GROWTH AND LAYING PERFORMANCE OF JAPANESE QUAILS FED ROSELLE (*Hibiscus sabdariffa* L) SEED CAKE BASED DIETS WITH OR WITHOUT ALLZYME SSF® SUPPLEMENTATION

BY

Olusiji Philip, SANNI

DEPARTMENT OF ANIMAL SCIENCE
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA
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BY

Olusiji Philip, SANNI
B.Agric ABU, (2008)
M.Sc/Agric/0817/2009-2010

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

DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA.

APRIL, 2016.

DECLARATION

I declare that the work in this dissertation entitled **"Growth and Laying Performance of Japanese Quails Fed Roselle (*Hibiscus sabdariffa* L) Seed Cake Based Diets With or Without Allzyme SSF® Supplementation"** was carried out by me in the Department of Animal Science under the supervision of Professor G.S. Bawa and Professor T.S.B. Tegbe. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this dissertation was previously presented for another degree or diploma at any university.

Olusiji Philip, SANNI	**……………………..**	**…………………….**
Name of student	Signature	Date

CERTIFICATION

This dissertation titled **"Growth and Laying Performance of Japanese Quails Fed Roselle (*Hibiscus sabdariffa* L) Seed Cake Based Diets With or Without Allzyme SSF® Supplementation"** by Olusiji Philip, SANNI meets the regulations governing the award of the degree of Master of Science (Animal Science) in Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

………………………………. ……………………………..
Prof. G. S. Bawa Date
Chairman, Supervisory Committee

……………………………….. ……………………………...
Prof. T.S.B. Tegbe Date
Member, Supervisory Committee

……………………………… ……………………………...
Prof. S. Duru Date
Head, Department of Animal Science
Ahmadu Bello University, Zaria.

…………………………… ……………………………
Prof. Kabir Bala Date
Dean, Post-Graduate School,
Ahmadu Bello University, Zaria.

DEDICATION

This dissertation titled **"Growth and Laying Performance of Japanese Quails Fed Roselle (*Hibiscus sabdariffa* L) Seed Cake Based Diets With or Without Allzyme SSF® Supplementation"** is dedicated to all those who believe in the potentials of the micro livestock to alleviate poverty and malnutrition around the world.

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ABSTRACT

A study was designed to evaluate the growth and laying performance of Japanese quails fed roselle (*Hibiscus sabdariffa* L) seed cake based diets with or without Allzyme SSF® supplementation. In experiment 1, five hundred and forty two-weeks old quails were used in a completely randomized design (CRD) using a 5 X 2 factorial arrangement with 3 replicates per treatment. Birds were fed control diets from day old for two weeks adjustment period prior to data collection. Growth performance, digestibility trial and carcass characteristic indicators were measured during the growth phase (2 to 6 weeks) while reproductive; egg production and economics of production as well as egg quality measures were monitored at the laying phase. Data obtained from the study were subjected to Analysis of Variance and significant differences among treatment means were compared using the Duncan Multiple Range Test. Proximate analysis of Roselle Seed Cake showed (RSC) with Dry matter (%) of 93.68; crude protein (%) was 25.38, Ether extract (%) 5.78, Crude fibre (%) 10.20, Ash (%) 8.03 and Nitrogen free extract (%) 50.61. Metabolizable Energy (ME) was determined as 2885.00Kcal/Kg. Higher final weight and weight gain were associated with diets 9 and 10 (22.50% RSC+0.01% Enzyme and 30.00% RSC+0.01% Enzyme) for growth characteristics. Mortality ratio during the first four weeks did not follow a particular trend though it showed significant differences. However, these differences could not be attributed to the dietary treatments when they were compared without interaction effects. Interaction effects showed reduction in mortality rate by enzyme supplementation with increasing RSC levels up to 22.5% and the average mortality at 30% RSC with enzyme supplementation was lower than that of 22.5% RSC without enzyme supplementation. Nutrient retention was observed to be better in diets with RSC but no enzyme compared to RSC with enzyme while carcass characteristics studies indicated higher carcass proportion due to interaction between Allzyme® and RSC compared to the absence of enzyme in the diets. Longer intestines were observed in RSC based diets compared to the control. In experiment 2, 270 quail hens at 6 weeks of age were used in a completely randomized design (CRD) using a 5 X 2 factorial with 3 replicates arrangement to determine laying performance. Egg laying phase revealed that in Feed cost/dozen egg (₦), all RSC based diets in this study compared favorably with the control diet; early age at sexual maturity was favoured by RSC based diets, average egg weight, egg number and egg mass, HDP and HHP and mortality ratio showed better performance with diets containing RSC compared to the control group. Egg quality characteristics showed superior performance of RSC containing diets to the control diets, no definite impact of the presence or absence of supplemented enzyme could be established in the study though interaction effects were established. It was concluded that RSC showed positive merits in replacing groundnut cake at 30% RSC with or without enzyme supplementation at all phases of production, not only in better performances but also in the absence of any deleterious effect on health of the birds with better synergistic effect when enzyme is supplemented.

CHAPTER ONE

1.0 INTRODUCTION

Inadequate feed supply has remained a major constraint to the expansion and sustainability of the livestock subsector of Agriculture in Nigeria. The Consequence of this is the low daily animal protein consumption in the developing nations of the world including Nigeria where animal protein intake is less than 10g compared to the FAO recommended 20g of animal protein per person per day (FAO, 2008). Conventional protein feedstuffs for poultry such as soybean cake, groundnut cake and fish meal are scarce and expensive because they are competed for by humans as food and other industrial uses. This explains why feed accounts for about 70% of the cost incurred in producing poultry. Hence, it becomes imperative to find cheap alternative protein feedstuffs of plant origin that can be fed to livestock without compromising their performance. This has also encouraged greater interest in the production of fast growing micro-livestock with poultry production seen as a major strategy of bridging the animal protein gap to the teeming populace within short-run considerations (Dafwang, 1990). Therefore, the Japanese quail as an important animal protein source has caught the attention of scientists and researchers in recent times (Edache *et al*., 2005).

Japanese quail (*Cortunix cortunix japonica*) was introduced to Nigeria in 1992 to expand the poultry sub-sector and help supplement the domestic chicken production through meat and eggs (Ani *et al.,* 2009). They are highly prolific and hardy (Anon, 1991) which make them adaptable to the tropical environment. They come to sexual maturity between 35-40 days of age and are usually reach peak egg production by 50 days of age, with hens laying an average of 250 eggs under favourable conditions in their first year of lay. The meat is lean and the egg is low in cholesterol (Okon *et al*., 2007) indicating its significance in public health in terms of managing diseases such as atherosclerosis. They are very economical to maintain as experimental birds or as commercial birds because they are fast growing poultry specie. Their small body size (150g at maturity) permits the housing of a large number of birds in a relatively small space. For instance, 8 to10 Japanese quails can occupy the same space as one chicken.

Research into the use of cheaper industrial by-products and wastes at various levels of dietary supplementation for poultry has been intensified in recent times to determine their efficiency of utilization in terms of growth and production (Adeniji and Balogun, 2002). The use of unconventional feedstuff such as Roselle Seed Cake (RSC) will therefore keep the cost of producing quails at the barest minimum without compromising their performance if well managed.

Roselle (*Hibiscus sabdariffa* Linn) belongs to the malvaceae family and is a popular vegetable in Indonesia, India and many tropical regions (Tindal, 1986). It is now widely grown in the North, Eastern and middle belt regions of Nigeria (Akanya *et al*.,1997) mainly for its calyxes used for the preparation of a local drink but the leaves are also used for soup and as a pot herb (Adigun, 2003). It is a crop well adapted to the semi-arid environment and it is mostly grown as a border crop. Roselle has two main varieties, of which the more important economically is kenaf, *H. sabdariffa* var. *altissima* Wester, and the other is roselle, *H. sabdariffa* var. *sabdariffa* Linnaeus. Both varieties are annual herbs extensively cultivated in tropical Africa, Asia, Central America and the Caribbean for the jute-like fibre or the red calyces surrounding the fruit; the basis of a popular red non-alcoholic drink, jams, jelly and colouring material for foods and beverages.

The seeds of both varieties are sources of protein and lipid (Kalyane, 1986; El-Adawy and Khalil, 1994; Rao, 1996) and are used for small-scale edible oil production. Dashak and Nwonegbo (2002) reported that roselle seeds contain 35.91% crude protein, 7.12% crude fibre, 10.14% ether extract and 10.09% ash. Studies showed that the seeds can be used as a potential source of protein (El-Adawy and Khalil, 1994; Al-Wandawi *et al.*, 1984). Mohammed *et al.,* (1994) studied the effects of feeding mechanically extracted roselle seed meal (RSM) to laying hens at dietary levels up to 200 g kg^{-1} over a 14-week period. They reported that RSM contains 491.1 g crude protein, 59 g ether extract, 169.6 g crude fibre, 113.5 g ash, 6.8 g calcium, 6.6 g total phosphorus and 0.6 g magnesium kg^{-1}. From chemical analysis, the metabolisable energy content of RSM would be expected to be 10.07 MJ kg^{-1} but a high value (11.63 MJ kg^{-1}) was obtained for true metabolisable energy using chick growth assay. As the supplementation rate of RSM increased in their experimental diets, rate of lay, feed intake and egg weight were increased. The dietary treatments had no significant effects on feed conversion ratio, mortality, shell thickness, albumen height, and yolk colour.

The resulting meals from this process however, contain low levels of anti-nutrients particularly tannin, F-amylase inhibitors, protease (chymotrypsin, trypsin) inhibitors, phytic acid, gossypol, (Liener, 1975; Abu-Tarboush and Ahmed, 1996; Abu-Tarboush *et al*., 1997, Hansawadi and Kawabata, 2000).

