked sweet

Table 2.6 Percentage Inhibition of Trypsin in Sweet Potato and Soybean

Specimen	Inhibition (%)
Raw soybean	89.5
Soybean meal	33.7
Raw Sweet potato	78.8
Cooked sweet Potato	16.7
Fresh vines	26.1
Vine meal	16.7

Source: Dominguez (1990)

potato. Boiling or heating to 90^0C for several minutes inactivates and removes acridity in sweet potato (Obidairo and Akpochafo, 1984; Wanda, 1995). Sasi and Padmaja (2003) reported that when sweet potato tuber was cooked, between 17 and 31% trypsin inhibitor activity remained and when it was prepared into flour, only 5 – 12% trypsin inhibitor activity was found.

2.6.2 Oxalate in Sweet Potato

The presence of oxalates has also been reported in sweet potato by Raven and Smith, (1976) and Smith, (1982), though only in minute quantities. Oboh *et al*. (1989) recorded the mean value of total oxalate content of 49 varieties of sweet potato as 0.71% of DM. Zhang and Corke, (2001) reported that, raw sweet potato contains oxalate up to 1.2g/Kg DM. The presences of non-identified factors, which inhibit the digestive and metabolic processes, are suggested in sweet potato based rations. These factors caused low dry matter digestibility and low metabolizable energy and protein values, when the rations contained adequate and high quality proteins (Gerpacio *et al*., 1978). Afolayan (2010) reported that the low level of phytic acid (0.091g/100g), HCN (0.96µg/100g) and TIA (9.01mg/100g) in raw sweet potato is below the levels that have been reported to be injurious to poultry. The slight increase observed in TIA as the dietary sweet potato meal (SPM) increased suggests that sweet potato as a tuber crop contains higher TIA than maize, the cereal crop it replaced in the diets.

2.6.3 Chemicals and phytochemicals in Sweet Potato

Das *et al*. (2003) studied the chemical modification of sweet potato (*Ipomoea batatas*) by acetylation using vinyl acetate ranging from 4 to 10% and dual modification using propylene oxide at specific level of 7% followed by adipic acid anhydride at levels ranging from 0.05 to 0.12%. Degree of substitution ranges between 0.020 to 0.034% and 0.018 to 0.058% for dual-modified and acetylated starch samples respectively. There was significant increase in water

binding and oil-binding capacities, solubility, paste clarity, gel strength due to modification; however, rupture strength, gel elasticity and adhesiveness decreased in both modified starches. Analysis of Standard error of means (SEM) revealed that the modification altered starch morphology. Acetylation brought about slight aggregation or cluster formation of granules with deep groove in the central core region whereas in dual-modified starches there were present a number of aggregates of starch granules with development of few blister like appearances along with protuberances on their surfaces. It was observed that morphology of sweet potato starch granule got altered due to chemical modification and in food application; all these modified starches could be used for development of different products depending on the quality requirement of the product, which could be evaluated with specific applications on them. Anti-oxidative activities by three methods in the sweet potato plant and in home processed roots were carried out by Jung *et al*. (2011).

Total phenolic content was highest in the leaves. Eight root varieties were partitioned and analyzed for phenolics. The stem end of the root had significantly more phenolics. In all samples the predominant chlorogenic acids were 5-caffeoylquinic acid (5-CQA) and 3,5-diCQA. 3,4-diCQA was present in significant amounts in the leaves and the flower, and 4,5-diCQA in the leaves. Six home-processing/cooking techniques reduced phenolic content from 7% (baking) to 40% (deep frying/boiling). High correlations were observed between phenolic compounds determined by high-performance liquid chromatography (HPLC) and Folin-Ciocalteu, radical scavenging activity by 2,2-diphenyl-1-picrylhydrazyl (DPPH), and oxidative activity by ferric thiocyanate (FTC) and thiobarbituric acid (TBA) methods. The results showed that there was a large variation in phenolics among sweet potato varieties and different parts of the plant and that high-phenolic sweet potato leaves, widely consumed in Asian countries as a vegetable, should be considered for diets of other countries. These observations

on anti-oxidative effects of sweet potatoes complement and extend previous cited findings on the relationships between content of phenolic compounds and anti-oxidative activities in other sweet potato genotypes. Their findings emphasize the substantial variation found among sweet potatoes and suggest that consumers have a choice in selecting sweet potato varieties with a high content of phenolic compounds and high anti-oxidative effects. The studies also showed that sweet potato leaves contain considerably more phenolic compounds than the roots, indicating that perhaps leaves, widely consumed as vegetables in Asian countries, may merit inclusion in diets of Western countries.

Ezekiel *et al*. (2013) reviewed the beneficial phytochemicals in sweet potato and reported that in addition to supplying energy, sweet potatoes contain a number of health promoting phytonutrients such as carotenoids, folates, flavonoids, anthocyanins, kukoamines, and phenolics. They established that phytochemicals content in sweet potatoes could be enhanced by developing new varieties from available germplasm high in these compounds. Antioxidant and natural colourant present in red-flesh- and purple sweet potatoes can be used for developing functional foods. Taking into consideration the large quantities in which sweet potatoes are consumed throughout the world, sweet potatoes could be a very good vehicle for addressing some health related problems. Available evidence suggests that postharvest storage of sweet potatoes do not significantly affect the content of phytochemicals, but antioxidant levels were generally higher in sweet potatoes grown in high-yielding environments, and increased during storage. Since the cost of production of sweet potatoes is relatively low as compared to other horticultural crops, pigmented sweet potatoes may also serve as a potential source of natural anthocyanins for use in food industry. Furthermore, sweet potato is a high yielding crop in which cultural and storage practices are well established in its usage.

However, for the economy of the whole process of pigment extraction, sweet potatoes with high concentrations of anthocyanins are desirable. In general, cooking leads to losses of nutrients in sweet potatoes, however, phytonutrients are either not affected or sometimes increased due to increase in extractability and bioavailability. There is a need for further research to explore the ways by which losses in phytochemicals can be reduced such as co-pigmentation, and their stability can be enhanced. Sweet potatoes contain enough phytochemicals to justify the claim of being health promoters, therefore, should form a substantial part of our daily diet. Different pigmented sweet potato based foods needs to be developed and evaluated especially with respect to the antioxidant capacity and other health benefits.

2.7 Uses of Sweet Potato in Poultry Feeding

Sweet potato tuber, vines and foliage products have been evaluated in many forms as feedstuff for livestock. They were fed raw, cooked, dehydrated or as silage (Afolayan, 2010). Results from various studies; Rosemberg and Sen, (1952), Yoshida and Morimoto, (1958), Edmond and Ammerman, (1971), Job *et al*. (1979) and Oboh, (1986) point to dehydrated sweet potato as fairly suitable in partial replacement for energy in livestock diets. Turner *et al*. (1976), evaluated various rations containing cooked sweet potato and a protein supplement for poultry feeding and reported that broiler chicks fed on the maize based control diet reached slaughter weight faster than those fed on sweet potato diets, however, broilers fed cooked sweet potato based diets had higher dressing percentages. Results of the organoleptic evaluation of birds slaughtered at 13 weeks of age showed that meat from chickens fed a diet in which 75% of the corn was replaced by sweet potato, had the best flavour (Mohammed *et al*., 1974). Yoshida and Morimoto (1958) and Ravindran (1995) reported the carbohydrate fraction in sweet potato to be about 90% digestible in chicks. Fetuga and Oluyemi (1976) obtained a coefficient of

metabolizable energy of 90.9 or 87.2% in diets where the tuber replaced 25 or 40% of the glucose in a basal diet. At both levels, the rate and efficiency of gain were best for the sweet potato diets. These results suggested that, as an energy source, sweet potato tuber is as efficiently utilized as maize by chicks.

Lee and Yang (1979) reported that chickens fed diets containing a 24 percent substitution of corn with sweet potato grew as well as on the all-corn diet, with no significant difference in carcass quality while the egg yolk contained more vitamin A. The performance of two-week old broiler chickens fed rations containing sweet potato root meal replacing 0, 50, 75 and 100% of corn in the rations up to 6 weeks of age was studied (Gerpacio *et al*., 1978). The comparison was carried out on the basis of feed intake, weight gain, feed efficiency, dressing percentage and digestibility or availability of the major nutrients (dry matter, fibre, protein and energy). It was reported that the performance of birds fed sweet potato especially at the higher levels was less satisfactory compared to corn, suggesting that for the tuber, only 50% or at the most, 75% replacement of the corn is advisable. Woolfe (1992) also reported the replacement of 50% to 75% maize in poultry fed with dried sweet potato flour without adverse effect on the growth of broiler chickens. Nguyen *et al*. (2001) recommended 20% and 30% sweet potato inclusion for young birds under 8 weeks and layers respectively. In a similar experiment Maphosa *et al*. (2003) reported that the inclusion of sweet potato produced negative effect on the performance of broiler chickens. A significant decline in weight gain was noticed with increase in the inclusion of sweet potato during the starter and finisher phases respectively. There was also a numerical decline in the feed intake, though not significantly different for up to 75% maize replacement level. Feed conversion declined with increase in inclusion of sweet potato meal though not significantly up to 50% inclusion level. Mortality was said to increase with increase in sweet potato inclusion beyond 25% level. Ravindran and Sivakanesan (1996)

reported that the level of SPM had no effect on mortality rate. Maphosa *et al*. (2003) also showed that sweet potato inclusion produced a relatively higher weight of pancreas, intestine and caeca for birds on and above 50% maize replacement levels, which was not different from those on control diet. Sweet potato had no effect on carcass quality of broiler chickens at eight weeks of age. Maphosa *et al*. (2003) recommended the inclusion of sweet potato at a level of 50% maize replacement in broiler finisher but none in starter diets. In another experiment, sweet potato meal (SPM) was fed to broiler chicks by Afolayan (2012) at graded levels of 0, 10, 20, 30, 40, 50 and 60% on weight for weight substitution for maize. Results showed that the weight gain, feed cost and total cost of raising birds decreased significantly while feed cost/kg weight gain and feed efficiency increased. The control, 10% and 20% SPM diets groups gave similar feed efficiency on weight to weight replacement of maize with SPM. In a separate experiment birds were fed at 0, 10, 20, 30, 40 and 50 in isonitrogenous broiler starter diets performance of those on 0, 10 and 20% SPM diets was not different from that of 30% when diets were made isonitrogenous (Afolayan, 2010).

However, results of the boiler finisher experiment showed that SPM had a significant adverse effect on performance at levels beyond 20% when SPM was used to replace maize on weight to weight basis. Performance was not affected until SPM was included beyond 30% level in isonitrogenous diets. Agwunobi (1999) recommended 27% and 30% levels of sweet potato in the starter and finisher diets respectively. Sobamiwa (1988) had earlier used sweet potato up to the level of 20% in the diet of laying chickens and reported no significant differences in daily feed intake, total egg production, average egg weight, average final live weight and feed conversion ratio when compared with the control diet. Tewe, (2001) evaluated the suitability of sun-dried sweet potato as poultry feed and reported that body weight gain and nutrient utilization reduced significantly with the inclusion of sweet potato at the levels of 50% and

100% maize replacement in broiler chicken diets, while performance was better in oven-dried sweet potato rations at all levels. Canope *et al*. (1977) reported that cooking improved digestibility of all nutrients, but especially of nitrogen. In a trial with broiler chickens placed on diets having 0, 10, 20, 30, 40 and 50 percent maize replacement levels, performance was found to be optimal at 30% maize replacement level compared with birds on the control diet, performance parameters were inferior on oven-dried sweet potato diets at the starter phase. At finisher phase, favourable results were obtained at up to 30% maize replacement level. Dressed carcass was reported to show poorer results for the test diet while the dressing percentages were similar with control group (Tewe, 2001). It was reported that mortality increased with higher levels of sweet potato inclusion, being higher in sun-dried complete maize replacement diet. Abdominal fat decreased with increase in sweet potato inclusion while replacement of maize with sweet potato decreased ME at levels above 30% at starter phase.

The presences of un-identified factors, which inhibit the digestive and metabolic processes, were suggested in sweet potato based rations. These factors caused low dry matter digestibility and low metabolizable energy and protein values even when the rations contained adequate and high quality proteins. (Gerpacio *et al*., 1978).

Dried sweet potato vines can be used in poultry rations as a source of protein and carotenoids, particularly beta-carotene and xanthophylls and have been included in diet to enhance yellow pigmentation of broiler skins and egg yolks. Early – harvested vines were as 25 efficient as alfalfa meal at colouring yolks. Late – harvested vines were less efficient at colouring broiler skin (Woolfe, 1992). An optimum of 10% level of sweet potato inclusion in broiler diets has been suggested, as higher levels resulted in decrease of dry matter intake and body weight gain (Berhann and Wude, 2010) and levels of 20-30% reduced the feed conversion efficiency (Kagya – Agyemang *et al*., 2008). However, dried vines included at up to 16% in broiler

chicken diets have been shown to be as efficient as alfalfa meal for growth rate, feed intake and feed efficiency (Ferrel *et al*., 2000) and 15% could be economically feasible if birds are sold on eviscerated carcass weight basis rather than live weight (Wude and Berhan, 2009).

2.8 Sweet Potato Peels as a Source of Dietary Fibre

The main portion of sweet potato peels consists of alcohol insoluble matter (Mahmood *et al*., 1998), with a dietary fibre content of approximately 40% (Camire and Flint, 1991). The starch content of sweet potato peels depends on the peeling process, while steam peels contained approximately 28% starch, abrasion peels had about twice as much starch (51%), since more sweet potato flesh is removed during the abrasion process (Camire *et al*., 1997). Initial studies on introduction of sweet potato peels to bread date back to the 1970s and 1980s when concerns about low levels of dietary fibre in the American diet and related health risks emerged. The addition of peels obtained from various processes (abrasion, steam, caustic and manual peeling) to wheat flours at levels of 5, 10 and 15% resulted in bread of acceptable sensory quality (Toma *et al*., 1979), but sensory evaluation of the products made with peels from caustic peeling revealed a musty aroma (Orr *et al*., 1982). Apart from the off flavour described it is also questionable whether consumers would accept a product that contains lye peeled potato waste. Later, comprehensive studies were conducted by Camire's group in the 1990's on the effects of extrusion cooking, a high temperature short time process that heats food under pressure, on the technological and functional properties of sweet potato peels. Camire and Flint (1991) reported that extrusion of abrasion potato peels reduced the hydration capacity and increased non starch polysaccharides. When sweet potato peels originating from steam peeling were extruded at barrel temperature of 104 and 143^0C and various feed moistures, the application of high temperature processing resulted in darker extrudates, probably caused by enzymic and non-enzymic browning reactions. Colour was the parameter that was affected

most by the extrusion process, as indicated by lower Hunter L value (Arora *et al*., 1993). Extrusion cooking reduced the starch content and increased total dietary fibre of steam peels, whereas the total dietary fibre content of peels obtained from abrasion peeling was not affected by the extrusion process. An increased level of soluble non starch polysaccharides was observed for both types of peels (Camire *et al*., 1997). As starch present in sweet potato peels increases the caloric value, which is undesirable if peels are to be used in low caloric products, attempts have been made to remove starch from extruded and unextrudate peels by enzymatic hydrolysis using α-amylase and / or amyloglucosidase. Comparable glucose yields were obtained from non-extruded peels treated with both enzymes and extruded peels treated with amyloglucosidase (Camire and Camire, 1994).

2.9 Miscellaneous Uses of Potato Peels

A number of studies have been conducted in various fields on the utilization of potato peels. Tsao and Yang (2006) screened selected Canadian crops such as squash, pepper peel, spinach, kale and potato for their lutein content and also described a method for the recovery of lutein from marigold flowers by high speed counter current chromatography. While squash and pepper proved to be a good source of free lutein (between 18 and 42mg/100g fresh weight), the amount found in potato peels were very low (0.4mg/100g fresh weight). Thus it appears that sweet potato peels are not an economically important source of lutein. In a randomized study, boiled sweet potato peels were compared to honey dressings in the treatment of burns. Although the subjective evidence of relief of pain was comparable, potato peels were inferior to honey with respect to wound healing time and antibacterial activity (Subrahmanyam, 1996). Okeke and Frankenberger (2005) used potato peel waste in combination with starch as a substrate for amylolytic bacteria in the bio reduction of perchlorate (ClO_4^{--}). The rate of perchlorate reduction was dependent on the amount of sweet potato peel, with over 90%

removal being achieved in 4 days with 2% (w/v) peels. Sweet potato peels as a by-product from potato processing are available in large amount and contain a wide variety of compound that could be used in foods and also in non-food application. Despite the numerous attempt that have been described in this review, so far no concept has been developed that holds promise for a complete utilization of sweet potato peels. Other sectors of food processing industry have already implemented strategies in this respect. For example, the pectin industry has long established processes for the exploitation of apple pomace as source of pectin, dietary fibre, natural sweetener, and apple seed oil, which lead to an almost complete utilization of pomace originating from juice production (Schieber *et al*., 2003).

Similar strategies in potato industry would add value to potato production and diversification and at the same time reduce the enormous amount of waste generated. Thus, Sweet potato peels differ greatly from other agricultural by products because of the presence of both nutritionally and pharmaceutically interesting constituents. In other to be economically feasible, separation and purification processes need to be as cost efficient as possible and the technologies applied should be environmentally acceptable (Saldana *et al*., 2007). Apart from the technical aspects, a market needs to be identified for the components obtained from sweet potato by product. However, in view of the increased trend towards natural compounds in various industrial sectors, the perspectives should be promising (Saldana *et al*., 2007).