Exogenous enzyme supplements are now widely used in poultry diets in an attempt to improve the nutrient utilization, health and welfare of birds, product quality and to reduce pollution as well as increase the choice and content of ingredients which are acceptable for supplementation in diets (Acamovic, 2001). Jovanović *et al*. (2000) stated that all enzymes do not have a consistent efficiency, and that enzymes of the digestive tract increase their catalytic ability with the addition of synthetic enzymes. Allzyme SSF® is a natural complex that improves profitability by maximizing nutrient release. Through an ancient process called solid-state fermentation (SSF), a selected strain of non-Genetically Modified Organism (non-GMO) *Aspergillus niger* is used to work in synergy with the animal's digestive system in breaking down layers of the feed that were previously inaccessible through digestion. This exposes more nutrient rich layers for the animal to digest: such as amino acids, energy, calcium and phosphorus. Allzyme SSF® allows for flexibility in feed formulation through the inclusion of by-products aand alternative raw materials, or by reducing the nutrient density in the diet. Allzyme SSF® is prepared by the company "Alltech" based in Kentucky, USA. It was created in 1991, as a research of nutrition of non-ruminants food of vegetable origin was used. It is an enzyme complex that has amylase, cellulase, phytase, B-glucanase, pectinase and protease.

1.1 Justification

Improved nutrition in livestock production began by adding various additives, especially synthetic enzymes. By better utilization of food, better results were achieved. Therefore utilization of additives raised production to modern levels, while reducing the bulk consumption of feed. Protein isolates or concentrates from Roselle seeds might be useful as low cost source of protein substitute in dietary supplement in the poultry industry, thus alleviating the problem of protein scarcity. Therefore the use of cheap non-conventional feedstuff such as mechanically extracted Roselle Seed Cake (RSC) will maximize its potential as a feedstuff and further reduce the cost of producing the Japanese quail while ensuring a continual development of this poultry specie, perhaps without limit and without compromising their nutritional requirements.

Roselle Seed Cake is presently cheaper than soybean meal and groundnut cake, the major protein sources thus justifying the need to investigate its use in feeding quails. From the standpoint of economics, availability and nutritional value, Roselle Seed Cake represents an attractive alternative to the use of conventional protein feedstuff of plant origin (soybean meal and groundnut cake) in quail diets. This study will evaluate the nutritive value of roselle seed cake as an alternative to the use of conventional protein feedstuff of plant origin in quail diets.

1.2 Objectives

The broad objective of this study was to determine the effect of roselle seed (*Hibiscus sabdariffa* L) cake and Allzyme SSF® supplementation on the growth and laying performance of Japanese quails (*Cortunix cortunix japonica*).

The specific objectives were:

i. To determine the nutritional composition of mechanically extracted RSC.
ii. To evaluate the effect of mechanically extracted RSC based diets supplemented with or without Allzyme SSF® on growth and carcass characteristics of Japanese quails.
iii. To determine the effect of mechanically extracted RSC based diets supplemented with or without Allzyme SSF® on the digestive performance of Japanese quails.

iv. To evaluate the effect of mechanically extracted RSC based diets supplemented with or without Allzyme SSF® on the feeding economies, egg quality and egg laying performance of Japanese quails.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Use of Unconventional Sources of Protein in Poultry Nutrition

One of the goals of nutrition for both developing and industrialized societies is to provide the population with adequate amounts of food proteins to meet the physiological and or nutritional requirements of the population (Volgarev and Waggle, 1992). The same workers classified protein sources into three groups, in the first group; they named conventional protein sources which include products from plant growing, animal husbandry, poultry farming, fishing and fish breeding and natural flora and fauna. Non-conventional protein sources, the second group, includes extracted isolates from seeds of different plants, waste from milling plants and hulling mills, biomass from leaf mass protein and non-fat milk and whey, blood and several tissues and organs of animals; non-commercial fish and sea products not used in food. The third group, new protein sources, examples of which are single and multi-celled alga, mycelium of higher and lower fungi, yeasts, non-pathogenic bacteria and protein from chemical synthesis (Volgarev and Waggle, 1992).

Plant proteins, are generally deficient in one or more amino acids; cereals in lysine, legumes and leaf proteins in methionine which are further compounded by deficiency in secondary amino acids such as threonine and or tryptophan. Also they possess plant secondary metabolites which exert deleterious effect upon ingestion. In search for sustainable alternatives for fish meal and overseas vegetable protein sources some selected protein sources are being evaluated. These include oil seed by-products, grain legumes and their concentrates, insects, leaf and aquatic proteins, etc. These sources differ substantially in terms of protein yield, environmental sustainability, nutritional value and availability. Products with a low dry matter content, i.e. lucerne, leaves, aquatic proteins are considered to be less sustainable due to the high energy costs for drying. Alternative plant protein sources and their nutritional potentials in the diets of monogastrics and human in developing countries like Nigeria have been highlighted (Kwari *et al*., 2011; Ari and Ayanwale, 2012; Ari *et al*., 2012a and Musa-Azara *et al*. 2013).

2.2 Roselle Seed Cake

Hibiscus sabdariffa L. also known as Roselle belongs to the family of Malvaceae which includes crops such as okro and jute. The plant is widely distributed in the tropical regions, especially in the Middle Eastern countries (Abu-Tarboush *et al*., 1997); Roselle is believed to have originated from tropical Africa (Mc Clean, 1973). In Nigeria, Roselle is grown as a border crop with the calyces used for the production of a popular non alcoholic beverage ("Zobo") as well as sauce, jams, jelly and colouring materials for food, wines and drugs (Kalyane, 1986; Rao, 1996; AbuTarboush *et al*., 1997; Tsai *et al*., 2002). The leaves form a popular vegetable in most regions of the world (Ojokoh, 2006). In recent years, because of the increased demand for the calyx in Nigeria for the commercial production of "Zobo" (local beverage), the cultivation practice of Roselle is gradually changing from the traditional border crop to a more integrated type with other crops. However, despite this increase in production, Roselle seeds have little food or industrial uses in Nigeria at the moment (Aruna *et al*., 2007; Kwari *et al*., 2011). Rosselle seeds are reported to be good sources of protein (Rao, 1996; Tomas-Jinez *et al*., 1998; AFRIS, 2004; Kwari *et al*., 2011) but contain several toxic factors (Morton, 1987; Aletor, 1993; Ojokoh *et al*., 2002; Mukhtar, 2007; Kwari *et al*., 2011) which are usually absorbed intact by monogastric animals causing various harmful effects. It is therefore a challenge to the poultry nutritionist to devise means of reducing these factors in sorrel seed with the view to maximizing its utilization. *Hibiscus Sabdariffa* is fast gaining prominence as one of the replacement of rich plant proteins in human, livestock and fisheries nutrition on account of cost and nutritional composition (Tounkara *et al*., 2011). Based on the colour of the calyx there are three (3) commonly grown cultivars of *Hibiscus sabdariffa.* These are the dark red, light red and white calyx bearing cultivars. Although, the colour has been reported to affect the chemical composition of the calyx (Kwari *et al*., 2011), chemical analyses of the seed have rarely differed between these cultivars.

2.2.1 Nutrient Composition of Roselle Seed Cake

Roselle seed is a moderate to excellent source of protein with the crude protein ranging from 21-39%. The fat (6-19%) and crude fibre (12-22%). An exceptional quality of Roselle seed is the amino acid profile of its protein. Literature shows that Roselle seed is comparable to soybeans with regards to the essential amino acid profile. The fat of the seed is a good source of essential fatty acids (arachidonic, linoleic and linolenic acids) which are required to prevent fatty acid deficiency diseases such as skin lesions and low growth rate (Kinsella, 1987). The protein, fat and crude fibre contents and the essential amino acid composition of Roselle seed as reported by different authors are shown in Table 2.1.

Table 2.1: Chemical and Essential Amino Acid Composition of Rosselle and Soybean

Constituents (%)	Rosselle							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**[8]Soybean**
Crude protein	24.00	26.48	39.40	21.35	22.20	32.28	38.57	40.00
Ether extract	22.30	20.13	6.10	17.43	6.00	19.90	13.50	19.00
Crude fibre	15.30		17.70	11.98	15.00	22.30	16.50	7.50
Arginine	3.60	10.65	9.60			11.69	5.18	3.69
Histidine	1.50	1.91	2.70			2.22	1.99	1.80
Isoleucine	3.00	2.96	4.70			4.24	3.30	2.20
Leucine	5.00	5.58	8.00			7.99	4.99	3.93
Lysine	3.90	5.12	5.90			4.84	2.58	3.54
Methionine	1.00	1.44	1.60			1.11	1.33	0.00
Phenylalanine	3.20	5.96	5.10			5.35	4.17	2.60
Threonine	3.00	2.67	3.40			3.34	2.83	1.93
Tryptophan		0.76	1.30				0.73	0.67
Valine	3.80	4.57	5.40			5.83	3.19	2.30

1: Morton (1987) 2: Abu-Tarboush et al.(1997) 3: Fagbenro et al.(2004) 4: Mukhtar (2007) 5: Aruna et al. (2007) 6: Abu El Gasim et al.(2008) 7: Kwari et al.(2011). 8: Olomu (1995)

As cited in Diarra et al. (2011)

Ari *et al*. (2013) stated that dry matter (DM) values ranged from 90.40 to 91.39% respectively for hydrothermal and crushed seeds while crude protein (CP) ranged from 19.54% to 23.43% for crushed and fermented seeds respectively. Crude fibre (CF) on the other hand had values ranging from 3.30% to 4.52% for fermented and crushed seeds respectively. The highest value of ether extract (EE) was obtained in fermented roselle (6.58%) while the least (5.70%) was obtained in crushed seeds. Total ash ranged from 5.39% to 6.94% while total carbohydrates expressed as nitrogen free extract (NFE) ranged from 50.43 to 55.36%.

The highest calcium (Ca) and phosphorous (P) values were 1.12 and 0.56% in hydrothermal and fermented Roselle seeds respectively. Roselle seeds (Karkade, local name of Roselle seeds) has also been reported to contain 21.35% protein, 15.4% ether extract, 21.04 MJ/kg metabolizable energy, 11.98% crude fiber and it is a good source of calcium and phosphorus (Mukhtar, 2007; Aruna *et al*., 2007 and Abu Elgasim *et al*., (2008). Kwari *et al*., (2011) found that Roselle seeds contain 38.57% CP, 13.5% EE, 16.5% CF, 5.18% argnine, 2.58% lysine and 1.33% Methionine. The seed oils were also reported to contain unusual fatty acids, namely epoxy oleic and cytopropenoid (Bakheit *et al*., 1993). Ojokoh *et al*. (2002) and Mukhtar, (2007) have reported that Rosselle seeds contains 11.98% insoluble fiber (arabino- xylanase) which decreases feed consumption, growth rate and feed utilization. These adverse effects could possibly be ameliorated by supplementation of dietary enzymes. Despite the rich nutritional composition of Roselle seed, there are reports of the presence of a number of antinutritional (toxic) factors. However, there has been conflicting results as per the presence/concentration of these factors probably due to varietal differences. The most commonly reported toxic factors in Rosselle seed are total phenols and tannins (Abu El Gasim *et al*., 2008; Kwari *et al*., 2011) and phytic acid (Kwari *et al*., 2011). Glucosides such as delphinidin-3-monoglucosides and delphinidin (Ojokoh *et al*., 2002) and cyanogenic glucosides (Aletor, 1993) have also been reported in Rosselle seed. Recently, Mukhtar (2007) reported that Rosselle seed contains traces of gossypol, a phenolic compound which causes undesirable physiological effects in poultry. Abu-Tarboush *et al*. (1997) and Hansawasdi and Kawabata (2000) reported low levels of tannin, amylase inhibitors, protease inhibitors, phytic acid and gossypol in sorrel seed. Gobley (1956) reported a high acid taste and sickly odour of Rosselle seed.

2.2.2 Effects of Roselle Seed Cake on the Performance of Chickens

Ari *et al.* (2013) reported insignificant differences in initial weight, weight gain, Feed Conversion Ratio and survival percentage for broilers fed differently processed roselle seeds at the starter phase, while differences were observed for performance indices at the finisher phase. The best values for body weight gain were broilers fed boiled (hydrothermal treated) and fermented (536.36g and 990.38g) at the starter and finisher phase respectively. The fermented presented higher feed intake values of 624.39g and 1272.67g in both the starter and finisher phase of the feeding trials. However, the best values recorded for (1.18 and 1.41) in the starter and finisher phases were for hydrothermal group.

The survival percentage and performance index values were better with fermented group (94.67% and 4536.36) respectively in the starter phase while in the finisher phase hydrothermal group presented better values of 96.5% and 85.75% respectively for survival percentage and performance index.

Mukhtar and Bakheit (2012) reported that the addition of Xylam enzyme to 15% Roselle seed based diet improved feed intake compared to broiler chicks fed the seed without enzyme supplementation. An important role on feeding of sorrel seed to poultry were cited in different studies. Mukhtar (2007) fed graded levels (0.0, 7.5, 15.0, and 22.5%) of raw Roselle seed meal and observed decreased feed intake, weight gain and feed conversion ratio in broiler chickens when the level of supplementation increased above 7.5%.

In another experiment, Kwari *et al*. (2011) replaced the soybean meal with raw Roselle seed meal at 0.0, 25.0, 50.0, 75.0, and 100.0% in broiler diets and reported a decreased performance (feed intake, weight gain, and feed conversion ratio) only above 50.0% replacement (12.0% of dietary Roselle seed). Similarly, feeding this level of Roselle seed (raw or processed) had no significant effects on feed intake, feed conversion ratio, egg production, and egg quality of laying hens (Kwari *et al*., 2011). Kwari *et al*. (2010) also reported no adverse effects of feeding raw Roselle seed on feed intake, growth, feed conversion and carcass yields of cockerels. The taste/odour rather than toxicity may be the reason for the poor performance as the weight of organs such as the liver, heart (Mukhtar, 2007; Kwari *et al*., 2011) and pancreas (Mukhtar, 2007) were not affected by the level of supplementation of the test material in both egg and meat type chickens. Damang and Guluwa (2009) included up to 30% raw Roselle seed meal in the diet of broiler chickens and reported no adverse effects on the performance of the birds at the starter or finisher phase. Kwari *et al*. (2011) however, reported improvements in the growth performance of broiler chickens when Roselle seed was processed by soaking, cooking, sprouting or fermentation. These processes might have brought about an improvement in the taste of the seed probably through leaching in processing water and enzyme activity during sprouting and fermentation as earlier observed by Yagoub and Abdalla (2007).

2.3 Enzyme Supplementation of Poultry Diets

Animal rearing practices depends on the application of feeds that are uniform in quality and have high nutritive value. The complex plant materials that are commonly used as feed ingredients, such as coarsely processed grains and high-fiber feedstuffs (e.g., cereal grains, forages and crop residues) have nutritive components that are resistant to endogenously-produced digestive enzymes. Some feed components also have antinutritive effects, for example phytate, which reduces the bioavailability of certain minerals and oligosaccharides and other soluble carbohydrates that increase viscosity and reduce nutrient absorption. Hence, obtaining the maximal nutritive value from such complex feedstuffs typically requires supplementation of autoenzymatic activity with alloenzymatic activity (i.e., exogenously produced digestive enzymes from non-host sources) (Klasing, 1998).

The application of feed enzymes to poultry diets for the enhancement of nutrient availability had been reported since 1926 (Munir and Maqsood, 2013). Previously, the research conducted on feed enzymes in poultry nutrition focused on non-starch polysaccharide (NSP) degrading enzymes, especially xylanase and β-glucanase, in diets containing wheat, rye and barley (Choct, 2006). The use of unconventional feedstuff for poultry production is however limited due to their fibrousity and inability of birds to produce the cellulase enzyme that can digest the fibre (Adebiyi *et al*., 2010).

The use of enzymes in animal feeds is becoming increasingly common. Reasons for this include; lower costs of commercial enzyme preparations, improved enzymes for animal feeds, and a better understanding of the composition of the anti-nutritive compounds. In order to obtain maximal benefits from enzyme supplementation in animal feeds, it is necessary to ensure that the enzymes are chosen on the basis of the feed composition. Simply put; the enzyme must be matched to the substrate. Enzyme cocktails containing more than one enzyme will often improve the response compared to pure, single enzymes, assuming that cost considerations are not ignored. This is due to the fact that feedstuffs are complex compounds containing protein, fat, fiber and other complex carbohydrates. Merely targeting a specific substrate such as Beta glucan may not provide maximal benefits since layers of other substrates may inherently protect some of the Beta glucan. For example, Beta glucans and arabinoxylans may be bound to peptide or protein moieties in the cell wall of the feedstuff. Therefore, enzymes capable of hydrolyzing protein may enhance the activity of pentosanases and beta glucanases.

Methods commonly used to determine the effects of enzymes on feedstuffs include determination of the non-starch polysaccharides (NSP) content of the ingredients or by measuring changes in the viscosity of the feed with enzyme supplementation Newman (2013). Feed enzymes are typically added to animal feed to increase the availability of nutrient by acting on feed components prior to or after consumption, i.e., within the gastrointestinal tract (Pariza and Cook, 2010). However, the influence of exogenous enzymes on the animal is modulated by several factors such as the type and concentration of the undesirable carbohydrate present in the feedstuff and the class and age of the livestock and poultry that consume it. Young chicks are affected to a greater degree by anti-nutritional compounds than older birds (Marquardt *et al*., 1996).

Most commercial enzymes contain a spectrum of different enzymes including xylanases and β-glucanases and therefore can be used effectively on a wide range of fibrous materials. It is, nevertheless, essential to ensure that the enzyme preparation has the appropriate activities of the specific enzymes that are required. Phytase, in addition to the above mentioned enzymes, is an enzyme, which increases the availability of phosphorus from phytate, a bound form of phosphate found in cereals and other plant material (Marquardt *et al*., 1996). It has become available for use in the feed industry and may assist in reducing phosphorus requirements in non-ruminant animals and therefore it can solve problems associated with environmental pollution. During the past decade, the supplementation of microbial phytase in poultry diets has increased drastically with proven success, mainly in response to heightened concerns over phosphorus pollution of the environment.

Slominski *et al.,* (2006) stated that an increase in the productive value with enzyme supplementation can be achieved by:

i. Release of available phosphorus from phytate hydrolysis,

ii. Elimination of the nutrient encapsulating effect of the cell walls and therefore improved energy and amino acid availability,

iii. Solubilization of cell wall, non-starch polysaccharides (NSP) for more effective hindgut fermentation and improved overall energy utilization,

iv. Hydrolysis of certain types of carbohydrate-protein linkages and therefore improved availability of amino acids, and

v. Elimination of the anti-nutritive properties of certain dietary components, including NSP, by their enzymatic hydrolysis to the probiotic type components which, in turn, may facilitate gut development and health in young chickens.

2.4 Response of Birds to Enzyme Supplementation

When supplementing poultry feed with enzymes, (Marquardt *et al*. 1996) have cited several factors which are important to follow:

i. The enzyme supplement must contain the proper spectrum of enzymes, so that anti-nutritive effects of target substrate will be neutralized.

ii. Different cereals contain different amounts of the enzyme-sensitive anti-nutritional factor. Therefore, the response to enzyme treatment may vary within a given cereal (i.e. barley and probably wheat).

iii Outcomes of the enzyme supplementation are affected by grade and age of poultry. The responses in swine are usually less dramatic than those of poultry and have not been clearly established.

iv. The activity of the enzymes must not be affected by processing or by the low pH (<4) or digestive enzymes in the gastrointestinal tract.

Results from several studies have shown increased phosphorus(P) digestibility and utilization, and hence reduced P excretion into the environment due to phytase addition to poultry diets (Applegate *et al*., 2003; Penn *et al*., 2004; Angel *et al*., 2006; Leytem *et al*., 2007).

Legume seeds such as soy contain NSP in the form of oligosaccharides, hemicellulose and pectin. Alpha galactosides are raffinose and stachyose based oligosaccharides that accumulate as the seed matures. Endogenous enzymes in monogastrics are specific for alpha-linked carbohydrates such as starch but have little or no effect on beta linked carbohydrates or galactose containing oligosaccharides. Degradation of these galactosides is accomplished by the gut microflora yielding volatile fatty acids and gas production. The net result is less energy and gastric disturbances in many species. Enzymatic degradation of these compounds can produce monosaccharides and result in better energy and protein utilization.