2.10 Japanese quail (*Coturnix coturnix*)

2.10.1 History of Japanese Quails (*Coturnix coturnix*)

Quail belong, along with chickens, pheasants and partridges to the Family *Phasianoidea* of Order *Galliformes* of the Class Aves of the Animal Kingdom. Species or subspecies of the genus *Coturnix* are native to all continents except the Americas. One of them *Coturnix*

coturnix or common quail is a migratory bird of Asia, Africa and Europe. Several interbreeding subspecies are recognized, the more important being the European quail, *Coturnix coturnix coturnix*, and the Asiatic or Japanese quail, *Coturnix coturnix japonica*. One subspecies that commonly migrates between Europe and Asia was eventually domesticated in China. These birds were raised as pets and singing birds. The domesticated coturnix were brought at about the eleventh century to Japan from China across the Korean bridge (Howes, 1964). The first written record of domesticated quail in Japan dates from the twelfth century. These birds were initially developed for song. It is claimed that a Japanese Emperor obtained relief from tuberculosis after eating quail meat, and this led to selection of domestic quail for meat and egg production in Japan in the latter part of the nineteenth century (Howes, 1964).

By 1910, the Japanese quails in Japan were widely cultured for their meat and eggs. Between 1910 and 1941, the population of Japanese quail increased rapidly in Japan especially in the Tokyo, Mishima, Nagoya, Gifu and Toyohashi areas. This period also represented a time of imperial expansion in Japanese history and domesticated Japanese quail were established in Korea, China, Taiwan and Hong Kong, and later on spread to Southeast Asia. The domesticated subspecies, *Coturnix coturnix japonica*, is called Japanese quail but is also known by other names such as: Common quail, Eastern quail, Asiatic quail, Stubble quail, Pharaoh's quail, Red-throat quail, Japanese gray quail, Japanese migratory quail, King quail, and Japanese King quail. The correct popular nomenclature for *Coturnix coturnix japonica* should be Japanese quail or *coturnix*, but not coturnix quail since in Latin "*coturnix*" may be translated as quail.

2.10.2 Japanese quail *coturnix* grower

Young *coturnix* are yellowish in appearance with stripes of brown and somewhat resemble turkey poults except for size. The newly hatched chicks weigh about 6 to 7 grams, but grow rapidly during the first few days. After three days flight feathers begin to appear and the birds are fully feathered at about four weeks of age. Partial sexing is possible by three weeks of age by the cinnamon-colored feathers on the breast of the male bird, but there are some birds that defy definite sexing by this method, even when adults. (Cheng *et al.*, 1985)

Adult male

Adult male coturnix weighs about 100 to 140 grams (3 $^{1}/_{2}$ to 5 ounces). The male birds can be identified readily by the rusty brown colored feathers on the upper throat and lower breast region. Males also have a cloacal gland, a bulbous structure located at the upper edge of the vent which secretes a white, foamy material. This unique gland can be used to assess the reproductive fitness of the males (Cheng *et al.*, 1985). The young birds begin to crow at 5 to 6 weeks old. Sanford (1957) described the voice of the male as a loud, castanet-like crow, producing sound as "pick-per awick" or "ko-turro-neex". During the height of the normal breeding season, *Coturnix* males will crow throughout the night.

Adult female

The adult female *Coturnix* is slightly heavier than the male, weighing from 120 to 160 grams (4 to 5 $^{1}/_{2}$ ounces). The body coloration of the female bird is similar to the male except that the feathers on the throat and upper breast are long, pointed, and much lighter cinnamon. Also, the light tan breast feathers are characteristically black-stippled.

Quail eggs

Coturnix eggs are characterized by a variety of colour patterns. They range from snow white to completely brown. More commonly they are tan and dark brown speckled or mottled brown with a chalky blue covering. The average egg from mature female weighs about 10 grams (1/3 ounce), about 8 percent of the body weight of the quail hen as compared to 3 percent for chicken eggs. The egg of Japanese quail contains 158 Cal. of energy, 74.6% water, 13.1% protein, 11.2% fat, and 1.1% total ash. The mineral content includes 0.59 mg calcium, 220 mg phosphorus and 3.8 mg iron. The vitamin content is 300 i.u. of vitamin A, 0.12 mg of vitamin B1, 0.85 mg of vitamin B2 and 0.10 mg nicotinic acid.

2.10.3 Nutritional Requirements of Japanese Quails

2.10.3.1 *Quail feeding*

Nutrition is one of the most important factors required to maintain quails in good physical condition and to obtain normal growth and egg production. Since feed constitutes 60-70% investment at the farm, for deriving maximum benefit out of quail farming it is necessary to feed a balanced ration which will have all the nutrients in necessary proportion. There are several forms in which a balanced ration may be fed to quail, which are; all dry mash pellets or crumbs. In tropics usually all dry mash feeding system is being used. A typical ration formulated by Shim and Lee (1988a) and widely used in experiments (Shim and Chen, 1989; 1990). The local farmers may use the chicken starter and layer diets for their growing and laying quails and supplement them with high protein ingredients, such as fish meal, soybean meal and skimmed milk. Fast early growth is achieved with high-protein diets. Japanese quails, which mature at 5 to 6 weeks of age, respond favourably to higher dietary protein concentration. These high protein starter feeds will give quick development to growing birds as well as bringing earlier and more consistent laying to hens. For birds just prior to maturity, the

dietary requirements are similar, except for calcium and phosphorus. A diet containing 1.25 percent total phosphorus and 3.50 percent calcium is recommended; this may need to be increased to 3.9 percent in hot weather when quail eat less food but still require calcium to maintain egg production. Broken oyster-shell or limestone grits may be given *ad libidum*. When the ration contains only plant protein, supplemental methionine and lysine may be beneficial. There are indications that these are the first limiting amino acids for Japanese quails (Howes, 1965).

It is important to obtain fresh feed and it should be stored in covered containers with tightly fitting lids in a clean, dry, cool area free from animals and vermin. Feed stored longer than 8 weeks is subject to vitamin deterioration and rancidity, especially in hot humid tropics. The nutrients that comprise a quail diet are water, protein, carbohydrate, fat, minerals, and vitamins. Although all are essential, adequate water may be considered the single most important nutrient. Fresh clean water should be provided continuously to all birds, especially under the tropical environment. Quails require at least twice, as much in weight of water as they require in weight of dry feed (Farrell *et al*., 1982). They may require more water if there are excess salts in the feed or during hot dry season.

2.10.3.2 Protein

Protein provides the amino acids for tissue growth and egg production. The dietary protein requirement of quail is influenced by metabolizable energy content and the ingredients used to formulate the diets. The earlier investigators raised their quail flocks successfully on turkey starter diets containing about 25-28% crude protein (Wilson *et al.*, 1959; Woodard *et al.,* 1973; NAS, 1969). Lee *et al.* (1977a and b) have shown that a dietary crude protein level of 24% is needed in starter diet for quail and the protein content may be reduced to 20% by 3rd week of age. Protein is the most expensive nutrient and must be provided from a high quality source.

Protein quality is generally based on the amino acid composition of the feedstuff and the availability of these amino acids from the feedstuff through digestion in the gut of the quail. Amino acids are considered as the building blocks of proteins. Out of 19 total amino acids required by quails, 13 are considered as essential amino acids, because they cannot be produced in the quail's body and must be supplied in the diet, and 6 are considered as nonessential, because they are synthesized by the body and need not be supplied in the diet. The 13 essential amino acids are: arginine, cysteine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, tyrosine and valine. Feedstuffs differ qualitatively and quantitatively in their amino acid composition. Quail diets consist mainly of plant materials. The most commonly used plant products are maize, soyabean meal, sorghum and rice or wheat bran. Methionine and lysine are generally low in plant products. Animal protein products such as fish meal, meat and bone meal etc., are good sources of most of the essential amino acids, but they are usually more expensive than plant protein ingredients. Synthetic methionine and lysine are usually added to the diets to balance the amino acid composition (Shim and Lee, 1984a and b; 1988a and b).

2.10.3.3 Energy

The amount of feed intake depends upon the metabolizable energy (ME) content of the diet, age of the birds, their reproductive status and the ambient temperatures. An energy requirement of 2,600 to 3,000 kcal ME/kg diet for growing quail has been reported from temperate regions (Farrell *et al.*, 1982), whereas, findings under our tropic condition indicated an energy requirement of about 2,800 kcal ME/kg for growing quails (Shim and Lee, 1988a) and 2,550 kcal ME/kg for laying quails (Shim and Lee, 1988b). Though raising the dietary energy levels from 2,600 to 2,800 kcal ME/kg did not influence the gain in weight, it affected significantly the efficiency of feed utilization as the feed consumption was reduced significantly (Shrivastav

and Panda, 1982). The main energy source is provided by the grains and cereals which are the main ingredients in most feed. Fat such as animal tallow, lard or other vegetable oils are added to the diet if high energy is required by the quail.

2.10.3.4 Vitamins

Vitamins may be categorized as fat soluble, (A, D, E, and K) and water soluble (the B-complex vitamins). Many vitamins are quite stable, but some deteriorate rapidly on exposure to heat, sunlight, or air. Housed quails are entirely dependent on the vitamins that are present in their compounded feed in the correct amount and proportions, for they have no access to the natural supply of these nutrients. The principal vitamin functions and requirements are as follows:

Vitamin A

The principal feature of vitamin A is its function in ensuring adequate growth and as a means of assisting in the birds' resistance to disease. Vitamin A is essential for normal vision, egg production, and reproduction. Laying quails receiving insufficient vitamin A produce fewer eggs and eggs produced frequently do not hatch. For egg production and fertility of females, a level of 2,500 I.U. vitamin A/kg diet was required (Parrish and Al-Hasani, 1983). The hatchability and survival of newly-hatched chicks were better with 3,200 I.U. vitamin A/kg diet. True vitamin A exists only in animal kingdom. It may be formed by synthesis in the body of the bird from the precursor, carotene, which is present in green vegetable matter or yellow corn. Due to increase in exposure to air, grinding of feed materials will hasten the deterioration of this vitamin during storage, particularly if storage areas are warm or hot. As a result, the feed industry does not depend upon the bird's receiving their vitamin A from ingredients in the diet. Dry or stabilized vitamin A is added to diet to meet the requirements of the bird. The supplementation of 4,000 I.U. vitamin A per kilo of diet for quails may be adequate for their optimum growth, production and reproductive traits.

Vitamin D

This vitamin has several forms, but D_2 and D_3 are the most important. Vitamin D_3 is utilized by birds and man, while vitamin D_2 is of value to man and four-footed animals. Thus D_3 becomes essential for quail. Vitamin D aids the absorption of calcium and phosphorus from the intestinal tract and the deposition of calcium on egg shell. Vohra *et al*. (1979) observed that dietary deprivation of supplementary vitamin D_3 did not affect body weight of male and female Japanese quails despite a reduction in feed intake. However, the production of eggs was reduced from 74% to 20%. In another experiment, the mature male quail remained in good physical condition on practical diets devoid of vitamin D_3 for 1 year. But a mortality of about 90% was observed in females and 16% in males even when both were in negative calcium balance of about the same order (Chang and McGinnis, 1967). Vitamin D is associated with sunlight, for sunlight provides irradiation that stimulates the manufacture of vitamin D in the skin of the bird. Unfortunately, laying quails are seldom exposed to direct sunlight, so the body's synthesis of vitamin D is limited. The quail producer normally adds vitamin D to the quail diet in required amounts to meet productive objectives rather than relying on synthesis or feed ingredients.

Vitamin E

A deficiency of vitamin E causes a disease of the nervous system in chicks known as 'crazy chick disease' (encephalomalacia). It is also essential to breeding stock for the good hatchability of their eggs. Encephalomalacia occurs when the diet contains unsaturated fats that are susceptible to rancidity. Several antioxidant compounds, in addition to vitamin E, are usually added to prevent the fat from going bad. The essentiality of vitamin E for quail was demonstrated by Price (1968), Cunningham and Soares (1979), Kling and Soares (1980) and

Shim *et al.* (1983). A deficiency of vitamin E in semi-purified diets containing isolated soybean protein and starch did not affect the body weight, feed consumption, or egg production of Japanese quails. However, it caused sterility in males, which was overcome by restoring 40 I.U. vitamin E/kg to the diet for about 2 weeks. The fertility and hatchability of quail eggs were severely depressed after the birds were fed a conventional diet containing glucose and soybean meal, but deficient in vitamin E for 20 weeks. No encephalomalacia or muscular dystrophy was observed in quails fed vitamin E deficient diets for 35 weeks. Whole grains and alfalfa meal are the best natural sources of vitamin E. Synthetic tocopherols (vitamin E) are available, and these are usually added to quail starter and breeder rations.

Vitamin K

Vitamin K is an essential element in the synthesis of prothrombin, a chemical necessary for blood clotting. A deficiency can lead to the rupture of blood vessels and causing excessive bleeding. It is present naturally in all green foods, especially rich in lucerne meal. The needs are small, and 2 i.u./kg will suffice under normal conditions. A synthetic, water-soluble form of vitamin K3 is generally added in the diet.

Vitamin B Complex

The B vitamins are well distributed in cereals and grains, and deficiencies are normally unlikely to occur. The main functions of the B vitamins are to assist the quail in achieving its optimum growth.

Thiamin (Vitamin B_1)

It is needed for the metabolism of carbohydrates. Charles *et al*. (1972) reported classical symptoms of polyneuritis in newly hatched quail chicks from a flock fed turkey breeder diet formulated to contain 3.2 mg thiamin/kg. These quails responded positively to thiamin injection. Breeding Japanese quails may have a higher requirement for thiamin (Shim and Boey, 1988) than breeding fowls which is reported to be 0.8 mg thiamin/kg diet (NRC, 1977).

Riboflavin (Vitamin B_2)

Ramchandran and Arscott (1974) suggested a minimum requirement of 8 mg riboflavin/kg diet in absence of vitamin B_{12} and vitamin C, but it decreased to 4mg per kg in presence of these vitamins. The characteristic symptoms of riboflavin deficiency were slow growth, high mortality, impaired gait and posture which are known as 'curled toe paralysis' in quails. Feathering was absent other than down at the end of two weeks of riboflavin deficiency. Shim (1985 b) studied the maternal riboflavin deficient on reproductive and embryonic development in Japanese quail and found high mortality in the riboflavin deficiency group. The 4 and 8 mg/kg of riboflavin were sufficient to maintain normal egg production. Data obtained in weekly hatches showed that the addition of small quantities of riboflavin supplement to the basal ration increased the incidence of curled-toe paralysis whereas larger amounts decreased it. Shim, (1985 b).

Nicotinic acid

Park and Marquardt (1982) fed a nicotinic acid-free diet to 4 week old quails and found a subsequent depression in growth, but no other classical deficiency symptoms. However, newly-hatched quail chicks died within 9 days of feeding this deficient diet. The age of the

birds determines the severity of symptoms of nicotinic acid deficiency. A marked depression in growth, closure of eyes, reduced activity and a marked atrophy of the pectoral muscle were observed in quails on nicotinic acid deficient diets. Ramachandran and Arscott (1974) suggested a level of 40 mg per kg diets for normal growing quails.

Pantothenic acid

A supplementary level of 7.5 mg calcium pantothenate/kg diet was needed in purified diets for prevention of mortality and for normal growth of quail chicks, but 10-30 mg was needed for normal feathering (Cutler and Vohra , 1977). On the other hand, Spivey-Fox *et al*. (1966) found the requirement to be 40 mg/kg diet for quails up to 5 weeks of age. Breeding quail needed 15 mg supplementary calcium pantothenate per kg diet for optimal fertility and hatchability. Eggs from pantothenic acid deficient hens were characterized by embryonic mortality late in incubation period, haemmorhagic embryos, oedema and embryos with crooked legs (Cutler and Vohra, 1977).

Choline

Growing Japanese quail required higher levels of dietary choline to support maximum growth, prevent perosis (Ketola and Young, 1973), and maintain maximum egg weight (Latshaw and Jensen, 1971), egg production and hatchability (Latshaw and Jensen, 1972) than chickens. Mature quails differ from laying fowls as they require preformed choline. The suggested requirement of quails for egg laying is about 3,100 mg/kg diet.

Folic acid

Folic acid deficiency in growing quails caused poor feathering, high mortality, leg weakness and cervical paralysis. These symptoms were similar to those observed in turkey poults. Quail

chicks also suffered from a mild anaemia, and a curled toe syndrome. The folic acid requirement of growing quails was between 0.3 to 0.36 mg/kg casein-gelatin based diet (Wong *et al.*, 1977).

Biotin

Dobalova and Pajtasova (1983) reported the need of supplementary biotin for gain in body weight of quails and for increase in egg production.

Vitamin B_{12} (Cobalamin)

Vitamin B_{12} is required for the development of normal red blood cells. For better hatchability, sufficient pantothenic acid and vitamin B_{12} are also essential. Substantial quantities of vitamin B complex are found in all the ingredients in feed. It should be stressed that vitamin B_{12} is found only in foods of animal origin.