2.4.1 Effects of Enzymes on the Gastrointestinal Environment

Microorganisms in the gastrointestinal tract utilize the digesta for energy in a similar manner as to the host animal. Changes in rate of passage and the type of nutrients available to the microbes influence the different microbial populations in the GI tract. The end products of metabolism of many of the anaerobic bacteria found in the gut are volatile fatty acids which have been shown to be altered with enzyme supplementation (Choct *et al.,* 1995). However, studies examining differences in specific microbial populations such as starch or xylan-degrading bacteria have yielded no significant effects (Persia, *et al*., 1999). This may be due to lack of technology to adequately examine these populations since it stands to reason that as the substrate changes so should the microorganisms that can use them. Gastrointestinal histology has also been shown to be affected by barley and wheat-based diets with reductions in villi height, increased diameter and damaged villi associated with wheat and barley diets (Viveros *et al*., 1994; Jaroni *et al*., 1999).

Enzyme supplementation of these diets counteracted some of these effects with supplemented birds having gut morphology more similar to birds receiving a corn/soy diet. This may also help explain reductions in mortality that is often seen in birds receiving enzyme supplementation. Damage to the GI tract may make the organ more susceptible to pathogenic bacteria invasion. In addition, enzyme supplemented birds had lower gut and pancreas weights. The strain of bird used also had a bearing on these results. Slominski *et al.* (2006) reported a 3.9% and 3.2% improvement of multi-carbohydrase over control in body weight gain and feed conversion ratio in seven trials using broiler chickens in a 14-day trial.

2.5 Enzymes Supplementation and Improved Poultry Health

The principal rationale for the use of enzyme technology is to improve the nutritive value of feed stuffs (Munir and Maqsood, 2013). Since the digestive process is nowhere near 100% efficient. For example, Swine are unable to digest 15-25% of the food they eat. Therefore, the supplementation of the animal feed with suitable enzymes to increase the efficiency of digestion can be seen as an extension of the animal's own digestion process (Pariza and Cook, 2010). In addition to improving diet utilization, enzyme addition can reduce the variability in the nutritive value between feedstuffs and improve the accuracy of feed formulations. Experimental trials have shown that ensuring feed consistency in this way can increase the uniformity of groups of animals, thus aiding management and improving profitability. The general health status of animals can also be indirectly influenced, resulting in fewer non-specific digestive upsets that are frequently provoked by the fibre components in the feed (Sheppy, 2003).

The improvements obtained by adding enzymes to the diet of poultry depends on many factors, including the type and amount of cereal in the diet; the level of anti-nutritive factor in the cereal, which can vary within a given cereal; the spectrum and concentration of enzymes used; the type of bird and their age (young bird tend to respond better to enzymes than older birds). Enzyme supplementation to field bean diets has been shown to be effective in improving chick performance (Castanon and Marquardt, 1989). Addition of a cell-wall degrading multi-enzymes complex and α-galactosidase improved the feed-to-gain ratio of raw high tannin pea diets fed to chickens, whereas no improvement of chick performance was observed for animals fed with a tannin-free pea variety (Brenes *et al*., 1993).

Many enzyme supplementations are known to have a positive impact on the overall performance of the poultry. Different feed ingredients are known to show different levels of response to different enzyme supplementation. For example, cereal grains which are not well digested by the poultry are more greatly influenced by enzyme addition than those which are well digested (Lobo, 2000). Some enzymes are known to destroy anti-nutritional factors or increase the digestibility of indigestible nutrients which can help in saving energy and improve overall nutrition. Other health implications of exogenous enzyme supplementation are stated below:

i. Improvement in animal hygiene and health.
ii. Corrects digestive disorders especially when birds are crowded.
iii. Fattening performance is increased.
iv. Checks cellular damages caused by toxins.
v. Prevents diarrhoea due to poor fibre digestion.
vi. Minimizes excreta, water droppings and buildup of ammonia.
vii. Reduces viscosity and ammonia level in intestine.

2.6 Digestibility Studies

Japanese quails are hardy birds that thrive in cages. They have less feed requirement of about 20- 25g feed per day compared to chicken that requires 120-130g per day. The Japanese quail attains market weight of 140 -180g between 5-8 weeks of age and, a high rate of egg production between 180-250 (Garwood and Diehl, 1987; Shwartz and Allen, 1981) and 200-300 eggs in their first year of lay (NRC, 1991).

Several reports have highlighted performance of quail and broiler birds fed different diets with or without enzyme supplementation.

Ngele *et al*. (2011) reported that feed intake increased with increasing level of spent sorghum residue in quail diet due to lower fibre level and higher protein content, they also reported average egg weight of 9.10g and age at sexual maturity of 5weeks, hen day production of 57.42-69.23%. Swain *et al.* (2013) reported that egg production, feed conversion ratio and egg weight were significantly improved by the supplementation of 5% Brewers' Dried Grain (BDG) by replacing maize, soybean meal and De-oiled rice bran(DORB) in control diet. The feed consumption and percentages of egg contents, albumen, yolk and shell and shape index were similar across all the treatments. The net profit in quails fed 5% BDG was higher than those fed control diet. Makinde *et al. (2014)* reported that Quails fed diet containing 30%BDG and 30%PKM consumed significantly higher feed compared to those fed the control and other diets. However, they reported no significant differences in daily weight gain, egg production and egg weight across the treatments. They also reported that peak egg production was significantly different, while the result of the egg quality characteristics showed no significant difference across the treatments when compared with the control.

Alu (2012) reported improvement in the digestibility of crude protein, crude fibre, ether extract, nitrogen free extract and fibre fraction components such as neutral detergent fibre, acid detergent fibre, acid detergent lignin and hemicellulose due to enzyme supplementation, supporting the general assertion that exogenous enzyme supplementation improves digestibility of nutrient (Adeola and Olukosi, 2008). Furthermore Omole *et al*. (2011) investigating the performance and nutrient digestibility of broiler birds fed diets containing exogenous Hamecozyme® observed significant improvement in crude protein and crude fibre digestibility as the level of Hamecozyme increased in the diets. Similarly, Alu *et al*. (2009) conducted an experiment using weaner pigs to investigate the effect of Nutrase Xyla® enzyme supplementation on nutrient digestibility where high and low fibre diets were fed to weaner pigs and he also noted significant improvement in the digestibility of neutral detergent fibre and hemicellulose. Dietary fibre significantly depressed the digestibility of nutrients except for crude fibre, ether extract and cellulose (Atteh, 2002 and Olomu, 2011). Adeola and Olukosi (2008) observed that high dietary fibre can only be properly digested and utilized in monogastric animals if exogenous enzymes are added to the diets. The authors maintained that when enzyme is added to feed, they break down the anti-nutritional factors that are present, many of which are not susceptible to digestion by the animals endogenous enzymes.

2.7 Carcass Traits

Carcass traits such as carcass weight, dressing percentage, meat to bone ratio and chemical analysis of meat are important factors in determining the income from meat production from Japanese quail. This is because the profitability of a quail enterprise depends not only on the number of birds produced per female, but also on the weight and quality of carcasses the birds produced. Furthermore, carcass traits like any other quantitative traits are largely affected by the interaction between genetic and non-genetic factors chief among which is nutrition.

Dressing percentage is a trait of prime interest to the poultry industry and Japanese quail may serve a useful role in studies involving dressing percentage. This trait determines the net output of carcass relative to either live body weight or empty body weight. The most important factors affecting dressing percentage are breed, body size, age at slaughter, sex, and nutrition during the growing period, time of fattening and the processing procedures (Abuol-Seoud, 2008). Wilson *et al*., 1961 as cited in Abuol-Seoud, (2008) reported a higher estimate of 69.4% for the dressing percentage of Japanese quail slaughtered at 6 weeks of age. At the same age, Bacon and Nestor (1983 as cited in Abuol-Seoud, 2008) and El-Fiky (1991 as cited in Abuol-Seoud, 2008) reported that dressing percentage ranged from 59.3 to 67.3%.

Makinde (2012) reported ranges of 122.03 – 134.53 for carcass weight; 66.34 – 67.74 for dressing %, 27.28 – 28.87, 8.18 – 8.84, 20.34 - 23.42 % for breast, thigh and back % relative to carcass weight. Ranges of 2.18 – 2.35, 3.72 – 4.52, 1.09 – 1.19 % for liver, gizzard and heart, while 56.19 – 62.70cm was reported for intestinal length.

2.8 Egg Quality Traits of Japanese Quail

Commercial quail breeding have become widespread (Altinel *et al.,* 1996). Although meat production was considered more commonly, the egg breeding became more important in some countries such as China. Besides, the productivity and quality of the breeding eggs have an overall significance for the continuity of the flocks and for economical breeding (Sogut *et al.,* 2001). Several factors have been reported to influence egg quality traits of poultry birds, chief amongst which are genetics, nutrition and climatic conditions. The issues related to the quality and compositions of eggs produced by domestic fowl are of primary importance. They have received a considerable attention since the middle of 19th century. The most detailed review on the subject was however published in 1949 by Romanoff and Romanoff in their fundamental research work "The Avian Egg", which turned out to be a kind of a Bible of the poultry industry as cited in Genechev (2012).

According to Kumar *et al.* (2000) egg quality is usually commented in connection with consumers' requirements and is performed by groups of methods, which give general characteristics of egg with intact eggshell (freshness, weight, size and shape, eggshell appearance) and the quality of egg parts (albumen, yolk and egg shell). The evaluation of the quality of egg parts is performed after breaking. The average weight of albumen of quail eggs ranges between 4.9-5.0 g while quail egg yolk weighs about 4.3-4.5 g and largely determines the nutritive value of the egg as a whole. (Salawu *et al.,* 2007).

The most important quality traits of the eggshell are its strength and thickness. The thickness of quail eggs with membranes varies from 0.191 (Kostova *et al.,* 1993) to 0.219 mm (Gonzalez, 1995). Kul and Seker (2004) reported mean values for egg weight, egg length, egg width, shell weight, shell thickness, albumen length, albumen width, albumen height, albumen weight, yolk diameter, yolk height, yolk weight, yolk colour, shape index, albumen index, yolk index and Haugh unit were 13.71g, 34.12mm, 26.98mm, 1.17g, 0 .21mm, 43.14mm, 33.81mm, 4.88mm, 7.80g, 25.19mm, 11.29mm, 4.74g, 5.37, 79.23, 0.13, 0.45 and 58.27, respectively.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

This study was carried out at the Poultry Unit of the Teaching and Research Farm, Department of Animal Science, Ahmadu Bello University, Samaru-Zaria. Zaria is located within the Northern Guinea Savannah zone of Nigeria, latitude 11^{o} 12′, N and longitude 7^{o} 33′ E at an altitude of 610m above sea level. The climate is relatively dry with a mean annual rainfall of 1100mm, (Google Earth).

3.2 Source of Experimental Materials

3.2.1 Roselle Seed Cake

Mechanically extracted RSC was purchased from an oil-extraction mill based in Sharada Industrial Layout Kano State, Nigeria.

3.2.2 Enzyme

Allzyme SSF® was purchased at DASOLAG AGRO ENTERPRISES, Kaduna.

3.3 Experimental Procedure

Two 5 x 2 factorial trials in a Completely Randomised Design (CRD) were conducted. There were nine (10) treatments and three (3) replications for each of the two experiments.

Experiment 1: Growth performance of Japanese Quails fed RSC based diets with or without Allzyme® supplementation (2 to 6 weeks of age).

Experiment 2: Egg production performance of Japanese Quail hens fed RSC based diets with or without Allzyme® supplementation (6 to 20 weeks of age).

3.3.1 Determination of the Chemical Composition of the Feed Ingredients Used

The proximate analysis of RSC was carried out in the Biochemistry Laboratory, Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria according to the methods described by Association of Analytical Chemist (AOAC, 1990). Crude Protein was determined by Kjedahl procedure, ether extract was determined by subjecting the samples to petroleum ether extraction at 60-80°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_2SO_4), then in weak sodium hydroxide (0.312N NaOH) for 1hour. The residue which consists of cellulose, lignin and mineral matter was dried and weighed. The ash content was determined by igniting a weighed sample in a Muffle furnace at 600°C. The nitrogen free extract (NFE) was obtained by subtracting the percentages of the other fractions from 100%. Gross Energy (GE) was determined by using the Ballistic Bomb Calorimeter.

3.3.2 Experiment 1: Experimental Design

3.3.2.1 Experimental animal, management and data collection

A total of Five Hundred and Forty day-old Japanese quail chicks were sourced from the National Veterinary Research Institute (NVRI) Vom, Plateau State, Nigeria and used for this experiment. The birds were weighed and fed the control diet shown in Table 3.1. After two-weeks of adjustment period, the quails were allotted to pens in a completely randomized design (CRD) using a 5 x 2 factorial with 3 replicates of 18 birds each. There were five dietary levels of roselle seed cake (0, 7.5, 15, 22.5 and 30.0%), with or without enzyme supplementation and they were compared to the 25%CP GNC-SBM-Maize based control diets. The diets were isonitrogenous (25%) and isocaloric (2800kcal/kgME). The birds were housed in 75cm long × 75cm wide × 60cm high cages and were offered feed and water *ad libitum* using appropriate feeding and drinking troughs. At the beginning of the trial, the birds were started on multivitamins (Ganaminovit) in drinking water to ameliorate transportation stress and to boost appetite.

3.3.3 Health Management of the Experimental Birds

Wet litter was removed regularly and no antibiotic was used throughout the course of the experiment.

Diet for Experiment 1: Nine iso-nitrogenous (25%CP) and iso-caloric (2800Kcal/kg M.E) Quail grower diets were formulated as follows:

Treatment 1: 0.00% RSC + 0.00% Enzyme
Treatment 2: 7.50% RSC + 0.00% Enzyme
Treatment 3: 15.00% RSC + 0.00% Enzyme
Treatment 4: 22.50% RSC + 0.00% Enzyme
Treatment 5: 30.00% RSC + 0.00% Enzyme
Treatment 6: 0.00% RSC + 0.01% Enzyme
Treatment 7: 7.50% RSC + 0.01% Enzyme
Treatment 8: 15.00% RSC + 0.01% Enzyme
Treatment 9: 22.50% RSC + 0.01% Enzyme
Treatment 10: 30.00% RSC + 0.01% Enzyme
The ingredient composition of the experimental diet is presented in Table 3.1.

Diet for Experiment 2: Ten isonitrogenous (22%CP) and isocaloric (2700Kcal/kg M.E) Quail layer diets were formulated as follows:

Treatment 1: 0.00% RSC + 0.00% Enzyme

Treatment 2: 7.50% RSC + 0.00% Enzyme

Treatment 3: 15.00% RSC + 0.00% Enzyme

Treatment 4: 22.50% RSC + 0.00% Enzyme

Treatment 5: 30.00% RSC + 0.00% Enzyme

Treatment 6: 0.00% RSC + 0.01% Enzyme

Treatment 7: 7.50% RSC + 0.01% Enzyme

Treatment 8: 15.00% RSC + 0.01% Enzyme

Treatment 9: 22.50% RSC + 0.01% Enzyme

Treatment 10: 30.00% RSC + 0.01% Enzyme

The ingredient composition of the experimental diet is presented in Table 3.2.

Table 3.1: Composition of RSC Based Diets Fed to Japanese Quails With or Without Allzyme SSF® Supplementation (2 to 6 Weeks)

ENZYME			0.00					0.01		
RSC (%)	0	7.5	15	22.5	30	0	7.5	15	22.5	30
Maize	47.69	43.53	39.50	35.43	31.36	47.68	43.54	39.51	35.44	31.37
Groundnut cake	32.66	29.22	25.75	22.32	18.89	32.66	29.22	25.75	22.32	18.89
Soybean meal	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Roselle seed cake	0.00	7.50	15.00	22.50	30.00	0.00	7.50	15.00	22.50	30.00
Maize Offal	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25	3.25
Bone Meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Broiler Pmx	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methione	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Allzyme SSF®	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ME($KcalKg^{-1}$)	2779.43	2764.59	2768.12	2763.55	2759.23	2779.43	2764.59	2768.12	2763.55	2759.23
Crude Protein (%)	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Ether Extract (%)	6.14	6.10	6.05	6.01	5.96	6.14	6.10	6.05	6.01	5.96
Crude Fibre (%)	3.54	4.18	4.70	5.22	5.75	3.54	4.18	4.70	5.22	5.75
Calcium (%)	1.18	1.19	1.21	1.23	1.25	1.18	1.19	1.21	1.23	1.25
Total Phosphorus	0.77	0.78	0.76	0.80	0.81	0.77	0.78	0.76	0.80	0.81
Lysine (%)	1.16	1.28	1.39	1.51	1.63	1.16	1.28	1.39	1.51	1.63
Methionine (%)	0.58	0.66	0.73	0.81	0.88	0.58	0.66	0.73	0.81	0.88
Cysteine (%)	0.25	0.36	0.46	0.57	0.68	0.25	0.36	0.46	0.57	0.68
Feed Cost/Kg (₦)	85.34	85.17	83.07	80.98	78.88	85.34	85.17	83.07	80.98	78.88

Vitamin-mineral premix provides per kg; 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, 0.668.mg, chloride, 400mg; Chlorotetracycline, 26.68mg; Manganese, 13mg; Iron, 66.68mg; Zinc, 53.34mg; Copper 3.2mg; Iodine, 1.86mg; Cobalt, 0268mg; Selenium, 0.108mg.

Table 3.2: Composition of RSC Based Diets Fed to Japanese quail Hens With Or Without Allzyme SSF® Supplementation (6 to 20 Weeks)

ENZYME	0.00					0.01				
RSC (%)	0	7.5	15	22.5	30	0	7.5	15	22.5	30
Maize	47.46	43.30	39.26	35.20	31.13	47.45	43.29	39.25	35.19	31.12
Groundnut cake	26.89	23.46	20.00	16.56	13.13	26.89	23.46	20.00	16.56	13.13
Soybean meal	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Roselle seed cake	0.00	7.50	15.00	22.50	30.00	0.00	7.50	15.00	22.50	30.00
Maize Offal	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75	7.75
Bone Meal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Limestone	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Broiler Pmx	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methione	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Allzyme®	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
ME($KcalKg^{-1}$)	2704.38	2696.65	2692.63	2688.40	2684.08	2704.38	2696.65	2692.63	2688.40	2684.08
Crude Protein (%)	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00
Ether Extract (%)	5.48	5.44	5.39	5.35	5.30	6.14	5.44	5.39	5.35	5.30
Crude Fibre (%)	3.80	4.29	4.82	5.34	5.86	3.54	4.29	4.82	5.34	5.86
Calcium (%)	2.50	2.52	2.54	2.55	2.57	1.18	2.52	2.54	2.55	2.57
Total Phosphorus	0.51	0.52	0.52	0.53	0.54	0.77	0.52	0.52	0.53	0.54
Lysine (%)	1.05	1.16	1.27	1.38	1.49	1.16	1.16	1.27	1.38	1.49
Methionine (%)	0.56	0.63	0.71	0.79	0.86	0.58	0.63	0.71	0.79	0.86
Cysteine (%)	0.23	0.34	0.45	0.55	0.66	0.25	0.34	0.45	0.55	0.66
Feed Cost/Kg (₦)	79.39	79.23	77.13	75.03	72.93	85.34	79.23	77.13	75.03	72.93

Vitamin-mineral Premix provides the following per kg: Vitamin. A4000i.u; Vit. D_3,8000i.u; Vit. E, 9000mg; Niacin, 12000mg; Vit.B_1, 15000mg;Vit. B_3,4000mg;Vit. B_6,12000mg; Vit. B_{12}, 6mg;Vit. K_3,800mg; Pantothenic acid, 3000mg; Biotin, 24mg;Folic acid, 300;Choline Chloride, 120000mg;Cobalt, 80mg; Copper, 1200mg; Iodine, 400mg; Iron, 8,000mg; Manganese,16000mg; Selenium, 80mg; Zinc, 12000mg; Anti-oxidant; 500mg.