2.10.3.5 Minerals

Besides protein, carbohydrates, fats, and vitamins, many other elements form a part of the quail's nutritional requirements. Minerals can be divided into macro minerals and micro minerals. Macro minerals are required in large amounts, and are often structured parts or acid-base elements. These are: calcium, phosphorus, potassium, magnesium, sulfur and salt (NaCl). The micro minerals are associated in activation or integrated parts of enzymes. These include: cobalt, copper, iodine, iron, manganese, selenium and zinc. Minerals make up 3 to 5% of the quail's body. Since minerals cannot be synthesized, they must be provided by the diet.

2.10.3.5.1 Calcium and Phosphorus

The main function of these two minerals is in the make-up of the bones of the body. Calcium is also essential for the deposition of egg shell. It is not only that calcium and phosphorus are required in sufficient quantity but also in the correct proportions. For the young growing quail the ratio should be 1:1 to 2:1. The young quail needs a minimum of 0.8 per cent of the diet as calcium and 0.45 per cent as available phosphorus, whilst the laying quail needs about 2.5% to 3% of calcium since this is the main constituent of the egg shell (Nelson *et al.,* 1965). Miller (1967) observed no difference in body weight or bone ash of quail up to 6 weeks of age as long as the diets contained 0.58% to 1.18% total phosphorus and 0.44% to 2.3% calcium. Lee and Shim (1971) found that 0.5% calcium was adequate for the growing quail and a level of 4.9% calcium retarded growth. Ong and Shim (1972) observed that growing as well as laying quails were in positive calcium balance as long as the diets contained 0.8%, 1.5%, 2.6% or 3.5% calcium. A level of 3.5% dietary calcium reduced hatchability. Minerals are present in many of the ingredients in the diet. Fish meal, meat and bone meal, milk products are good supplemental sources of calcium and phosphorus. Oyster shell, limestone, tricalcium phosphate or calcium carbonate is usually added to the feed to supplement these elements.

2.10.3.5.2 Magnesium

Magnesium is an essential constituent of tissues and body fluids. Its ions serve as activators of important enzymes involved in intermediary metabolism. When it is absent from the diets, quails grow slowly, exhibit convulsions and may eventually die (Harland *et al*., 1976). Deficiencies in laying rations produced a rapid drop in egg production. The magnesium requirement was recommended to be 300 mg/kg diet. In the studies of Vohra (1972), magnesium requirement for survival and growth was met by supplementing 150 mg

magnesium per kg diet, or 50 mg magnesium per litre drinking water. Sughara *et al*. (1982) found no detrimental effects from feeding 1,000 mg magnesium per kg purified diet. Natural feedstuffs contain adequate amount of magnesium. Some limestone (the dolomites) contain a high percentage of magnesium and are to be avoided because excess magnesium is laxative and interferes with calcium usage.

2.10.3.5.3 Manganese

The main function of manganese is to prevent paresis, a condition where the Achilles's tendon slips off its groove behind the hock joint, pulling sideways and backwards. It is also required for normal growth, egg shell deposition, egg production and good hatchability. It is supplemented in the diet in the form of manganese sulphate.

2.10.3.5.4 Salt (Sodium Chloride)

This is needed for protein digestion and these elements are also involved with acid-base equilibrium in the body. The growing Japanese quail fed a purified type of diet containing 0.042-0.051% sodium had poor growth , high mortality, adrenal enlargement, elevated haematocrit, and depressed plasma sodium suggestive of an aberration in fluid and electrolyte haemostasis. A dietary sodium level of 0.1% overcame these difficulties (Lumijarvi and Vohra, 1976). Natural feedstuffs usually require supplemental feeding of salt (NaCl) to satisfy the quail's requirement for sodium and chloride and this is normally added to the feed at amounts of 0.25 to 0.35 per cent. Too much salt produces a laxative effect and results in wet droppings and also wet litter.

2.10.3.5.5 Iron, Copper and Cobalt

These trace elements are essential for the formation of haemoglobin. Nutritional anaemia occurs when there are deficiencies of these minerals. The red blood cells contain iron. Copper is necessary for iron utilization when haemoglobin is formed. Harland *et al*. (1973) reported the iron requirement of growing Japanese quail as 90-120 mg/kg, and of copper as 5 mg/kg diet based on EDTA extracted isolated soybean protein. Cobalt is the integrated part of vitamin B_{12} which is involved in haemoglobin formation. The amount of these elements in the diet is quite specific; excesses may be toxic. Usually, only small amounts are added in the feed. Mackova *et al* (1981) studied the effect of supplementary 50, 100, 250 and 500 mg cobalt sulphate per kg diet on vitamin B_{12} concentration in liver and caeca and observed that the concentration was highest with 1200 mg cobalt sulphate/kg diet.

2.10.3.5.6 Selenium

Selenium is an essential element for growing quails even in the presence of vitamin E. Diets consisting of amino acids and 100 mg d-alpha-tocopheryl acetate/kg needed to be supplemented with 0.1mg selenium as selenite for proper survival of quail (Thompson and Scott, 1967). Impaired reproduction was observed in Japanese quails fed a diet low in selenium and vitamin E from hatching to maturity. Oviposition rate and fertility were not affected, but the hatchability of fertile eggs, viability of male and female adults and newly hatched chicks were reduced. Dietary supplementation with either 1 mg selenium or 30 I.U. vitamin E/kg diet prevented the impaired reproduction (Jensen, 1968). Selenium supplementation of the diet at 0.2 mg/kg diet prevented nutritional pancreatic atrophy and resulted in significant elevation in activity (Shim, 1985 a).

2.10.3.5.7 Zinc

Japanese quails are quite sensitive to a dietary deficiency of zinc. Zinc deficiency in quail chicks was characterized by slow growth, abnormal feathering, labored respiration and an in coordinated gait, low tibia ash, and a low concentration of zinc in liver and tibias. The zinc requirement for normal growth, feathering, tibia length and conformation was 25 mg/kg diet (Spivey-Fox and Jacobs, 1967). Harland *et al*. (1975) studied the protective effect of a high prior zinc intake for rapidly growing quail to a subsequently fed low zinc diet. The birds fed an initial level of 75 mg zinc/kg grew significantly better than those fed initially 25 mg zinc/kg. Bone might store zinc and it might be mobilized during zinc deprivation. A reduction in zinc absorption in adult quails by high levels of calcium was reported by Kienholz *et al*. (1965).

2.10.4 Performance of Japanese Quails

Japanese quails have the benefit of a very fast growth rate, and attaining weights of 163g for males and up to 190g for females in six week (Bonos *et al*., 2010) with a relatively short generation interval in terms of egg production. Protein of high quality with adequate amino acid balance is one of the most important nutrients for quails. It is also one of the most expensive nutrients. Murakami *et al.* (1993) documented that excessive protein intake results in higher nitrogen excretion and lower feed efficiency for egg production. Four crude protein levels (20, 22, 24 and 26%) were evaluated for Japanese quails and it was concluded that after lysine and methionine + cysteine requirements were met, 20% crude protein level resulted in best performance from 1 to 42 days of age. Bonos *et al*. (2010) reported significant linear and quadratic relationships between processing levels and increased body weight gain, carcass weight as well as decreased feed conversion ratio from 7 to 35 day of age. González-Alvarado *et al.* (2007) and Jiménez-Moreno *et al.* (2009) using different fibre sources reported that fibre decreased body weight gain and improved feed conversion ratio and feed intake, suggesting

that young birds require a minimal amount of fibre in the diet when the objective is to maximize growth performance.

Makinde *et al*. (2013) reported that utilization of Brewers Dried grain (BDG) and Palm Karnel Meal (PKM) up to 15% in quail diets did not pose any negative effect on the performance of Japanese quails. Sacakli *et al*. (2006) and Çakir *et al*. (2008) in their study reported that there was no significant difference in the body weight of birds fed acidifiers, whereas Ghosh *et al*. (2007) and Ocak *et al*. (2009) found higher bodyweights for birds fed acidifiers. Murakami *et al* (2008) showed that processed feeds affected significantly, egg production, egg mass, and daily feed intake of Japanese quails. As compared to the groups fed mash and extruded feeds and also reported that quails fed the pelleted feed presented higher egg production and egg mass. This may be attributed to improved diet digestibility caused by the process of pelletization, which changes the tertiary structure of proteins, favoring their digestion, and increasing amino acid availability for egg production (Vargas *et al*., 2001).

2.10.5 Haematological Indices of Quails

Blood parameters are good indicators of physiological, pathological and nutritional status of an animal, and changes in haematological parameters have the potential of being used to reveal the impart of nutritional factors and additives supplied in the diet on any living creature (Medugu *et al*., 2010; Toghyani *et al*., 2010). Luecocytes (white blood cells) increase sharply when infection occurs, as they are one of the first lines of defence of the body (Toghyani *et al*., 2010). Red blood cell (RBC) count is the number of red blood cells per unit volume of the whole blood and haemoglobin concentration is a good measure of the ability of the blood to carry oxygen throughout the body. Low RBC count and haemoglobin indicate anaemia, while too high levels may lead to ploycythaemia (WebMD Medical Reference, 2010).

Packed cell volume (PCV) is the proportion of whole blood volume occupied by the red blood cells. An abnormally high PCV (ploycythaemia) can be relative, due to a change in the proportion of circulating RBC to blood plasma without any alteration in the size of the erythrocyte, or absolute, due to a real increase in erythrocyte size. Abnormally low PCV (anaemia) may be caused by loss of blood (haemorrhage), breakdown of erythrocyctes by the bone marrow (hypoplasia or aplasia). Low PCV values are taken to indicate anaemia and fatigue, and higher values to indicate dehydration and PCV value ranges from 36–50% in quails (Terry and Campbell, 1988; Dawn, 2010).

Similarly Samar and AL-Gehani (2013) in an experiment on the effect of sub chronic exposure to malathion on haematological parameters in quails reported that there were statistically significant decreases in haemoglobin content (Hb), red blood cells (RBC), hematocrit (Hct) and increase in the number of white blood cells (WBC) in malathion treated- quail as compared to control. Deka and Borah (2008) in a study on haematological and biochemical changes in Japanese quails *Coturnix coturnix japonica* and chickens due to *Ascaridia galli* Infection showed that the total erythrocytic count (TEC), packed cell volume (PCV), haemoglobin (Hb) and Lymphocytes percentage decreased significantly in infected groups of quails and chickens, while the total leucocytic count (TLC), heterophils and eosinophils showed significant increase in infected groups of quails and chickens. Tuleun *et al*. (2013) in a study also demonstrated the effect of different levels of protein diets on erythrocyte osmotic fragility of quail, and that high protein level up to 21 % improves haematological parameters in quail tremendously. PCV, Hb concentration, Total Red Blood cell and TP in the quails placed on 21 % CP dietary treatment were higher while the lowest value was recorded in the group of quails placed on diet with 17 % crude protein. Nazifi and Asasi (2001) reported significant decrease of WBCs and lymphocytes following the administration of furazolidone, these

changes in haematological parameters are probably due to immunosuppressive effects of furazolidone and drug toxicity.

2.10.6 Carcass Characteristics of Quails

A high quality carcass is one with large amount of muscle and small amount of bones and fat. Carcass composition is referred to as the proportion of lean meat, bone and fat after dressing. Makinde *et al.* (2013) reported the mean weights of quail carcasses as percent of live weight to be, 28.87% breast, 8.84% thigh, 23.42% back, 7.71% wing, 2.29% liver, 3.59% gizzard and 5.67% intestine of quails fed palm kernel meal and brewers dried grain based diets. Tuleun *et al*. (2009) also reported mean weight in quail fed toasted mucuna seeds to have better carcass yield of drumstick of 8.50 %, thigh 15.80 %, breast 38.75 % and wing 9.10 %. Yalcin *et al.* (1999) conducted an experiment to evaluate the relationship between slaughter ages and carcass characteristics of Japanese quails. The birds were slaughtered at 5, 6, 7, 8 and 9 weeks of age and showed that carcass yield, carcass parts weight, weight of liver, heart, gizzard and alimentary tract obtained were studied for each sex, protein, fat, dry matter and ash contents of meat and concluded that body weight and eviscerated weight were affected by age. Also that age had no significant effect on the weight of liver, alimentary tract, gizzard and heart, but had on breast weight and relative leg weights.

2.10.7 Effect of Processing of Ingredients on Carcass Characteristics of Quails

Tuleun *et al*. (2009) reported that inclusion of toasted mucuna seed meal in the diets of quails did not cause significant disproportionate growth in carcass quality and visceral organs and that toasted mucuna seed meal could be included up to 15% level in practical diets of growing Japanese quails. Rezaei *et al.* (2014) in an experiment on inclusion of processed rice hulls as insoluble fibre in the diet on performance and digestive traits of Japanese quails reported that levels of processing increased the relative weight of digestive organs. The supplementation of

processed rice hulls resulted in increases in the intestinal villus height, villus thickness, villus height: crypt depth ratio and number of goblet cells, and decrease in litter moisture. This effect might be related to the higher fibre content and its processing levels. Rezaei *et al.* (2014) also reported that feeding high fibre diets increased the relative weight of the small intestine, gizzard, and proventriculus, but the magnitude of the effects differed with the fibre source used. Bach, (2001) reported that the main physicochemical characteristics of dietary fibre with nutritional significance is hydration properties, which influence solubility, water holding capacity (WHC), and swelling capacity. Sarica *et al*. (2007) in an experiment on effects of dietary supplementation of L-carnitine on performance, carcass and meat characteristics of quails reported that cold carcass yield of quails fed the diet containing sunflower oil was significantly higher than those receiving the diets containing fish oil and, that after 35 days of feeding the diet containing the standard energy level (12.13 MJ ME/kg) the thigh yield of the birds was significantly higher than that of the chicks on the lower energy diet.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

The study was conducted at the Quail Unit, Teaching and Research Farm, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria.

Zaria is located within the Northern Guinea Savanna Zone on latitude 11^0 11' 06" N and longitude 7^0 38' 55' E, at an altitude of 706m above sea level. The maximum temperature ranges from 26-32^{0}C depending on the season while the mean relative humidity during the dry and wet season are 21 and 72%, respectively. (Meteorological Unit, Institute of Agricultural Research, Ahmadu Bello University Zaria, 2016).

3.2 Source of Experimental Birds

A total of One thousand fifty six (1056) quail birds were purchased from Maizuma farm at Galma New Jos Road, Along Dakace Zaria, used for both experiment 1 and 2.

3.3 Source and Processing of Sweet Potato and Sweet Potato Peels

Sweet Potato was sourced from Samaru market while Sweet Potato Peels was sourced from Fast food restaurants in Zaria metropolis, Kaduna State (during dry season). The sweet potato was sliced into chips and the peels collected were washed and sun-dried on concrete floor (under hygienic condition), after which they were winnowed to get rid of any foreign materials. Sample of the winnowed sweet potato and sweet potato peels were oven dried, milled and used for chemical analysis. The other ingredients were sourced from Rebson Feed Mill, Samaru Zaria, Kaduna State.

3.4 Laboratory Analysis

3.4.1 *Determination of the proximate composition of sweet potato and sweet potato peel*

Samples of the Sweet Potato and Sweet Potato Peel were taken to the Animal Science Biochemical Laboratory for proximate analysis using the methods described by A.O.A.C. (2005). The analysis was done to obtain the nutrient composition (Dry matter, Crude protein, Ether extract, Crude fibre, Ash and Nitrogen free extract) of the Sweet Potato and Sweet Potato Peels.

3.4.2 Determination of the proximate composition of experimental diet

Samples of the diets were taken to the Animal Science Biochemical Laboratory for proximate analysis using the methods described by A.O.A.C. (2005). The analysis was done to obtain the nutrient composition (Dry matter, Crude protein, Ether extract, Crude fibre, Ash and Nitrogen free extract) of the diets and the materials. Crude protein was determined by the Kjedahl procedure A.O.A.C. (2005), Ether extract was determined by subjecting the samples to petroleum ether extraction at 40-60°C using the Soxhlet Extraction Apparatus. Dry matter was determined by oven drying the samples at 100°C over a 12-hour period. Crude fibre was determined by boiling the sample under reflux in weak sulphuric acid (0.255N H_2S0_4), then in weak sodium hydroxide (0.312N NaOH) for 1 hour. The residues which consist of cellulose, lignin and mineral matter were dried and weighed. The ash content was determined by igniting a weighed sample in a Muffle furnace at 500°C. The nitrogen free extract (NFE) was obtained by the difference after the percentages of the other fractions have been subtracted from 100%. Gross Energy (GE) and Metabolizable energy (ME) were computed using the method described by Pauzenga, (1985).

3.5 Experiment 1a: Growth Performance of Japanese Quails Fed Diet Containing Varying Levels of Sweet Potato Meal (2-6weeks)

3.5.1 Experimental Diets for Grower Japanese Quails

Four Experimental diets were formulated for the Experiment as detailed below:

Treatment 1 -- 0% inclusion of Sweet Potato Meal

Treatment 2 – 10% inclusion of sweet potato meal

Treatment 3 – 20% inclusion of sweet potato meal

Treatment 4 – 30% inclusion of sweet potato meal

Composition of Experimental diets is presented in Table 3.1

3.5.2 Experimental Design and Management of Birds (2- 6 weeks)

A total of three hundred (300) two weeks old quail birds were used for the study. On arrival, the quails were weighed and randomly assigned into four groups of 75 birds each. Each of the groups was subdivided into 3 replicates of 25 birds per replicate in a complete randomized design (CRD). Flat chick trays were used to supply feed for the chicks. Plastic chick drinkers of three litre capacity were used to supply fresh water daily. Small pebbles were placed in the drinkers during the first 2-3 weeks of life to prevent the quail chicks from being drowned. The feeders were changed to cone type placed in a flat feeder so as to minimize feed wastage. Common diet was given for a day and all necessary routine management practices were adhered to throughout the study period. The quail birds were given their respective diets and water *ad-libitum* throughout the growing period (2-6 weeks). Antibiotic (neoterramycin) was given every 2 months as a preventive measure. The birds were weighed at the beginning of the

Table 3.1: Composition of Experimental Diet Containing Varying Levels of Sweet Potato Meal for Grower Japanese Quails (2 - 6 weeks)

	Inclusion levels of Sweet Potato (%)			
Ingredients (%)	0	10	20	30
Maize	53.70	43.70	33.70	23.70
SPM	0.00	10.00	20.00	30.00
SBC	30.00	30.00	30.00	30.00
GNC	8.00	8.00	8.00	8.00
Fish meal	2.30	2.30	2.30	2.30
BDG	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Common salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Vitamin Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated Analyses				
ME (Kcal/kg)	2919.68	2906.98	2894.28	2887.58
CP (%)	23.45	23.02	22.60	22.17
E: Prot ratio	124.31	123.92	123.54	123.16
EE (%)	2.92	3.07	3.22	3.37
CF (%)	3.32	3.64	4.36	4.87
Ca (%)	1.22	1.24	1.26	1.28
Avail P (%)	0.77	0.76	0.76	0.75
Ca: P ratio	3.15	2.97	2.76	2.54
Lysine (%)	1.69	1.69	1.68	1.68
Methionine + cycsteine (%)	0.59	0.59	0.58	0.57

Vitamin-mineral premix provide per kg diet;Vit. A, 13340I.U; Vit D_3, 2680I.U; Vit E, 10 I.U.; Vit K, 2.68mg; Calcium pentothenate, 10.68; Vit. B_{12} 0.022mg; folic acid, 0.668mg, choline chloride,400mg; Chlorotetracycline, 26.68mg; Manganese, 13mg; Iron,66.68mg; Zinc,53.34mg; Copper,3.2mg; Iodine, 1.86mg; Cobalt,0.268mg; Selenium, 0.108mg. SPM = Sweet Potato Meal, SBC = Soya bean cake , GNC = Groundnut cake ME = Metabolisable Energy CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, Avail P = Available Phosphorus in percentage, Ca: P ratio = Calcium: Phosphorus ratio.

trial and weekly thereafter. Weight gain, feed intake, feed conversion ratio, feed cost/kg gain were calculated. Performance parameters was monitored which include weight gain, feed intake, feed conversion ratio and feed cost/kg gain. Feed intake and body weight gain were taken weekly. These were used to calculate average or daily feed intake and weight gain. Feed conversion ratio was calculated on the basis of unit of feed consumed to unit of body weight gain.

3.5.3 Determination of Haematological and Biochemical Parameters

At the end of the growth phase, two quails per replicate were slaughtered. 2.0ml blood was collected with the aid of needle and syringe into bottles containing 1mg/ml of EDTA (ethylene diamine tetra acetic acid) as anti-coagulant another 2.0ml of blood was collected with bottles without EDTA, taken to the Clinical Pathology Laboratory, Faculty of Veterinary Medicine, Ahamdu Bello University, Zaria. The blood samples were analyzed for Packed cell volume (PCV), leucocyte (WBC), erythrocyte counts (RBC), haemoglobin (Hb), Total protein (TP) and differential blood count (heterophils, eosinophils, basophils, lymphocytes and monocytes) according to the methods described by Schalms *et* al. (2000). The biochemical parameters measured include Total protein, Albumin, Globulins and Glucose according to the methods described by Coles (1986).

3.5.4 Digestibility Trial

Four male Japanese quail birds from each replicate were housed in a clean, separate and dis-infected metabolic cage. They were allowed 3 days for acclimatization before the commencement of the study. Faecal collection period commenced after the third day which lasted for 7days. Trays were placed under each cage for total faecal collection. Water and a known amount of feed were made available *ad libitum* throughout the digestibility trial period.

Faeces were collected daily for a period of four days. The faeces were air-dried and the total collected per bird was pooled and stored in a freezer till the end of the digestibility trial. Dried faeces were allowed to thaw, thoroughly mixed and samples taken to the Biochemical Laboratory, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria to determine the proximate composition according to the methods described by A.O.A.C (2005). The digestibility coefficients were calculated using the equation below:

$$\text{Apparent Nutrient digestibility} = \frac{\text{Nutrient intake - Nutrient output}}{\text{Nutrient intake}} \times 100$$

Where; Nutrient intake (g) = Dry feed intake x Nutrient in diet (%)

Nutrient output (g) = Dry faecal output x Nutrient in faeces (%)

3.5.5 Carcass Analysis

At the end of experiment 1, sixty-three (63) male quails obtained after sexing of birds were used for the carcass evaluation. Three birds from each replicate (nine birds per treatment) were fasted overnight (12 hours), bled and de-feathered manually using hot water at range of 65^{o}c - 70^{o}c and then eviscerated. The dressed quails were cut into prime cuts. The following parameters were measured: slaughter weight, carcass weight, weights of the prime cuts and organs weight. The prime cuts were expressed as percentage of carcass weight, while the organs were expressed as percentage of live weight. Dressing percentage was calculated.

$$\text{Dressing percentage} = \frac{\text{Carcass weight}}{\text{Live weight}} \times 100$$

Primal cuts measured include the thigh, back, drum stick, wing and head while the organs measured include liver, gizzard, heart and small intestine.

3.5.6 Statistical Analysis

Data generated were statistically analyzed using the General Linear Model Procedure of Statistical Analysis System (SAS, 2002). Significant means were separated using Dunnett's Test in the SAS package.

The linear model used for the experiment was:

$Y_{ij} = \mu + p_i + e_{ij}$

Y_{ij}= Performance of the j^{th} animal fed i^{th} inclusion of sweet potato and Sweet potato peel.

μ= Overall mean.

p_i= Effect of the i^{th} inclusion of sweet potato and sweet potato peel.

e_{ij}= Random Error

3.5.7 Cost Benefit Analysis

Cost benefit analysis was carried out to determine the profitability of inclusion of the sweet potato and sweet potato peels in diet for feeding Japanese quails. The prevailing costs of materials at the period of study were used for the computation.

3.6 Experiment 1b: Laying Performance of Japanese Quails fed Diets Containing Varying Levels of Sweet Potato Meal (7- 20 weeks)

3.6.1 Experimental Diets

Four Experimental diets were formulated for the experiment.

Treatment 1 -- 0% inclusion of Sweet Potato Meal

Treatment 2 – 10% inclusion of Sweet Potato Meal

Treatment 3 – 20% inclusion of Sweet Potato Meal

Treatment 4 – 30% inclusion of Sweet Potato Meal

Composition of Experimental diets is presented in Table 3.2

3.6.2 Determination of the Proximate Composition of Experimental Diets.

Same procedure used in experiment 1a was used.

3.6.3 Experimental Design and Management of Birds

Two hundred and twenty eight (228) quail hens with average initial weight of 137g from Experiment 1 were used in this Experiment. The quail hens were mixed up and placed on a common diet for three days. The birds were assigned to four treatment groups based on the average initial body weight. Each treatment group of 57 birds was further divided into three replicates of 19 birds. Experimental diet and water was provided *ad-libitum.* Body weight of birds was taken at the beginning, end of the trial and change in body weight was calculated. Feed intake, weight of feed/bird/day was determined by obtaining the differences between the quantity of feed offered and the left over on 24 hour period. Egg production was recorded daily and pooled weekly to calculate hen-day egg production and hen house egg production. Feed conversion ratio was calculated weekly. Cost per dozens of egg was calculated based on the prevailing market prices of the feed ingredients. All eggs laid each day in a replicate group were weighed to determine average egg weight. There was no mortality during the experimental period.

Table 3.2: Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal for Japanese Quails Hen (7 - 20 weeks)

	Inclusion Levels of Sweet Potato (%)			
Ingredients (%)	0	10	20	30
Maize	53.70	43.70	33.70	23.70
SPM	0.00	10.00	20.00	30.00
SBC	30.00	30.00	30.00	30.00
GNC	8.00	8.00	8.00	8.00
Fish meal	2.60	2.60	2.60	2.60
BDG	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	0.80	0.80	0.80	0.80
Common salt	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15
Methionine	0.25	0.25	0.25	0.25
Vitamin. Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated Analyses				
ME-Kcal/kg	2928.08	2915.38	2902.68	2889.98
CP (%)	23.55	23.13	22.70	22.28
E: Prot ratio	124.31	123.92	123.54	123.16
EE (%)	2.92	3.07	3.22	3.37
CF (%)	3.32	3.84	4.36	4.87
Ca (%)	1.16	1.18	1.20	1.22
Avail P(%)	0.78	0.77	0.85	0.76
Ca: P ratio	3.15	2.97	2.76	2.54
Lysine (%)	1.60	1.60	1.20	1.59
Methionine + cycsteine (%)	0.60	0.59	0.50	0.58

Vitamin-mineral premix provide per kg diet;Vit. A, 13340I.U; Vit D_3 2680I.U; Vit E, 10 I.U.; Vit K, 2.68mg; Calcium pentothenate, 10.68; Vit. B_{12} 0.022mg; folic acid, 0.668mg, choline chloride,400mg; Chlorotetracycline, 26.68mg; Manganese, 13mg; Iron,66.68mg; Zinc,53.34mg; Copper,3.2mg; Iodine, 1.86mg; Cobalt,0.268mg; Selenium, 0.108mg. SPM = Sweet Potato Meal, SBC = Soya bean cake, GNC = Groundnut cake ME = Metabolisable Energy CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, Avail P = Available Phosphorus in percentage, Ca: P ratio = Calcium: Phosphorus ratio.

The hen day production was calculated as shown below:

$$HDP = \frac{\text{Total number of eggs laid}}{\text{Total number of hens in lay} \times \text{number of days in lay}} \times 100$$

Where HDP= Hen day production

The hen house egg production was calculated as shown below:

$$HHP = \frac{\text{Total number of eggs laid}}{\text{Total number of hens housed initially} \times \text{number of days in lay}} \times 100$$

Where HHP= Hen housed production

Feed conversion ratio was calculated weekly using the formula

$$FCR = \frac{\text{Feed intake}}{\text{Egg weight (Total egg mass)}}$$

Where FCR= Feed conversion ratio

3.6.4 Determination of Egg Quality Parameters

Eggs were collected once daily (8:00 – 9:00am), counted, weighed and recorded per replicate pen. Three eggs with an average weight of the eggs from each replicate were used forth-nightly to determine the egg quality parameter throughout the 16weeks experimental period. Each egg was assessed separately for its internal and external egg quality trait. For external quality traits, egg weight, egg length, egg breath and shell thickness were measured while egg shape index was calculated. Individual egg weight was measured using a sensitive electronic balance (FEJ-1500 A series) Camry scale to the nearest 0.01g. After weighing, measurement of various internal egg quality parameters was done using a vernier caliper and micrometer screw gauge. The egg length was measured as the distance between the two extreme while the egg width was measured as the diameter of the egg at its widest circumference to the nearest 0.01mm. The

eggs were broken around the equator and were emptied out on a clean petri dish (care being taken to keep the yolk intact). The albumen and yolk height were measured, the albumen height was taken at three different points and the average was obtained.

The yolk width was taken at the widest circumference of the yolk while the yolk height was measured as the distance between the base of the petri dish and the highest point of yolk. The yolk was then separated from the albumen and the yolk was weighed. The shell weight was taken after removal of remaining albumen and subsequent air dried for 12 hours. The weight of albumen was calculated by subtracting the weight of yolk and shell from the weight of the whole egg. The thickness of the egg shell was obtained by average measurement of three areas (the blunt end, the pointed end and the middle part of the egg) using a micrometer screw gauge. Haugh unit was calculated from the measured height of albumen and weight of egg using the formula outlined by Haugh (1937).

$HU = 100 \log10 (h-1.7w^{0.37} + 7.6)$, where

HU = Haugh Unit

h = observed height of the albumen in millimeters

w = Weight of the egg in grams

The egg shape index was calculated using the formula described by Sauveur (1988).

ESI = EB/EL

Where;

ESI- egg shape index

EB- egg breadth (mm)

EL- egg length (mm)

Eggs shell thickness was determined using micro meter screw gauge

Each egg shell was dried and weighed to determine the shell weight. This was used to calculate the shell index using the formula below;

This formula was used to calculate the egg shell index according to Iposu *et al.*, (1994)

$I = 100\ SW/S$

Were, I = egg shell index

SW = shell weight

S = surface area (cm)

S was calculated from egg weight using equation $S = k.EW2/3$

Where k has value of 4.67 for egg weight less than 60g

Egg yolk height and width was measured using Vernier calipers and the values obtained were used to calculate the yolk index.

$YI = YW/YH$

Where:

YI = yolk index

YW = yolk width

YH = yolk height

Percentage shell was determined by using the formula:

Shell percentage = (shell weight/ egg weight)/100

Percent yolk was determined using formula

Percentage yolk = (yolk weight/ egg weight) x 100

Egg specific gravity (ESG) was estimated based on weight of egg and shell.

ESG = EW/ {(0.9680 (EW – SW) + (0.4921)}

Where:

ESG – egg specific gravity

EW - egg weight

SW – shell weight

3.6.5 Statistical Analysis

Same procedure used in Experiment 1a was used.

3.7 Experiment 2a: Growth Performance of Japanese Quails fed Diet Containing Varying Levels of Sweet Potato Peel Meal (2-6weeks)

3.7.1 Experimental Diets for Grower Japanese Quails

Four experimental diets were formulated for the experiment as detailed below:

Treatment 1 -- 0% inclusion of Sweet Potato Peel Meal

Treatment 2 – 10% inclusion of sweet potato Peel Meal

Treatment 3 – 20% inclusion of sweet potato Peel Meal

Treatment 4 – 30% inclusion of sweet potato Peel Meal

Composition of Experimental diets is presented in Table 3.3

3.7.2 Determination of the Proximate Composition of Experimental Diets.

Same procedure used in Experiment 1a.

3.7.3 Experimental Design and Management of Birds (2- 6 weeks)

Same procedure used in Experiment 1a was used.

3.7.4 Determination of Haematological and Biochemical Parameters

Same procedure used in Experiment 1a was used.

3.7.5 Digestibility Trial

Same procedure used in Experiment 1a was used.

3.7.6 Carcass Analysis

Same procedure used in Experiment 1a was used.

3.7.7 Statistical Analysis

Same procedure used in Experiment 1a was used.

3.7.8 Cost Benefit Analysis

Same procedure used in Experiment 1a was used.

Table 3.3: Composition of Experimental Diets Containing Varying Levels of Sweet Potato Peel Meal for Grower Japanese Quails (2 - 6 weeks)

	Inclusion Levels of Sweet Potato Peel (%)			
Ingredients (%)	0	10	20	30
Maize	53.70	43.70	33.70	23.70
SPPM	0.00	10.00	20.00	30.00
SBC	30.00	30.00	30.00	30.00
GNC	8.00	8.00	8.00	8.00
Fish meal	2.30	2.30	2.30	2.30
BDG	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	1.00	1.00	1.00	1.00
Common salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Vitamin Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated Analyses				
ME-Kcal/kg	2919.68	2880.28	2840.88	2801.48
CP (%)	23.45	22.88	22.32	21.76
E: Prot ratio	124.31	123.92	123.54	123.16
EE (%)	2.92	3.05	3.18	3.31
CF (%)	3.32	3.88	4.44	5.00
Ca (%)	1.22	1.24	1.26	1.28
Avail P(%)	0.77	0.76	0.76	0.75
Ca: P ratio	3.15	2.97	2.76	2.54
Lysine (%)	1.69	1.69	1.68	1.68
Methionine + cycsteine (%)	0.59	0.59	0.58	0.57

Vitamin-mineral premix provide per kg diet;Vit. A, 13340I.U; Vit D_3, 2680I.U; Vit E, 10 I.U.; Vit K, 2.68mg; Calcium pentothenate, 10.68; Vit. B_{12} 0.022mg; folic acid, 0.668mg, choline chloride,400mg; Chlorotetracycline, 26.68mg; Manganese, 13mg; Iron,66.68mg; Zinc,53.34mg; Copper,3.2mg; Iodine, 1.86mg; Cobalt,0.268mg; Selenium, 0.108mg. SPPM = Sweet Potato Peel Meal, SBC = Soya bean cake, GNC = Groundnut cake ME = Metabolisable Energy CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, Avail P = Available Phosphorus in percentage, Ca: P ratio = Calcium: Phosphorus ratio.

3.8 Experiment 2b: Laying Performance of Japanese Quails fed Diets Containing Varying Levels of Sweet Potato Peel Meal (7- 20 weeks)

3.8.1 Experimental Diets

Four Experimental diets were formulated for the experiment.

Treatment 1 -- 0% inclusion of Sweet Potato Peel Meal

Treatment 2 – 10% inclusion of Sweet Potato Peel Meal

Treatment 3 – 20% inclusion of Sweet Potato Peel Meal

Treatment 4 – 30% inclusion of Sweet Potato Peel Meal

Composition of Experimental diets is presented in Table 3.4

3.8.2 Determination of the Proximate Composition of Experimental Diets.

Same procedure used in experiment 1a was used.