3.4 Digestibility Trial

During the last week of the experiment, three birds were selected from each replicate making a total of nine (9) birds per treatment. Each bird was housed in 45cm long × 45cm wide × 45cm high metabolic crates during a one-week adjustment period before faecal collection period which lasted for 7 days. Trays were placed under each cage for the collection of droppings. Water and feed were provided *ad libitum* throughout the 7-day trial. Feed consumed was measured by weighing the left over feed daily and subtracting from amount of feed provided. The droppings collected daily were air-dried, weighed and then stored in a freezer for the 7-day period. Afterwards, the droppings were thawed, thoroughly mixed and the samples obtained were assayed for proximate composition (Dry matter, Nitrogen, Ether extract, Crude fibre and Ash) in the Department of Animal Science Laboratory, Ahmadu Bello University, Zaria using the methods described by Association of Analytical Chemist (AOAC, 1990). The percentage digestibility was calculated using the equation below;

$$\text{Digestibility} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Nutrient Intake}} \text{ X } 100$$

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

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

3.5 Carcass Evaluation

At the end of the 4-week feeding trial, four male quail birds were selected from each replicate based on the average weight of the group for carcass evaluation. The birds were fasted for 12 hours prior to slaughtering which was done by severing the jugular vein while allowing the blood to drain. Thereafter, they were de-feathered, eviscerated and the carcass, primal cuts;

breast, thigh, drumstick, wings, back, and organs; heart, liver, gizzard and intestines were weighed and expressed as a percentage of dressed weight using 0.01g sensitive digital scale. This evaluation was carried out at the Meat and Animal Products Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria.

3.6 Experiment 2: Experimental Design

3.6.1 Experimental animal, management, procedure and data collection

In the second experiment, two hundred and seventy six-week old quail hens were allotted in a completely randomized design (CRD) using a 5 x 2 factorial with 3 replicates of 9 birds. There were five dietary levels of roselle seed cake (0, 7.5, 15, 22.5 and 30.0%), with or without enzyme supplementation and they were compared to the 22% CP GNC-SBM-Maize based control diets. The diets were isonitrogenous (22%) and isocaloric (2700kcal/kg ME). The birds were housed in 75cm long × 75cm wide × 60cm high cages and were offered feed and water *ad libitum* using appropriate feeding and drinking troughs.

Egg production was recorded daily and pooled to calculate hen-day egg production (HDP) and hen-housed egg production (HHP). The 1st egg, age at peak production and egg production at peak were also recorded. The initial and final weights were measured to calculate the percentage change in body weight. Average daily feed intake, feed conversion ratio (gram feed per gram egg) were calculated weekly and the feed cost per dozen eggs laid were calculated based on the prevailing market prices of feed ingredients. All eggs laid in a particular replicate group were weighed to determine mean egg weight. Egg quality traits (egg weight, egg length, egg breadth, egg shape index (ESI), Haugh Unit, egg yolk width, egg yolk height, egg yolk weight, egg yolk index, egg yolk colour, albumen height, albumen width, egg shell thickness and egg proportion-yolk, albumen, shell and membrane) were evaluated weekly using 10 freshly laid eggs from each treatment. The weight of each egg and yolk was recorded to the accuracy of 0.01g.

After weighing, the eggs were broken out one after the other into a tri-pod micrometre (Ames S-6428, U.S.A) and with this, the albumen heights was measured for the calculation of Haugh unit values according to the formula of Oluyemi and Roberts (2000).

$$HHP = \frac{\text{Number of Eggs Collected}}{\text{Number Of Birds stocked}} x\ 100$$

$$HDP = \frac{\text{Number of Eggs Collected}}{\text{Number of Birds at time of collection}} x\ 100$$

HU=100log 10 (H-1.7W$^{0.37}$ + 7.6)

Where;

HU= Haugh Unit

H = Observed height of the albumen in millimetres

W = Weight of the eggs in grams

Egg length and breadth will be measured using venier callipers and the values will be used to calculate the Egg Shape Index (ESI) using the formula reported by Sauveur (1998):

$$ESI = \frac{EB}{EL}$$

Where;

ESI= Egg Shape Index

EB = Egg Breadth

EL = Egg Length

The egg shells were dried for three (3) days and weighed to determine the shell weight. The Egg Shell Index was calculated according to Iposu *et al* (1994) using the formula:

$$I = \frac{100SW}{S}$$

Where;

I = Egg Shell Index

SW = Shell Weight (g)

And S = Surface Area (cm^2)

S was calculated from egg weight (EW) using the Equation S= K.EW $^2/_3$

Where; K has a range of constants for a range of egg weights. Formula for estimating the egg specific gravity (ESG) was based on weight of egg and shell as used by poultry adviser (1992):

$$ESG = \frac{EW}{\{0.9680\ (EW - SW) + (0.4921\ SW)\}}$$

Where;

ESG = Egg Specific Gravity

EW = Egg Weight

SW = Shell Weight

The shell thickness was measured using venier callipers. The yolk height and width were measured for the calculation of the yolk index (Funk, 1948). The yolk height was measured by placing the movable pin of the venier callipers on the centre of the yolk and pressing down the calliper until the base touches the top of the yolk. The yolk width was measured by adjusting the two gripping forceps of the calliper to touch both ends of the yolk.

3.7 Statistical Analysis

Data obtained from the study were subjected to Analysis of Variance (SAS, 2008). Also, the control diet was isolated from the other diets to allow for a factorial evaluation of the diets containing RSC with or without enzyme supplementation. Significant differences among treatment means were compared using the Duncan Multiple Range Test (Steel and Torrie, 1988).

Statistical model for the analysis is as follows:

$Y_{ijk} = \mu + E_i + R_j + (E \times R)_{ij} + e_{ijk}$, (j=1, 2...5)

Where;

Y_{ijk} = a random variable corresponding to the observation yijk obtained from the i^{th} replicate of the j^{th} treatment.

μ = Population mean.

E_i = the fixed effect of enzyme supplementation

R_j = the fixed effect of dietary treatment

(E x R)ij = the effect of interaction between enzyme supplementation and dietary treatment.

eijk = error component.

CHAPTER FOUR

4.0 RESULTS

4.1 Proximate Composition of Roselle Seed Cake (RSC)

Table 4.1: Proximate Composition (%) and Metabolizable Energy (Kcal/Kg) of Roselle Seed Cake (RSC)

Composition	Quantity
Dry Matter	93.68
Crude Protein	25.38
Ether Extract	5.78
Crude Fibre	10.20
Ash	8.03
Nitrogen Free Extract	50.61
Metabolisable Energy	2885.00 (Calculated)

4.2 Growth Performance of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation (2 - 6 Weeks)

Tables 4.2 and 4.2.1 show the single effect of RSC and enzyme supplementation on growth performance. There were no significant differences (($p>0.05$) observed for average daily feed intake (g), mean values ranged from 18.26g (diet 2) to 19.05g (diet 5). Similar trend was observed for Feed cost (N), Feed: Gain, Feed Cost: Gain, Protein intake (g) and Protein efficiency ratio (PER) due to single effect of enzyme supplementation. However, significant ($P<0.05$) differences were obtained with average daily weight gain (g/day) and average mortality with the best performance in enzyme supplemented diet

RSC levels showed similar trend across indices as observed with enzyme supplementation, the best weight gain were obtained with increasing levels of RSC supplementation from 15% to 30% while the 0% and 7.5% were similar with significantly lower values. Average mortality increased with increasing levels of RSC in the diet.

4.3 Effect of the Interaction between Allzyme SSF® and RSC on Performance of Japanese Quails Fed RSC Based Diets with or Without Allzyme® Supplementation (2 - 6 Weeks)

Table 4.2.2 shows the interaction between test ingredients on growth and economic characteristics of quails fed the test diet. Significant ($P<0.05$; 0.01) differences existed in Final Weight, Average Daily Weight gain and Average Mortality at 1-4 Wks. The interaction of 0.01% Allzyme SSF® with 22.5% and 30% RSC had the best final weight (149.66 and 149.14) among all levels of interaction. Significant variation was however absent among the remaining levels.

Table 4.2.1: Growth Performance of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (2 - 6 Weeks)

Single Effect of Enzyme

Level of Enzyme (%)	**0.00**	**0.01**	**SEM**	**LOS**
Parameters				
Initial Weight (g)	29.62	29.27		
Final Weight (g)	143.47	146.28	1.69	NS
Average Daily Weight Gain (g/day)	4.05[b]	4.18[a]	0.06	*
Average Daily Feed Intake (g)	18.69	18.3	2.27	NS
Feed:Gain	4.62	4.38	0.8	NS
Feed Cost:Gain	0.28	0.25	0.04	NS
Protein Intake (g)	4.67	4.54	0.57	NS
Protein Efficiency ratio	0.91	0.88	0.11	NS
Average Mortality	0.33[b]	0.07[a]	0.13	**

[a,b,c] means within rows differ significantly at $P<0.05$, %= percentage, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

Table 4.2.2: Growth Performance of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (2 - 6 Weeks)

Single Effect of RSC

Level of RSC (%)	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Parameters							
Initial Weight (g)	29.19	29.15	30.56	28.7	29.63		
Final Weight (g)	143.26	144	145.87	145.69	145.57	1.50	NS
Average Daily Weight Gain (g/day)	4.07^{b}	4.10^{b}	4.12^{a}	4.18^{a}	4.14^{a}	0.04	*
Average Daily Feed Intake (g)	18.375	18.26	18.355	18.45	19.05	2.27	NS
Feed:Gain	4.52	4.45	4.46	4.41	4.60	0.8	NS
Feed Cost:Gain	0.27	0.27	0.27	0.27	0.27	0.04	NS
Protein Intake (g)	4.52	4.57	4.59	4.61	4.76	0.57	NS
Protein Efficiency ratio	0.91	0.89	0.88	0.89	0.92	0.11	NS
Average Mortality	0.00^{a}	0.17^{ab}	0.17^{ab}	0.34^{b}	0.33^{b}	0.10	**

^{a,b} means within rows differ significantly at P<0.05, %= percentage, RSC= Roselle seed cake, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

Table 4.2.3: Effect of the Interaction between Allzyme SSF® and RSC on Performance of Japanese Quails fed RSC Based Diets with or without Allzyme® Supplementation (2 - 6 Weeks)