3.8.3 Experimental Design and Management of Birds

Same design and management of birds used in Experiment 1b was used.

3.8.4 Determination of Egg Quality Parameters

Same procedure used in Experiment 1b was used.

3.8.5 Statistical Analysis

Same procedure used in Experiment 1a was used.

Table 3.4: Composition of Experimental Diets Containing Varying Levels of Sweet Potato Peel Meal for Japanese Quails Hens (7-20 weeks)

	Inclusion Levels of Sweet Potato Peel (%)			
Ingredients (%)	0	10	20	30
Maize	53.70	43.70	33.70	23.70
SPPM	0.00	10.00	20.00	30.00
SBC	30.00	30.00	30.00	30.00
GNC	8.00	8.00	8.00	8.00
Fish meal	2.60	2.60	2.60	2.60
BDG	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	0.80	0.80	0.80	0.80
Common salt	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15
Methionine	0.25	0.25	0.25	0.25
Vitamin Premix	0.25	0.25	0.25	0.25
Total	100	100	100	100
Calculated Analyses				
ME-Kcal/kg	2928.08	2888.68	2849.28	2809.88
CP (%)	23.55	22.99	22.43	21.87
E: Prot ratio	124.31	122.92	122.54	120.10
EE (%)	2.92	3.05	3.18	3.31
CF (%)	3.32	3.88	4.44	5.00
Ca (%)	1.16	1.18	1.20	1.22
Avail P(%)	0.78	0.77	0.77	0.76
Ca: P ratio	3.15	2.97	2.76	2.54
Lysine (%)	1.60	1.60	1.60	1.59
Methionine + cycsteine (%)	0.60	0.59	0.58	0.58

Vitamin-mineral premix provide per kg diet;Vit. A, 13340I.U; Vit D_3 2680I.U; Vit E, 10 I.U.; Vit K, 2.68mg; Calcium pentothenate, 10.68; Vit. B_{12} 0.022mg; folic acid, 0.668mg, choline chloride,400mg; Chlorotetracycline, 26.68mg; Manganese, 13mg; Iron,66.68mg; Zinc,53.34mg; Copper,3.2mg; Iodine, 1.86mg; Cobalt,0.268mg; Selenium, 0.108mg. SPPM = Sweet Potato Peel Meal, SBC = Soya bean cake, GNC = Groundnut cake ME = Metabolisable Energy CP = Crude Protein, CF = Crude Fibre, EE = Ether Extract, Avail P = Available Phosphorus in percentage, Ca: P ratio = Calcium: Phosphorus ratio.

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate Composition of Sweet Potato Meal

The result of proximate composition of sweet potato is shown in table 4.1. the result showed DM 92.95%, Crude protein 5.25, Ash 6.29, Crude fibre 7.29, Ether extract 5.28 and Nitrogen free extract of 76.85.

4.2 Experiment 1a: The Effect of Diets Containing Varying Levels of Sweet Potato Meal on Growth Performance, Digestibility, Haematological Parameters, Carcass Characteristics and Cost Benefit Analysis of Grower Japanese Quails.

The result of proximate compositions of experimental diets is shown in Table 4.2.

The effect of diets containing varying levels of sweet potato meal on the growth performance of grower Japanese quails is presented in Table 4.3. The final weight (141.47g) and weight gain (109.47g) were significantly ($P < 0.05$) higher in birds fed 10% sweet potato based diets. The feed intake was significantly ($P < 0.05$) higher in birds fed 10% sweet potato based diets (130.07g). The feed conversion ratio showed no significantly ($P < 0.05$) difference across dietary treatments. The average age at first egg (AAFL) showed no significant difference ($P > 0.05$) across dietary treatments.

The weight of first egg showed no significantly difference ($P < 0.05$) across dietary treatments. The cost of daily feed intake (₦10.88) and cost total feed intake (₦304.67) were significantly better in birds on 30% sweet potato based diets.

The effect of diets containing varying levels of sweet potato meal on apparent nutrient digestibility and ash retention of grower Japanese quails is presented in Table 4.4.

Table 4.1: Proximate and Metabolizable Energy Composition of Sweet Potato

Parameters (%)	Sweet Potato
Dry matter	92.95
Crude protein	5.25
Ash	6.29
Crude fibre	7.29
Ether Extract	5.28
Nitrogen free Extract	76.85
ME (Kcal/ Kg)	3343.83

ME= metabolisable energy . ME (Kcal/Kg) = (35.0 x %CP) + (81.8 x EE) + (35.5 x NFE), Pauzenga, 1985

Table 4.2: Proximate Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal for Grower Japanese Quails (2 – 6 weeks)

	Inclusion levels of Sweet Potato (%)			
Parameters (%)	0	10	20	30
Dry matter	93.50	93.03	93.02	92.70
Crude protein	21.44	22.50	26.38	20.19
Ash	8.74	8.81	6.79	6.81
Crude fibre	6.33	7.39	6.44	6.78
Ether Extract	4.48	4.69	4.66	5.08
Nitrogen free Extract	59.01	56.61	60.39	61.14

[abcd] Means with different superscript on the same row are significantly different ($P < 0.05$) SEM= Standard Error of Means.

Table 4.3: Effect of Diets Containing Varying Levels of Sweet Potato Meal on Growth Performance of Grower Japanese Quails (2 – 6 weeks)

Parameters	Inclusion levels of sweet potato (%)				SEM
	0	10	20	30	
Initial weight (g/b)	32.00	32.00	32.00	32.00	0.00
Final weight (g/b)	141.28^{a}	141.47^{a}	137.60^{b}	134.80^{c}	0.44
WG (g/b)	109.28^{a}	109.47^{a}	105.60^{b}	102.80^{c}	0.44
Total Feed intake (g/b)	128.37^{ab}	130.07^{a}	127.37^{ab}	124.97^{b}	1.17
DFI (g/b/d)	4.59^{ab}	4.65^{a}	4.55^{ab}	4.46^{b}	0.04
FCR	1.18	1.19	1.21	1.22	0.01
AAFL (d)	36.67	37.67	38.67	37.67	0.67
AWFE (g)	8.87	8.44	9.12	8.49	0.34
Cost/kg WG (₦/kg)	31.42^{b}	30.80^{ab}	30.41^{ab}	29.74^{a}	0.22
Cost of feed (₦/kg)	26.63^{d}	25.88^{c}	25.13^{b}	24.38^{a}	0.00
Cost of daily feed intake (₦)	12.21^{c}	12.02^{c}	11.43^{b}	10.88^{a}	3.57

^{abcd} Means with different superscript on the same row are significantly different ($P < 0.05$) SEM: Standard Error of Means. WG: weight gain. DFI: daily feed intake. FCR: feed conversion ratio. AAFL: average age at first lay. AWFE: Average weight of first egg. (g/b): gram/bird. (g/b/d): gram/bird/day

The dry matter digestibility of birds fed 10% sweet potato based diets (95.72) was significantly ($P < 0.05$) better compared to birds fed other diets. Crude protein digestibility of birds fed 10% sweet potato based diets (97.59) was statistically ($P < 0.05$) better compared to birds fed other diets. Crude fibre (CF) digestibility (96.90) was significantly ($P < 0.05$) higher in birds fed 30% sweet potato based diets compared to birds on other diets. Ether extract (EE) digestibility (98.32) was significantly ($P < 0.05$) higher in birds fed 10% sweet potato diets. Bird fed 0% sweet potato (97.28) had significantly ($P < 0.05$) higher ash retention. Nitrogen free extract (NFE) digestibility (94.13 and 94.07) of birds fed 10 and 0% sweet potato were statistically ($P < 0.05$) similar and better.

The effect of diets containing varying levels of sweet potato meal on some biochemical parameters of grower Japanese quails is presented in Table 4.5. Total protein (93.33 and 90.00) was significantly ($P < 0.05$) higher in birds fed 0 and 10% sweet potato meal based diets compared to birds fed other diets. The albumin (39.00), globulin (57.00) and glucose (39.00) concentration of birds fed 10% sweet potato diets were significantly ($P < 0.05$) higher compared to birds fed other dietary treatments.

The result on the effect of diets containing varying levels of sweet potato meal on haematological parameters of grower Japanese quails is presented in Table 4.6. The results showed that there were significant ($P < 0.05$) differences in haemoglobin, white blood cell, lymphocytes, heterophils and red blood cell between dietary treatments. Packed cell volume showed no significant ($P > 0.05$) difference across dietary treatments. Birds on diet 10% sweet potato inclusion showed higher values white blood cells, red blood cells, heterophils and lymphocutes compared to birds on other diet.

Table 4.4: Apparent Digestibility of Nutrients and Ash Retention of Grower Japanese Quails Fed Diets Containing Varying Levels of Sweet Potato Meal (2 – 6weeks)

	Inclusion levels of sweet potato (%)				
Parameters (%)	0	10	20	30	SEM
DM	95.61[b]	95.72[a]	95.46[c]	95.37[c]	0.03
CP	97.26[b]	97.59[a]	97.17[c]	96.89[d]	0.01
CF	96.88[a]	96.80[a]	96.59[b]	96.90[a]	0.03
EE	98.12[b]	98.32[a]	98.02[c]	98.04[c]	0.02
ASH retention	97.28[a]	96.97[ab]	96.26[ab]	96.04[b]	0.27
NFE	94.07[a]	94.13[a]	93.85[b]	93.82[b]	0.04

[abc]= Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means. NFE= nitrogen free extract. CF= Crude fibre. CP= Crude protein. EE= Ether extract. DM= Dry matter

Table 4.5: Effect of Varying Levels of Diets Containing Varying Levels of Sweet Potato Meal on Some Biochemical Parameters of Grower Japanese Quails (2 – 6 weeks)

	Inclusion levels of sweet potato (%)				
Parameters	0	10	20	30	SEM
TP (g/l)	90.67[a]	93.33[a]	83.67[b]	66.00[c]	4.21
Albumin (g/dl)	37.00[ab]	39.00[a]	36.33[abc]	29.00[b]	1.76
Globulin (g/dl)	51.67[ab]	57.00[a]	46.67[ab]	37.00[b]	4.95
Glucose (mg/dl)	37.00[ab]	39.00[a]	34.00[b]	29.00[c]	4.25

[abc] Means with different superscript on the same row are significantly different ($P < 0.05$). SEM: Standard Error of Means. TP: Total protein

Table 4.6: Effect of Diets Containing Varying Levels of Sweet Potato Meal on Haematological Parameters of Grower Japanese Quails (2 – 6 weeks)

	Inclusion levels of sweet potato (%)				
Parameters	0	10	20	30	SEM
PCV (%)	49.67	44.00	44.33	48.67	1.98
Hb (g/dl)	16.53^{a}	16.20^{ab}	14.77^{b}	14.63^{bc}	0.66
WBC $x10^{9}$/l	9.27^{b}	11.70^{a}	9.13^{b}	8.60^{c}	1.30
Heterophils	10.67^{b}	12.33^{a}	10.00^{bc}	8.67^{c}	2.16
Eosinophils	0.00	0.00	0.00	0.00	0.00
Monocytes	0.00	0.00	0.00	0.00	0.00
Lymphocytes	90.00^{a}	91.00^{a}	86.00^{bc}	88.67^{b}	2.41
Basophils	0.00	0.00	0.00	0.00	0.00
RBC $x10^{6}$/l	8.37^{a}	8.43^{a}	7.33^{b}	7.20^{bc}	0.39
Band	0.00^{a}	0.67^{c}	1.33^{a}	0.33^{b}	0.50

[abc] Means with different superscript on the same row are significantly different ($P < 0.05$). SEM: Standard Error of Means. PCV:packed cell volume. Hb: Haemoglobin. WBC: Total white blood cell. RBC: Total red blood cell

The result of the effect of diets containing varying levels sweet potato meal on the carcass characteristics of grower Japanese quails are shown in Table 4.7. The result showed significant ($P < 0.05$) differences in live weight, slaughtered weight and carcass weight across dietary treatments. Birds fed 10% sweet potato diets had the highest live weight (110.5g), carcass weight (101.52g) and slaughter weight (107.90g) compared to birds fed other diets. Birds showed no statistical ($P > 0.05$) difference for dressing percentage, head and organ weights in all dietary treatments.

4.3 Experiment 1b: Effect of Diets Containing Varying Levels of Sweet Potato Meals on Laying Performance and Egg Quality Characteristics of Japanese Quails.

The result of proximate composition of experimental diets is shown in table 4.8. The result of the effect of diets containing varying levels of sweet potato meal on the performance of quail birds during the laying phase is presented in Table 4.9. The result showed significant ($P < 0.05$) differences in all parameters measured except for initial weight which was equal at the beginning of the study. Birds fed diets containing 10% sweet potato meal had the best performance in most parameters compared to birds in other dietary treatments. It was observed that highest final body weight was obtained in birds fed diets containing 0 and 10% sweet potato meal which were similar to those on 20 and 30% sweet potato meal. The change in body weight also followed the same trend with final body weight.

The daily feed intake (25.73g) and total feed intake (2881.58g) were significantly ($P < 0.05$) higher in birds fed diets containing 10% of sweet potato meal. Birds fed diets containing 0 and 10% sweet potato meal had significantly ($P < 0.05$) better feed conversion ratio (4.19 and 4.07) compared to birds fed other dietary treatment.

Table 4.7: Carcass Characteristics of Grower Japanese Quails Fed Diets Containing Varying Levels of Sweet Potato Meal (2 – 6 weeks)

Parameters	Inclusion levels of sweet potato (%)				SEM
	0	10	20	30	
Live weight(g)	108.10^{b}	110.5^{a}	106.00^{c}	103.03^{d}	0.52
Slaughter Weight(g)	105.27^{b}	107.90^{a}	103.00^{c}	100.53^{d}	0.57
Carcass Weight(g)	98.80^{b}	101.52^{a}	96.90^{c}	93.87^{d}	0.71
Dressing percentage (%)	91.40	91.87	91.42	91.11	0.49
Major cuts expressed as percentage of carcass weight (%)					
Head	8.57	8.67	8.37	8.37	0.11
Shank	2.03^{b}	2.14^{a}	2.03^{b}	1.99^{bc}	0.04
Neck	1.71^{bc}	1.83^{a}	1.63^{c}	1.75^{b}	0.41
Wing	5.40^{b}	5.57^{a}	5.23^{c}	5.13^{d}	3.55
Back	23.13^{ab}	23.32^{a}	23.07^{b}	23.07^{b}	0.06
Drum stick	9.43^{b}	9.77^{a}	9.10^{d}	9.27^{c}	0.17
Thigh	10.80^{ab}	11.02^{a}	10.80^{ab}	10.70^{b}	0.01
Breast	17.33^{b}	17.74^{a}	17.71^{a}	17.07^{b}	0.11
Organs expressed as percentage of live weight (%)					
Liver	0.63	0.67	0.60	0.59	0.04
Gizzard	2.53	2.83	2.73	2.67	0.12
Heart	1.29^{ab}	1.32^{a}	1.26^{ab}	1.23^{b}	0.02
Small intestine	9.07^{ab}	9.13^{a}	9.00^{b}	9.00^{b}	0.04

^{abcd}= Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means

Table 4.8: Proximate Composition of Experimental Diets Containing Varying Levels of Sweet Potato Meal for Japanese Quails Hen (7 – 20 weeks)

	Inclusion levels of Sweet Potato (%)			
Parameters	0	10	20	30
Dry matter	88.92	88.60	88.12	88.33
Crude protein	25.19	26.56	24.63	21.63
Ash	8.75	9.83	9.58	11.26
Crude fibre	4.10	4.51	5.22	6.66
Ether Extract	4.87	4.66	4.90	4.86
Nitrogen free Extract	57.09	57.74	54.22	53.81

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Hen day egg production (55.71%) was significantly ($P < 0.05$) higher in birds fed 10% sweet potato based diets compared to birds on other treatments. The peak egg production (82.31% and 83.33%) and age at peak egg production (80.67 days and 81.67 days) reveals that birds on dietary treatments containing 0 and 10% sweet potato meal were significantly ($P < 0.05$) higher compared to birds fed other dietary treatments. Average total number of eggs (62.39), average total weight of eggs (708.13g) and average egg weight (11.35g) were was significantly ($P < 0.05$) higher in birds fed diets containing 10% sweet potato meal compared to birds fed other diets.

The results of the effect of diets containing varying levels of sweet potato meal on external egg quality of Japanese quail birds during the laying phase are presented in Table 4.10. Eggs from birds fed 10% diets containing sweet potato meal was significantly ($P < 0.05$) higher in egg weight (11.35g), egg height (28.97mm), egg diameter (22.70mm) and shell weight (1.03g) compared to eggs from birds fed other dietary treatments.

The results of the effect of diets containing sweet potato meal on the internal egg quality of quail birds during the laying phase are presented in table 4.11. Eggs from birds fed diets containing 10% sweet potato meal had significantly ($P < 0.05$) better albumen height (25.47 mm), yolk height (94.00mm) and yolk weight (3.39g) compared to eggs from birds fed other diets. The albumen width (55.18 and 55.59mm) and albumen weight (2.87 and 2.85g) were significantly ($P < 0.05$) higher in eggs from birds fed diets containing 0 and 10% sweet potato meal compared to egg from birds fed other diets.

Table 4.9: Effect of Diets Containing Varying Levels of Sweet Potato Meal on Performance of Japanese Quail Hens (7 – 20 weeks)

	Inclusion levels of sweet potato (%)				
Parameters	0	10	20	30	SEM
Initial weight (g/b)	137.61	137.54	137.54	137.54	0.36
Final weight (g/b)	146.58^{a}	147.11^{a}	145.88^{ab}	145.70^{ab}	0.62
Change in body weight (%)	8.97^{ab}	9.56^{a}	8.34^{ab}	8.16^{ab}	0.56
Daily feed intake (g/b/d)	23.55^{b}	25.73^{a}	23.89^{b}	23.18^{b}	0.26
Total feed intake (g/b)	2637.72^{b}	2881.58^{a}	2675.44^{b}	2595.61^{b}	26.01
FCR (g egg mass)	4.19^{a}	4.07^{a}	4.45^{ab}	4.35^{a}	0.08
Hen-day egg production (%)	51.19^{b}	55.71^{a}	50.33^{ab}	49.28^{bc}	0.94
Peak egg production (%)	82.31^{a}	83.33^{a}	77.89^{b}	76.87^{b}	0.54
Hen house egg production (%)	51.19^{b}	55.71^{a}	50.33^{ab}	49.28^{bc}	0.94
Age at peak production(days)	80.67^{a}	81.67^{a}	76.33^{b}	75.33^{b}	0.53
Average total number of eggs	57.33^{b}	62.39^{a}	56.37^{b}	55.19^{bc}	0.92
Average total weight of eggs(g)	628.91^{b}	708.13^{a}	600.90^{b}	596.05^{b}	9.50
Average egg weight (g)	10.97^{b}	11.35^{a}	10.66^{c}	10.80^{bc}	0.09
Mortality (%)	0.00	0.00	0.00	0.00	0.00

^{abc}= Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means, (g/b) = gram per bird. (%)= percent. (g)= gram. (g/b/d) = gram per bird per day.

Table 4.10: Effect of Diets Containing Varying Levels of Sweet Potato on External Egg Quality Characteristics of Japanese Quail Hens (7 – 20 weeks)

	Inclusion of sweet potato (%)				
Parameters	0	10	20	30	SEM
Egg Weight(g)	10.97^{b}	11.35^{a}	10.66^{bc}	10.80^{c}	0.09
Egg height(mm)	28.19^{b}	28.97^{a}	28.10^{b}	28.00^{b}	0.17
Egg diameter(mm)	22.15	22.70	21.84	22.27	0.32
Egg shape index	0.79	0.78	0.78	0.79	0.01
Shell Weight(g)	1.09^{a}	1.03^{a}	0.98^{ab}	0.99^{ab}	0.01
Shell thickness(mm)	2.44	2.45	2.47	2.45	0.02
Egg shell percentage (%)	9.08^{ab}	9.04^{ab}	9.16^{a}	9.21^{a}	0.09
Egg shell index	2.90	2.89	2.93	2.94	0.03
Egg specific gravity	1.09	1.08	1.08	1.08	0.00

^{abc}= Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means.

4.4 Proximate Composition of Sweet Potato Peel Meal

The result of proximate composition of sweet potato peel is shown in table 4.12. the result showed DM 92.86%, Crude protein 3.88, Ash 11.38, Crude fibre 7.70, Ether extract 5.10 and Nitrogen free extract of 70.99.

4.5 Experiment 2a: The Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Growth Performance, Digestibility, Haematological Parameters, Carcass Characteristics and Cost Benefit Analysis of Grower Japanese Quails.

The result of proximate composition of experimental diets is shown in table 4.13

The effect of diets containing varying levels of sweet potato peel meal on the growth performance of grower Japanese quails is presented in Table 4.14. The final weight (141.33g) and weight gain (109.33g) was significantly ($P < 0.05$) higher in birds fed 10% sweet potato peel based diets. The feed intake was significantly ($P < 0.05$) higher in birds fed 20% sweet potato based diets (155.62g).

Feed conversion ratio was significantly ($P < 0.05$) better in birds fed 10% sweet potato peel diets. The average age at first egg was significantly ($P < 0.05$) higher in birds fed 10% sweet potato peel diets. The weight of first egg was significantly ($P < 0.05$) higher in birds fed 10% sweet potato peel diets. Feed cost per kg gain (10.50) was significantly ($P < 0.05$) better in birds fed 30% sweet potato peel based diets. The cost of daily feed intake (₦8.82) and cost of total feed intake (₦247.08) were significantly better in birds fed 30% sweet potato peel based diets.

Table 4.11: Effect of Diets Containing Varying Levels of Sweet Potato on Internal Egg Quality Characteristics of Japanese Quail Hens (7 – 20weeks)

	Inclusion levels of sweet potato (%)				
Parameters	0	10	20	30	SEM
Albumen height(mm)	24.17[b]	25.47[a]	23.47[b]	23.17[b]	0.04
Albumen width(mm)	55.18[a]	55.59[a]	45.72[b]	42.32[c]	0.55
Albumen Weight(g)	2.87[a]	2.85[a]	2.84[a]	2.77[b]	0.01
yolk height(mm)	90.10[b]	94.00[a]	87.70[c]	88.03[c]	0.09
Yolk diameter(mm)	20.81	20.91	20.35	20.47	0.20
Yolk weight(g)	3.51[ab]	3.59[a]	3.53[ab]	3.48[b]	0.30
Yolk index	2.31	2.24	2.32	2.34	0.03
Yolk percentage	31.96[ab]	31.64[b]	33.07[a]	32.29[ab]	0.33
Haugh unit	62.20[b]	66.07[bc]	59.84[a]	59.34[ab]	1.11

[abc] Means with different superscript on the same row are significantly different ($P < 0.05$) SEM= Standard Error of Means.

Table 4.12: Proximate and ME Composition of Sweet Potato Peel

Parameters (%)	Sweet potato peel
Dry matter	92.86
Crude protein	3.88
Ash	11.38
Crude fibre	7.70
Ether Extract	5.10
Nitrogen free Extract	70.99
ME (kcal/Kg)	3073.07

ME= metabolisable energy . ME (Kcal/Kg) = (35.0 x %CP) + (81.8 x EE) + (35.5 x NFE) Pauzenga, 1985

Table 4.13: Proximate Composition of Experimental Diets Containing Varying Levels of Sweet Potato Peel Meal for Grower Japanese Quails (2 – 6 weeks)

	Inclusion levels of Sweet Potato Peel (%)			
Parameters (%)	0	10	20	30
Dry matter	93.50	93.07	92.75	93.45
Crude protein	21.44	25.31	23.75	25.19
Ash	8.74	9.24	8.08	9.02
Crude fibre	6.33	6.19	6.08	6.80
Ether Extract	4.48	4.56	4.84	4.75
Nitrogen free Extract	59.01	54.70	57.25	54.25

Table 4.14: Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Growth Performance of Grower Japanese Quails (2 – 6 weeks)

Parameters	Inclusion levels of sweet potato peel (%)				SEM
	0	10	20	30	
Initial weight (g/b)	32.00	32.00	32.00	32.00	0.00
Final weight (g/b)	141.28^{a}	141.33^{a}	132.70^{b}	132.32^{c}	0.11
WG (g/b)	109.28^{a}	109.33^{a}	100.70^{b}	100.32^{c}	0.10
Total Feed intake (g/b)	128.37^{b}	128.33^{b}	155.62^{a}	119.77^{c}	10.30
DFI (g/b/d)	4.59^{b}	4.58^{b}	5.56^{a}	4.28^{c}	0.37
FCR	1.18^{ab}	1.00^{a}	1.55^{c}	1.19^{ab}	0.10
AAFL (d)	36.67^{b}	39.67^{a}	35.50^{c}	39.33^{ab}	0.77
AWFE (g)	8.87^{b}	9.78^{a}	8.49^{bc}	9.72^{a}	0.19
Cost of feed/kg	26.63^{d}	24.64^{c}	22.63^{b}	20.63^{a}	0.00
Cost/kg WG (₦)	31.42^{bc}	12.87^{b}	15.13^{c}	10.50^{a}	2.32

^{abcd} Means with different superscript on the same row are significantly different ($P < 0.05$) SEM: Standard Error of Means. WG: weight gain. DFI: daily feed intake. FCR: feed conversion ratio. AAFL: average age at first lay. AWFE: Average weight of first egg. (g/b): gram/bird. (g/b/d): gram/bird/day.

The effect of diets containing varying levels of sweet potato peel meal on apparent nutrient digestibility and ash retention of grower Japanese quails is presented in Table 4.15. The dry matter digestibility of birds showed no statistical ($P < 0.05$) difference across the dietary treatments. Crude protein digestibility of birds fed 10% sweet potato peels based diets (97.67) was statistically ($P < 0.05$) better. Crude fibre (CF), Ether extract (EE) and Nitrogen free extract digestibility of birds showed no significant ($P > 0.05$) difference across the dietary treatments. Bird fed 20% sweet potato (96.58) had significantly ($P < 0.05$) lower Ash retention.

The effect of diets containing varying levels of sweet potato peel meal on some biochemical parameters of grower Japanese quails is presented in Table 4.16. The total protein (90.67 g/l) was significantly ($P < 0.05$) higher in birds fed 0% sweet potato meal based diets compared to birds fed other treatments. Albumin concentration (39.00 g/dl) of birds fed 0% sweet potato peel diets was statistically ($P < 0.05$) better compared to birds fed other diets. Globulin (56.33 g/dl) and glucose (44.00 mg/dl) concentration of birds fed 10% sweet potato diets were significantly ($P < 0.05$) higher compared to birds fed other dietary treatments.

The result on the effect of diets containing varying levels of sweet potato peel meal on some haematological parameters of grower Japanese quails is presented in Table 4.17. The results showed significant ($P < 0.05$) differences in haemoglobin, white blood cell, lymphocytes, heterophils, and red blood cell across treatments. Pack cell volume (PCV), Haemoglobin, Red blood cells were significantly ($P < 0.05$) higher in birds on diets containing 0% inclusion of sweet potato peel meal compared to birds on other dietary treatments. Birds on diet containing 10% sweet potato meal showed significantly ($P < 0.05$) higher values white blood cells, heterophils and lymphocytes compared to birds on other diets.

Table 4.15: Apparent Digestibility of Nutrients and Ash Retention of Grower Japanese Quails Fed Diets Containing Varying Levels of Sweet Potato Peel Meal (2 – 6 weeks)

	Inclusion levels of sweet potato peel (%)				
Parameters (%)	0	10	20	30	SEM
DM	95.46	95.76	95.35	95.26	0.29
CP	97.17[ab]	97.67[a]	97.31[ab]	97.44[ab]	0.21
CF	96.88	96.39	96.71	96.48	0.28
EE	98.04	98.26	98.02	98.23	0.22
ASH retention	97.28[a]	97.36[a]	96.58[b]	97.26[a]	0.12
NFE	93.85	93.65	93.57	93.06	0.42

[ab] Means with different superscript on the same row are significantly different ($P < 0.05$). SEM: Standard Error of Means. NFE: Nitrogen free extract. CF: Crude fibre. CP: Crude protein. EE: Ether extract. DM: Dry matter.

Table 4.16: Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Some Biochemical Parameters of Grower Japanese Quails (2 – 6 weeks)

	Inclusion Levels of Sweet Potato Peel (%)				
Parameters	0	10	20	30	SEM
TP (g/l)	90.67[a]	90.00[ab]	85.33[b]	72.67[c]	4.47
Albumin (g/dl)	39.00[a]	33.67[b]	32.00[c]	30.67[d]	1.68
Globulin (g/dl)	51.67[c]	56.33[a]	53.33[b]	42.00[d]	5.14
Glucose (mg/dl)	37.00[c]	44.00[a]	31.00[d]	39.00[b]	3.19

[abcd] Means with different superscript on the same row are significantly different ($P < 0.05$). SEM: Standard Error of Means. TP: total protein.

Table 4.17: Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Haematological Parameters of Grower Japanese Quails (2 – 6 weeks)

	Inclusion of sweet potato peel (%)				
Parameters	0	10	20	30	SEM
PCV (%)	49.67^{a}	43.67^{b}	41.67^{c}	36.00^{d}	2.71
Hb (g/dl)	16.53^{a}	14.53^{b}	13.83^{c}	11.97^{d}	0.90
WBC $x10^{9}$/l	9.27^{b}	10.00^{a}	7.40^{c}	6.20^{d}	1.13
Heterophils	10.67^{b}	12.00^{a}	9.00^{c}	8.33^{d}	2.47
Eosinophils	0.00	0.00	0.00	0.00	0.00
Monocytes	0.00^{b}	0.00^{b}	0.00^{b}	1.00^{a}	0.29
Lymphocytes	90.33^{a}	91.67^{a}	88.67^{b}	87.00^{b}	2.66
Basophils	0.00	0.00	0.00	0.00	0.00
RBC $x10^{6}$/l	8.43^{a}	7.40^{b}	6.93^{c}	6.00^{cd}	0.41
Band	0.00^{d}	0.00	0.67^{b}	0.00	0.33

^{abcd} Means with different superscript on the same row are significantly different ($P < 0.05$). SEM: Standard Error of Means. PCV: packed cell volume. Hb: Haemoglobin. WBC: Total white blood cell. RBC: Total red blood cell.

The results of the effect of diets containing varying levels of sweet potato peel meal on the carcass characteristics of grower Japanese quails are shown in Table 4.18. The result showed significant ($P < 0.05$) differences in live weight, slaughtered weight, carcass weight, head, shank and the weight of intestine of birds across the dietary treatments. Results showed that birds on diet containing 0% sweet potato peel meal had the highest live weight; carcass and slaughter weight. Birds showed no significant ($P > 0.05$) difference across all dietary treatments for dressing percentage, neck, thigh, back, drum stick, wing, breast, liver, gizzard and heart. The intestine was significantly ($P < 0.05$) higher in birds on diets containing 0 and 10% sweet potato peel meal compared to birds on other dietary treatments.

4.6 Experiment 2b: Effect of Diets Containing Varying Levels of Sweet Potato Peel Meals on Laying Performance and Egg Quality Characteristics of Japanese Quails.

The result of proximate composition of experimental diets is shown in table 4.19. The result of the effect of diets containing varying levels of sweet potato peel meal on the performance of quail birds during the laying phase is presented in Table 4.20. Birds on diet containing 10% sweet potato peel meal had the best performance in most parameters compared to birds fed other diets. The final weight (147.46g), change in body weight (10.09g), daily feed intake (24.49g), total feed intake (2742.98g), hen day egg production (52.43%) and hen house egg production (52.43%) were significantly ($P < 0.05$) higher in birds fed diets containing 10% sweet potato meal compared to birds fed other diets. The feed conversion ratio (feed/g egg) (4.19 and 4.21), peak egg production (82.31%) and age at peak production (80.67 days) were significantly ($P < 0.05$) higher in birds fed diets containing 0 and 10% sweet potato peel meal compared to birds fed other diets. Average total number of eggs (57.33 and 58.72) and average total egg weight (628.91 and 651.79g) were significantly ($P < 0.05$) higher in birds fed 0 and 10% sweet potato peel diets.

Table 4.18: Carcass Characteristics of Grower Japanese Quails Fed Diets Containing Varying Levels of Sweet Potato Peel Meals (2 – 6 weeks)

Parameters	Inclusion levels of sweet potato peel (%) 0	10	20	30	SEM
Live weight(g)	108.10[a]	100.54[b]	100.34[b]	100.24[b]	0.29
Slaughter Weight(g)	105.27[a]	98.46[b]	98.11[b]	97.67[b]	0.26
Carcass Weight(g)	98.80[a]	91.83[b]	91.62[b]	91.19[b]	0.28
Dressing percentage (%)	91.40	91.34	91.31	90.97	0.23
Major cuts expressed as percentage of carcass weight (%)					
Head	8.57[a]	8.57[a]	8.33[ab]	8.17[b]	0.14
Shank	2.03[b]	2.11[ab]	2.05[b]	1.92[c]	0.04
Neck	1.71	1.76	1.85	1.73	0.05
Thigh	10.80	10.83	10.73	10.77	0.07
Back	23.13	23.27	23.23	23.27	0.09
Drum stick	9.43	9.63	9.63	9.53	0.16
Wing	5.40	5.56	5.43	5.41	0.10
Breast	17.33	17.60	17.49	17.53	0.21
Organs expressed as percentage of live weight (%)					
Liver	0.63	0.65	0.62	0.58	0.02
Gizzard	2.53	2.83	2.77	2.63	0.12
Heart	1.29	1.29	1.24	1.26	0.02
Small intestine	9.07[a]	9.13[a]	9.03[ab]	8.95[b]	0.03

[abc]= Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means.

Table 4.19: Proximate Composition of Diets Containing Varying Levels of Sweet Potato Peel Meal for Japanese Quails Hen (7 – 20 weeks)

	Inclusion levels of Sweet Potato Peel (%)			
Parameters	0	10	20	30
Dry matter	93.36	94.15	93.12	88.92
Crude protein	25.19	25.30	24.88	24.01
Ash	8.44	8.38	8.75	7.66
Crude fibre	4.10	4.16	6.78	7.04
Ether Extract	4.87	4.98	4.77	5.10
Nitrogen free Extract	57.09	57.60	56.03	54.90

[abcd]= Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means.