Level of Enzyme (%)	**0.00**					**0.01**						
Level of RSC (%)	**0.00**	**7.5**	**15**	**22.5**	**30**	**0.00**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Parameters												
Initial Weight (g)	29.63	29.60	30.56	28.70	29.63	28.75	28.70	30.56	28.70	29.63		
Final Weight (g)	142.77[c]	144.64[b]	146.24[b]	141.71[b]	141.99[c]	143.75[c]	143.36[b]	145.50[b]	149.66[a]	149.14[a]	1.53	*
Average Daily Weight Gain (g/day)	4.04[c]	4.11[b]	4.13[b]	4.04[c]	4.01[c]	4.11[b]	4.10[b]	4.11[b]	4.32[a]	4.27[a]	0.05	*
Average Daily Feed Intake (g)	18.12	18.55	18.59	18.81	19.40	18.63	17.97	18.12	18.09	18.69	2.10	NS
Feed:Gain	4.49	4.51	4.50	4.66	4.84	4.53	4.38	4.41	4.19	4.38	0.40	NS
Feed Cost:Gain	0.28	0.27	0.27	0.30	0.28	0.25	0.26	0.26	0.24	0.25	0.04	NS
Protein Intake (g)	4.53	4.64	4.65	4.70	4.85	4.50	4.49	4.53	4.52	4.67	0.52	NS
Protein Efficiency ratio	0.89	0.89	0.89	0.92	0.96	0.92	0.88	0.87	0.85	0.88	0.10	NS
Average Mortality	0.00[a]	0.33[b]	0.33[b]	0.67[c]	0.33[b]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.33[b]	0.14	**

[abc]= means within rows differ significantly at P<0.05, RSC= Roselle seed cake, %= percentage, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

The same pattern was obtained for Average daily weight gain. The lowest mortality at 1-4 weeks was obtained with RSC (7.5, 15 and 22%) supplemented with Allzyme SSF®, but increased with increasing levels of RSC and absence of Allzyme SSF® supplementation. The least mean was 4.48 (0.01 Allzyme SSF® and 7.5% RSC) and the highest was 5.49 (0.00% Allzyme SSF® and 22.5% RSC). All feed intake traits increased with increasing RSC levels for all Allzyme SSF® levels. No specific pattern could be established for cost related indices.

4.4 Nutrient Retention of Japanese Quails Fed RSC Based Diets With or Without Allzyme SSF® Supplementation (6 - 20 Weeks)

Tables 4.3 and 4.3.1 show the single effects of Enzyme supplementation and RSC on nutrients retained by birds fed various diets. Significant ($P<0.01$) differences were observed for all parameters across the treatments for single effect of enzyme supplementation while Nitrogen free extract retention did not differ significantly ($P>0.05$) for single effect of RSC inclusion. Dry matter, Crude protein, Crude fibre and Nitrogen free extract retention were significantly higher with enzyme supplementation while Ether extract and Ash were better without enzyme supplementation.

Single effect of RSC inclusion indicated that higher dry matter were retained at 0 and 22.5% levels compared to other levels, while crude protein retention were significantly better at the same level, crude fibre retention were significantly better at 15 and 22.5% but poorly retained at 7.5%. The best ether extract retention was obtained 22.5% inclusion rate. Ash retention followed the same trend as obtained with crude fibre and crude protein retention.

Table 4.3.1: Nutrient Retention of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation

Single Effect of Enzyme

Level of Enzyme (%)	0.00	0.01	SEM	LOS
Dry Matter (%)	57.85[b]	64.12[a]	2.12	**
Crude Protein (%)	66.51[b]	68.75[a]	1.12	**
Crude Fibre (%)	48.19[b]	58.87[a]	1.41	**
Ether Extract (%)	74.21[a]	68.47[b]	2.12	**
Ash (%)	54.47[a]	50.07[b]	1.77	**
Nitrogen Free Extract (%)	57.87[b]	65.75[a]	1.77	**

[ab]= means within rows differ significantly at P<0.01, %= percentage, SEM= Squre error of means, LOS= Level of significance, NS= Not significant.

Table 4.3.2: Nutrient Retention of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation

Single Effect of RSC

Level of Enzyme RSC (%)	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Dry Matter (%)	64.89[a]	58.00[b]	58.64[b]	64.31[a]	59.11[b]	2.12	**
Crude Protein (%)	71.04[a]	65.84[b]	66.02[b]	68.37[ab]	66.90[b]	2.12	**
Crude Fibre (%)	54.67[b]	43.48[d]	60.36[a]	60.44[a]	48.72[c]	1.41	**
Ether Extract (%)	72.75[b]	71.04[b]	67.07[bc]	78.04[a]	67.81[bc]	2.12	**
Ash (%)	54.95[a]	49.35[b]	55.29[a]	56.60[a]	45.16[c]	1.77	**
Nitrogen Free Extract (%)	63.58	60.35	62.08	61.50	61.55	1.77	NS

[abc]= means within rows differ significantly at $P<0.05$, RSC= Roselle seed cake, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

4.5 Effect of the Interaction between Allzyme SSF® and RSC on Nutrient Retention of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation

Apparent digestibility and nutrient retention by Japanese Quails fed experimental diets is described in Table 4.3.2. All parameters showed significant differences (P<0.01) due to interaction between enzyme and RSC levels. The highest dry matter (69.16 and 67.65%) was retained in diets containing 22.5 and 30% RSC supplemented with Allzyme SSF® while the least (50.56%) was in diets containing 30% RSC with no enzyme supplementation. All other combinations were similar. Crude protein digestibility had the highest (73.20%) value with 22.5% RSC and 0.01% enzyme supplementation and it differed from all other interaction levels which were similar. The best (68.06%) crude fibre retained was with 15% RSC and 0.01 % enzyme; the least (33.96%) was with 7.5% without enzyme supplementation. Also Nitrogen free extract was better retained in 7.5 and 15% RSC with 0.01 enzyme supplementation but poorly so with all levels of RSC at zero enzyme level. Only with Ether extract and Ash retention was the absence of enzymes in diets showed better retention than enzyme supplemented RSC based diets. The highest ether extract was 81.55% in 22.5% and 0.00% enzyme diet, while Ash was 61.73 and 62.15% (15 and 22.5% RSC with 0.00% enzyme).

4.6 Carcass Characteristics of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation (2 to 6 Weeks)

Tables 4.4 and 4.4.1 show single effect of Enzyme and RSC on the carcass characteristics of quails fed the experimental diet. The single effect of enzyme supplementation showed significant (P<0.01) variation with %Breast and intestinal length only.

Table 4.3.3: Effect of the Interaction between Allzyme SSF® and RSC on Nutrient Retention of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation

Level of Enzyme (%)	**0.00**					**0.01**						
Level of RSC (%)	**0**	**7.5**	**15**	**22.5**	**30**	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Dry Matter (%)	65.66^{a}	55.23^{bc}	58.36^{b}	59.46^{b}	50.56^{c}	64.11^{a}	60.76^{b}	58.91^{b}	69.16^{a}	67.65^{a}	2.12	**
Crude Protein (%)	72.32^{a}	64.82^{b}	64.64^{b}	63.53^{b}	67.25^{b}	69.76^{a}	66.85^{b}	67.41^{b}	73.20^{a}	66.54^{b}	2.12	**
Crude Fibre (%)	58.11^{a}	33.96^{f}	52.66^{d}	56.17^{c}	40.05^{e}	51.23^{e}	52.99^{d}	68.06^{a}	64.70^{b}	57.38^{c}	1.41	**
Ether Extract (%)	72.3^{c}	66.25^{c}	75.87^{b}	81.55^{a}	75.08^{b}	73.2^{c}	75.83^{b}	58.27^{d}	74.53^{b}	60.53^{d}	2.12	**
Ash (%)	55.45^{b}	45.49^{c}	62.15^{a}	61.73^{a}	47.54^{c}	54.45^{b}	53.20^{b}	48.44^{b}	51.47^{b}	42.77^{cd}	1.77	**
Nitrogen Free Extract (%)	64.23^{b}	52.94	55.19^{c}	58.16^{c}	58.84^{c}	62.93^{b}	67.76^{a}	68.98^{a}	64.83^{b}	64.26^{b}	1.77	**

^{abcdef}= means within rows differ significantly at P<0.01, RSC= Roselle seed cake, %= percentage, SEM= Squre error of means, LOS= Level of significance.

Table 4.4.1: Carcass Characteristics of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (2 to 6 Weeks)

Level of Enzyme (%)	0.00	0.01	SEM	LOS
Live weight (g)	128.53	129.28	2.42	NS
Dressing %	76.62	79.76	1.97	NS
% Thigh	18.79	19.56	0.71	NS
% Breast	24.34^{b}	25.93^{a}	0.71	**
% Back	17.46	18.62	0.71	NS
% Wings	7.69	7.98	0.55	NS
% Neck	5.79	5.43	0.55	NS
% Gizzard+Proventriculus	3.31	3.23	0.35	NS
% Liver	2.26	2.46	0.35	NS
% Kidney	2.70	2.53	0.35	NS
% Heart	2.47	1.83	0.35	NS
% Lungs	1.27	1.24	0.07	NS
Intestinal length (cm)	68.09^{b}	70.98^{a}	0.87	*

^{ab}= means within rows differ significantly at P<0.01, %= percentage, SEM= Square error of means, LOS= Level of significance, Not significant.

Table 4.4.2: Carcass Characteristics of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (2 to 6 Weeks)

Level of RSC (%)	0	7.5	15	22.5	30	SEM	LOS
Liveweight (g)	122.79^{b}	122.79^{b}	129.66^{a}	130.49^{a}	130.71^{a}	3.42	**
Dressing %	95.91^{a}	95.91^{a}	73.54^{b}	73.89^{b}	75.70^{b}	2.77	**
% Thigh	18.18^{b}	18.18^{b}	20.78^{a}	18.47^{b}	19.23^{b}	0.61	**
% Breast	21.66^{b}	21.66^{b}	26.62^{a}	25.81^{a}	25.28^{a}	0.71	**
% Back	15.50^{b}	15.50^{b}	19.00^{a}	18.60^{a}	18.33^{a}	0.71	**
% Wings	8.02^{a}	8.02^{a}	8.46^{a}	7.20^{b}	7.53^{b}	0.35	**
% Neck	6.35^{a}	6.35^{a}	5.44^{b}	5.07^{b}	5.25^{b}	0.35	**
% Gizzard+Proventriculus	2.95^{b}	2.95^{b}	2.85^{b}	3.82^{a}	2.99^{b}	0.35	**
% Liver	2.85^{a}	2.85^{a}	2.24^{a}	2.38^{a}	1.90^{b}	0.35	**
% Kidney	3.70^{a}	3.70^{a}	2.01^{b}	2.60^{b}	2.46^{b}	0.35	**
% Heart	1.90	1.90	2.29	2.16	2.22	0.35	NS
% Lungs	1.90	1.90	1.10	1.00	1.14	0.57	NS
Intestinal length (cm)	64.05^{b}	64.05^{b}	71.36^{a}	69.59^{a}	69.54^{a}	2.87	*

^{ab}= means within rows differ significantly at P<0.01, %= percentage, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

The highest breast proportion and intestine length was obtained with enzyme supplemented diets. With the exception of %Heart and %Lungs, all other indices were significantly influenced by RSC inclusion. Live weight, Dressing %, %Breast, %Back and intestine length increased with increase in RSC inclusion, the highest weight were from 15-30% inclusion levels. While %Wings, neck, liver and kidney decreased with increasing levels of RSC. The proportion of empty gizzard+proventriculus was best at 22.5% inclusion rate while all other levels were statistically similar.