Table 4.20: Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Performance of Japanese Quail Hens (7 – 20 weeks)

	Inclusion levels of sweet potato peel (%)				
Parameters	0	10	20	30	SEM
Initial weight (g/b)	137.61^{ab}	137.37^{ab}	137.10^{b}	139.39^{a}	0.66
Final weight (g/b)	146.58^{ab}	147.46^{a}	144.04^{b}	145.97^{ab}	0.79
Change in body weight (%)	8.97^{ab}	10.09^{a}	6.93^{b}	8.33^{b}	0.78
Daily feed intake (g/b/d)	23.55^{b}	24.49^{a}	23.28^{b}	23.35^{b}	0.27
Total feed intake (g/b)	2637.72^{b}	2742.98^{a}	2607.89^{b}	2614.91^{b}	26.33
FCR (g egg mass)	4.19^{a}	4.21^{a}	4.24^{a}	4.605.25^{b}	0.10
Hen-day egg production (%)	51.19^{ab}	52.43^{a}	49.61^{b}	46.27^{bc}	1.21
Peak egg production (%)	82.31^{a}	82.31^{a}	77.89^{b}	77.89^{b}	1.02
Hen house egg production (%)	51.19^{ab}	52.43^{a}	49.61^{b}	46.27^{bc}	1.21
Age at peak production (day)	80.67^{a}	80.67^{a}	76.33^{b}	76.33^{b}	0.93
Average total number of eggs	57.33^{a}	58.72^{a}	55.56^{ab}	51.82^{b}	1.18
Average total weight of eggs (g)	628.91^{a}	651.79^{a}	615.61^{a}	568.47^{b}	9.51
Average egg weight (g)	11.97	11.10	11.08	10.97	0.04
Mortality (%)	0.00	0.00	0.00	0.00	0.00

^{abc} Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means, (g/b) = gram per bird. (%)= percent. (g)= gram. (g/b/d) = gram per bird per day.

The results of the effect of diets containing varying levels sweet potato peel meal on external egg quality of Japanese quail birds during the laying phase are presented in Table 4.21. The result showed no significant ($P < 0.05$) difference in all parameters measured. 10% sweet potato peel inclusion was numerically higher in egg weight, egg height, egg diameter, shell thickness and egg specific diameter compared to 0% sweet potato peel inclusion and other dietary treatments.

The results of the effect of diets containing varying levels of sweet potato peel on internal egg quality of quail birds during the laying phase are presented in table 4.22. Egg from birds fed diets containing 0 and 10% sweet potato peel meal had significantly ($P < 0.05$) higher albumen height (24.17 and 24.77 mm) compared to egg of birds fed other diets. The albumen weight (2.92g), yolk height (91.27 mm) and yolk weight (3.57 g) are significantly ($P < 0.05$) higher in egg from birds fed diets containing 10% sweet potato peel meal compared to egg of birds fed other diets. No mortality was recorded throughout the study.

Table 4.21: Effect of Diets Containing Varying Levels Sweet Potato Peel Meal on External Egg Quality Characteristics of Japanese Quail Hens (7 – 20 weeks)

	Inclusion levels of sweet potato peel (%)				
Parameters	0	10	20	30	SEM
Egg Weight (g)	10.97	11.10	11.09	11.08	0.04
Egg height (mm)	28.19	28.64	28.52	28.24	0.24
Egg diameter (mm)	22.15	22.54	22.18	21.32	0.05
Egg shape index	0.79	0.79	0.78	0.75	0.02
Shell Weight (g)	1.09	1.02	0.97	1.03	0.02
Shell thickness (mm)	2.44[b]	2.51[a]	2.51[a]	2.52[a]	0.02
Egg shell percentage (%)	9.08	9.19	8.78	9.28	0.18
Egg shell index	2.90	2.94	2.80	2.97	0.06
Egg specific gravity	1.09	1.08	1.08	1.08	0.00

[ab] Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means.

Table 4.22: Effect of Diets Containing Sweet Potato Peel Meal on Internal Egg Quality Characteristics of Japanese Quail Hens (7 – 20weeks)

	Inclusion sweet potato peel (%)				
Parameters	0	10	20	30	SEM
Albumen height (mm)	24.17[a]	24.77[a]	21.00[c]	22.37[b]	0.77
Albumen width (mm)	55.18[a]	46.35[b]	46.43[b]	45.42[b]	0.33
Albumen Weight (g)	2.87[ab]	2.92[a]	2.85[ab]	2.83[b]	0.03
yolk height (mm)	90.10[b]	91.27[a]	91.23[a]	87.20[c]	0.50
Yolk diameter (mm)	20.81	20.83	20.67	20.33	0.22
Yolk weight (g)	3.51[ab]	3.57[a]	3.51[ab]	3.34[b]	0.04
Yolk index	2.31	2.28	2.27	2.33	0.03
Yolk percentage	31.96[a]	32.17[a]	31.64[a]	30.17[b]	0.40
Haugh unit	62.20[a]	63.89[a]	54.69[b]	57.82[b]	5.10

[abc]= Means with different superscript on the same row are significantly different ($P < 0.05$). SEM= Standard Error of Means.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Proximate Composition of Sweet Potato and Sweet Potato Peel Meals

The proximate composition of sweet potato meal showed a DM of 92.95%, Crude protein 5.25%, ash 6.29%, crude fibre 7.29%, ether extract 5.28% , nitrogen free extract of 76.85% and proximate composition of sweet potato peel showed a DM of 92.86%, crude protein 3.88%, ash 11.38%, crude fibre 7.70%, ether extract 5.10%, nitrogen free extract of 70.99% were higher in DM, Ash, Crude fiber, Ether extract and Nitrogen free extract compared to report of Aduku (1993) that the proximate composition of maize showed DM 86.00%, Crude protein 8.40%, Ash 1.30%, Crude fibre 1.30%, Ether extract 4.50% and Nitrogen free extract of 69.81%.

The proximate composition of sweet potato and sweet potato peel meal showed a DM 92.95% and DM 92.86, crude protein of 5.25 and 3.88, ash of 6.29 and 11.38, crude fibre of 7.29 and 7.70, ether extract of 5.28 and 5.10, nitrogen free extract of 76.85 and 70.99 respectively. The proximate composition of the sweet potato meal was similar to values reported by Afolayan (2010) that sweet potato meal contained 92.76% DM, 5.36%CP and 81.78% NFE. The result was not in support of Khajarem *et al*. (1979) who reported 21% DM, 5.4% CP, 0.9% EE, 3.9% CF, 5.0% Ash and 78% NFE. Several environmental factors such as growing season (Bouwkamp *et al.*1985 and Lin, 1989), rainfall, location (Bradbury *et al.,* 1985) genotype (Purcell *et al*., 1982), nitrogen fertilization (Purcell *et al.,* 1982 and Zhang *et al.*, 1998) as well as cultural management and growth duration have been reported to influence proximate composition of sweet potato (Purcell *et al., 1976).*

5.2 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Growth Performance, Cost Benefit Analysis, Nutrient Digestibility, Haematological Parameters and Carcass Characteristics of Grower Japanese Quails (2 – 6 weeks)

Birds on 10% sweet potato meal performed better on the basis of feed intake, weight gain, feed conversion ratio, dressing percentage and digestibility compared to the control diet and other treatments. This may be due to the increased level of digestibility of the diets. Yoshida and Morimoto (1958) and Ravindran (1995) reported the carbohydrate fraction in sweet potato to be about 90% digestible in grower birds. The result showed significant difference between the weight gained and the level of dietary Sweet potato. The 10% sweet potato diets appeared to be the most efficiently utilized compared to the other diets. The 30% diets were the most poorly utilized. The increase in the inclusion levels of sweet potato resulted in decline in feed intake and growth. This agreed with the report of Maphosa *et al*. (2003) who reported that a significant decline in weight gain was noticed with increase in the inclusion of sweet potato during the starter and finisher phases.

The significantly reduced weights of birds on diets containing 30% sweet potato meal could be as a result of increased fibre in the sweet potato meal which also increase the fibre content and anti nutrients factor (Oladunjoye and Ojebiyi, 2012). Bach, (2001) reported that the main physiochemical characteristics of dietary fibre with nutritional significance was hydration properties, which influence solubility, water holding capacity (WHC), and swelling capacity. Birds on 10% sweet potato inclusion in their diets had better feed conversion ratio compared to those on 0% sweet potato inclusion in their diets. This agreed with the observation of Gerpacio *et al* (1978) who reported that the performance of birds fed diets containing sweet potato especially at the higher levels was less satisfactory compared to corn. The significant difference in feed conversion ratio observed across the dietary treatments is in agreement with the observation of Afolayan *et al.* (2012) who reported that quails fed diets containing 10% to

20% sweet potato meal performed better than those on 30 and 40% inclusion levels. The significant difference among dietary treatments may be as a result of the presence of anti nutritional factors which affected nutrient utilization. Elkin *et al*. (1995) reported that the growth of poultry birds has been known to reduce due to the presence of anti nutritional factors in the diet which reduced the utilization of energy, protein and specific amino acids. No mortality was observed across the treatments. This is in agreement with earlier reports that though sweet potato may contain unidentified growth inhibitors, the level in sweet potato definitely posed no danger of death to birds. Many researchers (Tewe, 1994; Ravindran and Sivakanesan, 1996) have attested to the claim that sweet potato in broiler chickens diets does not result in mortality. Observation by Maphosa *et al* (2003) however differed and the authors attributed the high mortality recorded in their experiment to sweet potato inclusion in the diets. The difference in the present result and that of Maphosa *et al*. (2003) may be due to the difference in the type of sweet potato cultivars used. It was concluded that 10% inclusion of sweet potato meal in the diets of quails at the growth phase is most appropriate for optimum growth performance of grower Japanese quails.

Sweet potato meal had significant effect on the digestibility of dry matter, crude protein, crude fibre, ash, ether extract and nitrogen free extract. The birds on diets containing 10% sweet potato meal had higher digestibility of DM, CP, EE and NFE and this may have resulted in higher final weight, better feed conversion ratio and high average weight of first egg observed in these treatment groups. Mansoub (2010) and Nobakhut (2011) reported that improvement in body weight gain and feed conversion ratio are due to the active materials found in feed and their digestibility, causing greater efficiency in the utilization of the feed and resulting in enhanced growth. There is evidence to suggest that seeds, roots, herbs, spices and various plant extracts have appetite and digestion stimulating factors, in addition to their antimicrobial

activity against bacteria found in the intestine (Mansoub, 2010). The nutrient digestibility coefficients revealed that the inclusion of sweet potato resulted in significantly difference in all nutrient digestibilities by quails. This may possibly be attributed to the level of inclusion of sweet potato meal in the diets of the various treatment groups.

The levels of haematological parameters particularly Hb, PCV of Japanese quails observed in this study were in the normal range reported for Japanese quails by Coenen *et al*. (1994), Ayub *et al*. (2012) Terry and Campbell (1988) Dawn (2010). An increase in PCV value in the birds may probably be due to their higher growth rate, metabolic activities, sex and metabolic hormone production (Puspamitra *et al*., 2014). The PCV value of 36.00 - 49.67% reported in this study is in agreement with the report of Terry and Campbell, (1988); Dawn, (2010) who reported PCV value ranges from 36 – 50 % in quails. Low PCV values are taken to indicate anaemia and fatigue, and higher values to indicate dehydration (Terry and Campbell, 1988; Dawn, 2010). Higher number of circulating lymphocytes beyond normal range might be physiologic, reactive, or proliferative (Jain, 1993). The values of lymphocytes and heterophils obtained from this study is similar to the report of Fouad *et al*. (2008) that greater heterophil; lymphocytes ratio were observed in caged chicken compared to those reared in floor pens. This is a reliable indicator of stress associated with injury, reproductive cycles and seasonal changes in the birds (Moreno *et al*., 2002). The results for PCV, Hb, WBC obtained from this study are similar to that reported by Aina and Ajibade (2014). The significant difference observed in PCV, Heterophil and RBC observed in this study is in concordance with the findings of Osman (2007), Tuleun *et al*. (2011) and Dawn (2010) who reported decrease in Hb to be an indication of reduced concentration of circulating haemoglobin (aneamia).

A high quality carcass is one with large amount of muscle and small amount of bones and fat. Carcass composition is referred to as the proportion of lean meat, bone and fat after dressing. The carcass characteristics of quails fed sweet potato and sweet potato peel meals in this study

revealed some effects that are traceable to the diets. The trends in slaughter and carcass weights are reflections of growth performance. The carcass values reported from this study are not in agreement with the observation of Makinde *et al.* (2013) who reported the mean weights of quail carcasses as percent of live weight to be, 28.87% breast, 8.84% thigh, 23.42% back of quails fed palm kernel meal and brewers dried grain based diets. Tuleun *et al*. (2009) also reported mean weight in quails fed toasted mucuna seeds to have better carcass yield of drumstick of 8.50 %, thigh 15.80 %, breast 38.75 % and wing 9.10 %. The slight variation observed in this study on carcass characteristics and the reports of Tuleun *et al*., (2009) and Makinde *et al.* (2013) could be as a result of environmental differences and error in cutting and weighing the individual parts.

Values recorded for dressing percentage were not significantly different among all dietary treatments for sweet potato. This showed further that inclusion of 10% sweet potato meal in quail diets did not have any negative effect on the dressing percentage compared with the control. Visceral organs expressed as percent live weight were statistically similar with the corresponding visceral organ weights in the control; this is in agreement with the findings of Tuleun *et al*. (2009).

In the current trial, the gizzard weight showed no significant difference among all dietary groups. The liver was found to be not significantly different in all dietary groups which is not in agreement with the observation of Rezaei *et al*. (2014) who reported that feeding high fibre diets increased the relative weight of the small intestine, gizzard, and proventriculus, but the magnitude of the effects differed with the fibre source used.

At the growing phase diets containing 10, 20 and 30% sweet potato meal reduced cost of production by 1.97% (₦ 0.62), 3.2% (₦ 1.01) and 5.35% (₦ 1.68) respectively.

5.3 Effect of Diets Containing Varying Levels of Sweet Potato Meal on Laying Performance and Egg Quality Characteristics of Japanese Quail Hens (7 – 20 weeks)

The observed significant differences in feed intake of laying quails fed the control diets compared to those fed diets containing 10% sweet potato meal is in agreement with the findings of Afolayan *et al*. (2012) who reported that there is likelihood that the sweetness of the potato meals may have played a positive role in the consumption of diets containing Sweet potato meal, considering the fact that the diet without Sweet potato inclusion was the least consumed when compared to 10% inclusions sweet potato meal. Quails on the control diets consumed less feed compared to those on 10% sweet potato meal. This maybe an indication that 10% sweet potato meal inclusion in the diets are more palatable and acceptable to the birds and can be introduced and included in diet of quails. It is evident from the result of the study that 10% sweet potato meal inclusion is very effective in enhancing the nutritive value of diets containing sweet potato meal. Quails fed the control diet had significantly depressed growth rate (evidenced by body weight changes) compared to those fed diets containing 10% sweet potato meal. This observation is similar to the report of Afolayan *et al.* (2012) who reported that feed intakes were statistically similar except for the birds on control diet which consumed significantly less feed compared with birds on the sweet potato meal diets. Significant differences in feed intake may be as a result of breed differences. This is in agreement with Ladokun and Tewe (2003) who reported significant differences in young layers, probably as a result of breed differences and coarseness of the ground sweet potato chips. The rate and efficiency of gains have been reported to be closely related to the nutrient intake and utilization (Fetuga *et al*., 1975). The significantly depressed daily feed intake of quails on the control diets compared to those quails on diets containing 10% sweet potato meal may be responsible for the observed decrease in weight gain of the quails.

The feed conversion ratio in this study was calculated for the layers as the amount of feed taken divided by the weight of eggs produced. The poorer results observed at the higher levels of Sweet potato meal inclusion in the diets could be related to the extra amount of nutrients required to meet up with the body growth, as birds on these diets attained physical maturity later than those on other groups. The feed conversion ratio values in this study were generally good (4.07 – 4.19). This may be because substantial amounts of feeds were diverted to growth purposes in the young layers before attaining physical maturity. In the same manner, depression in feed efficiency was observed by Agwunobi, (1995) when sweet potato peel meals was included beyond 23.1% level or 40% maize substitution in chicken layers diet.

The inclusion of sweet potato meal at different inclusion levels had significant effects on hen-day egg production (HDEP) and hen-house egg production (HHEP). The birds on diets containing 10% Sweet potato meal proved superior to the rest of the dietary treatments in hen-day egg production, thus suggesting that Sweet potato meal should not be included beyond 10% level in young layers' diets. For cumulative egg production, the result showed significant difference across the dietary treatments. This result agreed with that of Sobamiwa (1988), who recorded significant difference in the cumulative egg production when sweet potato was incorporated up to 20% in chicken layers diets. The results obtained from this study showed that quails fed diets containing10% sweet potato meal inclusion supported the production of bigger, heavier egg and good quality characteristics than the other diets in terms of egg weight, diameter, shape index, shell index, shell weight and specific gravity. Lin *et al*. (2004); Bawa *et al*. (2011) and Tuleun *et al*. (2013) reported that egg mass or weight can be used as criterion in assessment of nutritional stress especially if they are obtained from birds of the same age, breed and health status. The egg weight from this study varied from 10.66 – 11.35g. Yamane *et al*. (1979) reported that a good quail egg should weigh about 9.3g or more. The egg weight recorded from this study was higher than those reported by Tuluen *et al*. (2013).

Generally, means for egg shell thickness showed that quails fed diets containing 20% sweet potato meal produced significantly thicker egg shell than those fed other diets. The values obtained for shell, egg weight, shape index, egg shell thickness in this study is in consonance with the reports of Nazligul *et al*. (2001); Orhan *et al*. (2001) and Zita *et al*. (2013) who reported in their findings that there was increase in egg weights and that the age of the quails influenced egg weight.

The result of the internal egg quality showed no significant differences in the Internal egg quality characteristics. The albumen weight, albumin width, yolk height, yolk diameter and yolk weight are higher in eggs from birds fed diets containing10% sweet potato meal.

Eggs from quails on diets containing sweet potato meal at 10% inclusion levels had better performance in most of the internal egg parameters measured. The values observed from this study agreed with the values obtained from the reports of Nazligul *et al*. (2001); Orhan *et al*. (2001) Tuluen *et al*. (2013) and Zita *et al*. (2013). The haugh unit score is the accepted unit for measuring the albumen quality of eggs, of the entire egg quality traits, only the haugh unit score is considered to be the best objective mathematical expression to measure egg quality. The Haugh units across the treatments differ significantly. This is not in agreement with the report given by Williams (1992) that albumen quality is not influenced by nutrition. The values recorded for eggs produced from sweet potato and sweet potato peel meals ranges from 66.07 – 59.34 respectively. These values indicate that all the eggs resulting from sweet peel diets as of high quality.

Monitoring of the quality traits of Japanese quail eggs is important when considering health, feed safety and storage stability. The differences in some egg quality traits of Japanese quails observed in this study from other reports may be due to the age of the birds as it affects eggs, storage length or perhaps even their hatchability like other poultry species. Zita *et al*. (2013) reported that with the increasing age of quails, the biological value and quality of eggs needed

for successful development of the embryo slowly decreases. There was no mortality throughout the period of the experiment and this may be an indication that the health, nutrient requirement and environment were adequately taken care of during the study.

5.4 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Growth Performance, Cost Benefit Analysis, Nutrient Digestibility, Haematological Parameters and Carcass Characteristics of Grower Japanese Quails (2 – 6 weeks)

Birds on 10% sweet potato peel meal performed better on the basis of feed intake, weight gain, feed conversion ratio, dressing percentage and digestibility compared to the control diet and other treatments. This may be due to the increased level of digestibility of the diets. Yoshida and Morimoto (1958) and Ravindran (1995) reported the carbohydrate fraction in sweet potato to be about 90% digestible in grower birds. The result showed significant difference between the weight gained and the level of dietary Sweet potato. The 10% sweet potato peel diets appeared to be the most efficiently utilized compared to the other diets. The 30% diets were the most poorly utilized. The increase in the inclusion levels of sweet potato resulted in decline in feed intake and growth. This agreed with the report of Maphosa *et al*. (2003) who reported that a significant decline in weight gain was noticed with increase in the inclusion of sweet potato during the starter and finisher phases. The significantly reduced weights of birds on diets containing 30% sweet potato meal could be as a result of increased fibre in the sweet potato meal which also increase the fibre content and anti nutrients factor (Oladunjoye and Ojebiyi, 2012). Bach, (2001) reported that the main physiochemical characteristics of dietary fibre with nutritional significance was hydration properties, which influence solubility, water holding capacity (WHC), and swelling capacity. Birds on 10% sweet potato peel inclusion in their diets had better feed conversion ratio compared to those on 0% sweet potato peel inclusion in their diets. This agreed with the observation of Gerpacio *et al* (1978) who reported that the performance of birds fed diets containing sweet potato especially at the higher levels was less satisfactory compared to corn. The significant difference in feed conversion ratio observed

across the dietary treatments is in agreement with the observation of Afolayan *et al.* (2012) who reported that quails fed diets containing 10% to 20% sweet potato meal performed better than those on 30 and 40% inclusion levels. The significant difference among dietary treatments may be as a result of the presence of anti nutritional factors which affected nutrient utilization. Elkin *et al*. (1995) reported that the growth of poultry birds has been known to reduce due to the presence of anti nutritional factors in the diet which reduced the utilization of energy, protein and specific amino acids. No mortality was observed across the treatments. This is in agreement with earlier reports that though sweet potato may contain unidentified growth inhibitors, the level in sweet potato definitely posed no danger of death to birds. Many researchers (Tewe, 1994; Ravindran and Sivakanesan, 1996) have attested to the claim that sweet potato in broiler chickens diets does not result in mortality. Observation by Maphosa *et al* (2003) however differed and the authors attributed the high mortality recorded in their experiment to sweet potato inclusion in the diets. The difference in the present result and that of Maphosa *et al*. (2003) may be due to the difference in the type of sweet potato cultivars used. It was concluded that 10% inclusion of sweet potato and 10% inclusion of sweet potato peel meals in the diets of quails at the growth phase is most appropriate for optimum growth performance of grower Japanese quails.

Sweet potato peel meal had significant effect on the digestibility of dry matter, crude protein, crude fibre, ash, ether extract and nitrogen free extract. The birds on diets containing 10% sweet potato peel meal had higher digestibility of DM, CP, EE and NFE and this may have resulted in higher final weight, better feed conversion ratio and high average weight of first egg observed in these treatment groups. Mansoub (2010) and Nobakhut (2011) reported that improvement in body weight gain and feed conversion ratio are due to the active materials found in feed and their digestibility, causing greater efficiency in the utilization of the feed and

resulting in enhanced growth. There is evidence to suggest that seeds, roots, herbs, spices and various plant extracts have appetite and digestion stimulating factors, in addition to their antimicrobial activity against bacteria found in the intestine (Mansoub, 2010). The nutrient digestibility coefficients revealed that the inclusion of sweet potato resulted in significantly difference in all nutrient digestibilities by quails. This may possibly be attributed to the level of inclusion of sweet potato meal in the diets of the various treatment groups.

The levels of haematological parameters particularly Hb, PCV of Japanese quails observed in this study were in the normal range reported for Japanese quails by Coenen *et al*. (1994), Ayub *et al*. (2012) Terry and Campbell (1988) Dawn (2010). An increase in PCV value in the birds may probably be due to their higher growth rate, metabolic activities, sex and metabolic hormone production (Puspamitra *et al*., 2014). The PCV value of 36.00 - 49.67% reported in this study is in agreement with the report of Terry and Campbell, (1988); Dawn, (2010) who reported PCV value ranges from 36 – 50 % in quails. Low PCV values are taken to indicate anaemia and fatigue, and higher values to indicate dehydration (Terry and Campbell, 1988; Dawn, 2010). Higher number of circulating lymphocytes beyond normal range might be physiologic, reactive, or proliferative (Jain, 1993). The values of lymphocytes and heterophils obtained from this study is similar to the report of Fouad *et al*. (2008) that greater heterophil; lymphocytes ratio were observed in caged chicken compared to those reared in floor pens. This is a reliable indicator of stress associated with injury, reproductive cycles and seasonal changes in the birds (Moreno *et al*., 2002). The results for PCV, Hb, WBC obtained from this study are similar to that reported by Aina and Ajibade (2014). The significant difference observed in PCV, Heterophil and RBC observed in this study is in concordance with the findings of Osman (2007), Tuleun *et al*. (2011) and Dawn (2010) who reported decrease in Hb to be an indication of reduced concentration of circulating haemoglobin (aneamia).

A high quality carcass is one with large amount of muscle and small amount of bones and fat. Carcass composition is referred to as the proportion of lean meat, bone and fat after dressing. The carcass characteristics of quails fed sweet potato and sweet potato peel meals in this study revealed some effects that are traceable to the diets. The trends in slaughter and carcass weights are reflections of growth performance. The carcass values reported from this study are not in agreement with the observation of Makinde *et al.* (2013) who reported the mean weights of quail carcasses as percent of live weight to be, 28.87% breast, 8.84% thigh, 23.42% back of quails fed palm kernel meal and brewers dried grain based diets. Tuleun *et al*. (2009) also reported mean weight in quails fed toasted mucuna seeds to have better carcass yield of drumstick of 8.50 %, thigh 15.80 %, breast 38.75 % and wing 9.10 %. The slight variation observed in this study on carcass characteristics and the reports of Tuleun *et al*., (2009) and Makinde *et al.* (2013) could be as a result of environmental differences and error in cutting and weighing the individual parts.

Values recorded for dressing percentage were not significantly different among all dietary treatments for sweet potato and sweet potato peel. This showed further that inclusion of 10% sweet potato peel meal in quail diets did not have any negative effect on the dressing percentage compared with the control. Visceral organs expressed as percent live weight were statistically similar with the corresponding visceral organ weights in the control; this is in agreement with the findings of Tuleun *et al*. (2009).

In the current trial, the gizzard weight showed no significant difference among all dietary groups. The liver was found to be not significantly different in all dietary groups which is not in agreement with the observation of Rezaei *et al*. (2014) who reported that feeding high fibre diets increased the relative weight of the small intestine, gizzard, and proventriculus, but the magnitude of the effects differed with the fibre source used.

At the growing phase diets containing 10 and 30% sweet potato peel meal reduced cost of production by 59.04% (₦ 18.55) and 20.92% (₦ 66.58%) respectively.

5.5 Effect of Diets Containing Varying Levels of Sweet Potato Peel Meal on Laying Performance and Egg Quality Characteristics of Japanese Quail Hens (7 – 20 weeks)

The observed significant differences in feed intake of laying quails fed the control diets compared to those fed diets containing 10% sweet potato peel meal is in agreement with the findings of Afolayan *et al*. (2012) who reported that there is likelihood that the sweetness of the potato meals may have played a positive role in the consumption of diets containing Sweet potato meal, considering the fact that the diet without Sweet potato inclusion was the least consumed when compared to 10% inclusions sweet potato peel meal. Quails on the control diets consumed less feed compared to those on 10% sweet potato peel meal. This maybe an indication that 10% sweet potato peel meal inclusion in the diets are more palatable and acceptable to the birds and can be introduced and included in diet of quails. It is evident from the result of the study that 10% sweet potato peel meal inclusion is very effective in enhancing the nutritive value of diets containing sweet potato peel meal. Quails fed the control diet had significantly depressed growth rate (evidenced by body weight changes) compared to those fed diets containing 10% sweet potato peel meal. This observation is similar to the report of Afolayan *et al.* (2012) who reported that feed intakes were statistically similar except for the birds on control diet which consumed significantly less feed compared with birds on the sweet potato meal diets. Significant differences in feed intake may be as a result of breed differences. This is in agreement with Ladokun and Tewe (2003) who reported significant differences in young layers, probably as a result of breed differences and coarseness of the ground sweet potato chips. The rate and efficiency of gains have been reported to be closely related to the nutrient intake and utilization (Fetuga *et al*., 1975). The significantly depressed daily feed

intake of quails on the control diets compared to those quails on diets containing 10% sweet potato peel meal may be responsible for the observed decrease in weight gain of the quails.

The feed conversion ratio in this study was calculated for the layers as the amount of feed taken divided by the weight of eggs produced. The poorer results observed at the higher levels of Sweet potato peel meal inclusion in the diets could be related to the extra amount of nutrients required to meet up with the body growth, as birds on these diets attained physical maturity later than those on other groups. The feed conversion ratio values in this study were generally good (4.07 – 4.19). This may be because substantial amounts of feeds were diverted to growth purposes in the young layers before attaining physical maturity. In the same manner, depression in feed efficiency was observed by Agwunobi, (1995) when sweet potato peel meals was included beyond 23.1% level or 40% maize substitution in chicken layers diet.

The inclusion of sweet potato meal at different inclusion levels had significant effects on hen-day egg production (HDEP) and hen-house egg production (HHEP). The birds on diets containing 10% Sweet potato peel meal proved superior to the rest of the dietary treatments in hen-day egg production, thus suggesting that Sweet potato peel meal should not be included beyond 10% level in young layers' diets. The result obtained by Agwunobi (1995) was not different when sweet potato peel meal was fed to layers, as depression in egg production only set in when the inclusion went beyond 23.1% level. For cumulative egg production, the result showed significant difference across the dietary treatments. This result agreed with that of Sobamiwa (1988), who recorded significant difference in the cumulative egg production when sweet potato was incorporated up to 20% in chicken layers diets. Cost per kg weight gain did not follow a particular pattern as sweet potato meal levels in the diets increased.

The results obtained from this study showed that quails fed diets containing10% sweet potato peel meal inclusion supported the production of bigger, heavier egg and good quality characteristics than the other diets in terms of egg weight, diameter, shape index, shell index,

shell weight and specific gravity. Lin *et al*. (2004); Bawa *et al*. (2011) and Tuleun *et al*. (2013) reported that egg mass or weight can be used as criterion in assessment of nutritional stress especially if they are obtained from birds of the same age, breed and health status. The egg weight from this study varied from 10.66 – 11.10g. Yamane *et al*. (1979) reported that a good quail egg should weigh about 9.3g or more. The egg weight recorded from this study was higher than those reported by Tuluen *et al*. (2013).

Generally, means for egg shell thickness showed that quails fed diets containing 20% sweet potato peel meal produced significantly thicker egg shell than those fed other diets. The values obtained for shell, egg weight, shape index, egg shell thickness in this study is in consonance with the reports of Nazligul *et al*. (2001); Orhan *et al*. (2001) and Zita *et al*. (2013) who reported in their findings that there was increase in egg weights and that the age of the quails influenced egg weight.

The result of the internal egg quality showed no significant differences in the Internal egg quality characteristics. The albumen weight, albumin width, yolk height, yolk diameter and yolk weight are higher in eggs from birds fed diets containing10% sweet potato peel meal.

Eggs from quails on diets containing sweet potato peel meal at 10% inclusion levels had better performance in most of the internal egg parameters measured. The values observed from this study agreed with the values obtained from the reports of Nazligul *et al*. (2001); Orhan *et al*. (2001) Tuluen *et al*. (2013) and Zita *et al*. (2013). The haugh unit score is the accepted unit for measuring the albumen quality of eggs, of the entire egg quality traits, only the haugh unit score is considered to be the best objective mathematical expression to measure egg quality. The Haugh units across the treatments differ significantly. This is not in agreement with the report given by Williams (1992) that albumen quality is not influenced by nutrition. The values recorded for eggs produced from sweet potato and sweet potato peel meals ranges from 63.89 – 54.69 respectively. These values indicate that all the eggs resulting from sweet potato diets as

of high quality. Monitoring of the quality traits of Japanese quail eggs is important when considering health, feed safety and storage stability. The differences in some egg quality traits of Japanese quails observed in this study from other reports may be due to the age of the birds as it affects eggs, storage length or perhaps even their hatchability like other poultry species. Zita *et al*. (2013) reported that with the increasing age of quails, the biological value and quality of eggs needed for successful development of the embryo slowly decreases. There was no mortality throughout the period of the experiment and this may be an indication that the health, nutrient requirement and environment were adequately taken care of during the study.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATION

6.1 Summary

Sweet potato meal and sweet potato peel meal could be used to substitute maize in quails diets as energy source. The sweet potato meal contained 92.95% dry matter, 5.25% crude protein, 7.29% crude fibre, 5.28% ether extract, 6.29% ash, 76.85% nitrogen free extract, while the sweet potato peel meal contained 92.86% dry matter, 3.88% crude protein, 7.70% crude fibre, 5.10% ether extract, 11.38% ash, 70.99% nitrogen free extract respectively.

The 10% inclusion of sweet potato meal and 10% inclusion of sweet potato peel meal performed better than other dietary treatments. The increase in the level of inclusion increased the fibre constituents of diet, which affect nutritive value of diet.

The feed conversion ratio of quails in the control diets was similar to those quails in all treatment groups during the grower phase for sweet potato meal but different for sweet potato peel meal.

The inclusion of 10% sweet potato meal and 10% sweet potato peel meal in the diets did not result in any detrimental effect on quail performance. The quails attained an acceptable average weight of 141g at six weeks of age.

Inclusion of 10% sweet potato meal and 10% sweet potato peel meal diets did not show any negative effect on egg quality parameters measured.

Inclusion of 10% Sweet potato meal and 10% sweet potato peel meal diets had no significant effects on haematological and biochemical indices in this study.

Generally, quails on diet containing 10% inclusion of sweet potato peel meal came in lay earlier than those other dietary treatments.

Quails on diets containing 30% sweet potato and 30% sweet potato peel meal generally had the lowest performance in terms of hen-housed egg production, age at peak production, average total number of eggs, average total egg weight.

Cost of feed intake was higher at the control compared to other dietary treatments.

6.2 Conclusion

Sweet potato meal and sweet potato peel meal inclusion at 10% enhanced growth performance of quails up to 6 weeks of age compared to those on the control diets. It also enhanced laying performance at least cost. Twenty percent 20% inclusion resulted in a slight decrease in the growth performance and egg production of the quails.

Inclusion of 10% sweet potato meal and 10% sweet potato peel meal increased the apparent digestibility and utilization of nutrients to bring about the significant improvement in laying quails. From the study 10% inclusion of sweet potato and 10% inclusion of sweet potato peel dietary treatments are most appropriate for optimum growth and laying performance.

6.3 Recommendations

Sweet potato meal and sweet potato peel meal should be incorporated into quail diets not beyond 10% maize substitution. More interest should be placed on sweet potato meal and sweet potato peel meal as a dietary feed material which can serve as energy source in quail diets without severely affecting the performance of birds in areas where it is readily available.

Further studies into the utilization of sweet potato meal and sweet potato peel meal at different inclusion levels, different processing methods and enzyme supplementation should be conducted.

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