4.7 Effect of the interaction between Allzyme SSF® And RSC on carcass characteristics of Japanese Quails fed RSC based diets with or without Allzyme SSF® supplementation (2 to 6 Weeks)

The relative proportion of cut carcass parts to live weight of Japanese quail fed test diets is presented in Table 4.4.2. Interaction between enzyme and RSC showed significant variations ($p<0.01$) for all parts with the exception of Live weight and % Lungs. Dressing % was significantly superior in the diets containing enzyme where all RSC levels had similar values for this parameter and differed from the diet without enzyme supplementation. The highest means obtained was 78.07% (0.01% Allzyme SSF® and 30% RSM). % Thigh was highest (22.35) with enzyme supplementation and 7.5% RSC and differed from all other diets, this was followed by 15 and 30% RSC with Allzyme SSF® and 7.5, 15 and 22.5% without Allzyme SSF® diets which were similar. The least thigh proportion was with 22.5% RSC with Allzyme SSF® and 30% RSC without Allzyme SSF® respectively. Percent breast significantly varied with the effect of enzyme supplementation providing better breast proportion than its absence except for 7.5% RSC without enzyme supplementation.

Proportions of breast cut increased with increasing RSC levels with enzyme supplementation but decreased without it. Back (%) was highest (21.39) at 15% RSM with enzyme

Table 4.4.3: Effect of the Interaction between Allzyme SSF® and RSC on Carcass Characteristics of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (2 to 6 Weeks)

Level of Enzyme (%)			**0.00**					**0.01**				
Level of RSC (%)	**0.00**	**7.5**	**15**	**22.5**	**30**	**0.00**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Liveweight (g)	128.13	129.10	131.36	130.65	129.43	129.10	130.21	130.45	130.32	131.98	2.42	NS
Dressing %	73.04^{b}	72.28^{b}	69.01^{c}	72.43^{b}	73.33^{b}	72.28^{b}	74.79^{a}	74.83^{a}	75.35^{a}	78.07^{a}	1.77	**
% Thigh	18.00^{b}	19.20^{b}	19.33^{b}	18.99^{b}	18.42^{c}	19.20^{b}	22.35^{a}	19.10^{b}	17.95^{c}	20.03^{b}	0.71	**
% Breast	21.00^{c}	27.02^{a}	25.58^{b}	24.09^{b}	24.03^{b}	27.02^{a}	26.21^{b}	27.04^{a}	27.53^{a}	26.53^{a}	0.71	**
% Back	15.12^{c}	18.79^{b}	16.18^{c}	18.30^{b}	19.05^{b}	18.79^{b}	19.21^{b}	21.39^{a}	18.90^{b}	17.60^{bc}	0.71	**
% Wings	8.03^{b}	8.53^{a}	7.86^{a}	6.63^{c}	7.40^{b}	8.53^{a}	8.38^{a}	8.10^{a}	7.76^{b}	7.66^{b}	0.35	**
% Neck	6.33^{a}	6.22^{a}	5.94^{a}	5.14^{b}	5.34^{b}	6.22^{a}	4.66^{c}	5.93^{a}	5.00^{b}	5.15^{b}	0.35	**
% Gizzard+Proventriculus	2.93^{b}	2.91^{b}	3.44^{b}	3.42^{b}	3.89^{a}	2.91^{b}	2.79^{c}	4.07^{a}	4.21^{a}	2.09^{d}	0.35	**
% Liver	2.50^{a}	2.24^{a}	2.34^{a}	2.06^{a}	1.77^{b}	2.24^{a}	2.23^{a}	2.57^{a}	2.70^{a}	2.02^{a}	0.35	**
% Kidney	3.17^{a}	1.88^{b}	2.27^{b}	2.64^{a}	3.03^{a}	1.88^{b}	2.13^{b}	2.39^{a}	2.55^{a}	1.88^{b}	0.35	**
% Heart	1.92^{b}	2.45^{a}	2.84^{a}	2.84^{a}	2.34^{a}	2.45^{a}	2.13^{b}	1.55^{b}	1.48^{b}	2.09^{b}	0.35	**
% Lungs	1.91^{a}	1.12^{b}	1.17^{a}	0.99^{b}	1.17^{a}	1.12^{b}	1.07^{b}	1.12^{b}	1.01^{b}	1.11^{b}	0.07	*
Intestinal length (cm)	63.89^{c}	66.83^{b}	71.67^{a}	69.00^{b}	69.08^{b}	66.83^{b}	75.89^{a}	74.62^{a}	70.17^{a}	70.00^{b}	2.87	*

^{abcd}= means within rows differ significantly at P<0.01, %= percentage, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

supplementation and lowest at 15% RSM without enzyme supplementation. All other means were statistically similar. % wings cut and % neck cut were higher and similar for 7.5 and 15% RSC with or without Allzyme SSF® supplementation and differed from the other levels which were similar with the same trend. Proportion of Giblets showed no definite trends with the gizzard + proventriculus, while % Kidney were similar across all levels of RSC and enzyme with the exception of 30% RSC with no enzyme supplementation which had the least value. Percentage heart was similar for Allzyme SSF® supplemented diets and were lower than their converses which were also similar amongst themselves. Percentage Lungs showed almost similar pattern as % Heart with the exception of 22.5% RSC which were similar with the diets containing Allzyme SSF®. Intestinal lengths were significantly higher with the supplementation of Allzyme SSF® compared with diets not supplemented with it. Values ranged from 66.83cm (0.00 Allzyme SSF® and 7.5% RSC) to 75.89cm (0.01% Allzyme SSF® and 7.5% RSC).

4.8 Productive Performance of Laying Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Tables 4.5 and 4.5.1 show growth and economic performances of laying Quails fed diets containing RSC with or without enzyme supplementation. The single effect of both RSC and enzyme supplementation was not significant (P>0.05) on any of the productive performance of laying Japanese quail fed test diets. Total Feed intake and total protein intake were highest with enzyme supplemented diets while feed cost/dozen egg increased nominally without enzyme supplementation. Single effect of RSC did not indicate any linear trend with regards to feed intake and protein intake. Feed cost per dozen eggs decreased nominally with increasing RSC inclusion.

Table 4.5.1: Productive Performance of Laying Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 weeks)

Level of Enzyme (%)	0.00	0.01	SEM	LOS
Total Feed Intake (g)	2127.77	2181.07	169.82	NS
Average Daily Feed intake (g)	20.32	20.76	3.57	NS
Feed Conversion Ratio	5.55	5.56	1.97	NS
Feed cost/dozen egg (N)	41.91	41.89	8.53	NS
Total Protein Intake (g)	469.87	476.68	38.35	NS

SEM= Square error of means, %= percentage, LOS= Level of significance, NS= Not significant.

Table 4.5.2: Productive Performance of Laying Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 weeks)

Level of RSC (%)	0	7.5	15	22.5	30	SEM	LOS
Total Feed Intake (g)	1860.67	2237.77	2156.53	2262.25	2254.92	166.92	NS
Average Daily Feed intake (g)	17.89	21.12	20.77	21.54	21.47	2.77	NS
Feed Conversion Ratio	5.80	5.64	5.31	5.61	5.42	0.97	NS
Feed cost/dozen egg (N)	43.87	43.06	40.20	42.41	39.96	7.63	NS
Total Protein Intake (g)	405.87	487.91	478.84	497.70	496.08	37.39	NS

SEM= Square error of means, LOS= Level of significance, NS= Not significant

4.9: Effect of the interaction between Allzyme SSF® And RSC on Productive Performance of Laying Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

The effect of the interaction between RSC and Allzyme® levels on growth and economic performance is outlined in Table 4.5.2. All parameters measured indicated no significant differences (p>0.05) across all dietary treatment levels, however the highest total feed intake and total protein intake was with enzyme supplemented diets compared to non-enzyme diets. was highest at 0.00% enzyme supplemented with 22.5% RSC (6.01) and the least was 4.94 in 15% RSC and 0.00% enzyme. Feed cost/dozen egg ranged from 37.30 (15% RSM and 0.00% enzyme) to 44.81 (22.5% RSC with 0.00% enzyme).

4.10 Egg Production Performance of Japanese Quails Fed RSC based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Tables 4.6 and 4.6.1 show Egg production performance of birds fed the experimental diets. Age at first egg (AFE in days) and all other parameters measured were not influenced significantly (P>0.05) by the single effect of enzyme supplementation, however nominal differences indicated that birds fed enzyme supplemented diets reached sexual maturity faster than those without supplementation. Similar trend were observed in average egg weight, egg number, egg mass and average mortality.

Table 4.5.3: Effect of the Interaction between Allzyme SSF® and RSC on Productive Performance of Laying Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 weeks)

Level of Enzyme (%)			**0.00**					**0.01**				
Level of RSC (%)	**0**	**7.5**	**15**	**22.5**	**30**	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Total Feed Intake (g)	1805.8	2232.3	2150.12	2245.46	2205.18	1915.54	2243.24	2162.93	2279.03	2304.61	165.22	NS
Average Daily Feed intake (g)	17.19	21.25	20.81	21.38	20.99	18.58	20.99	20.59	21.69	21.94	1.57	NS
Feed Conversion Ratio	5.73	5.6	4.94	6.01	5.47	5.86	5.68	5.67	5.21	5.37	0.97	NS
Feed cost/dozen egg (₦)	44.3	43.22	37.3	44.81	39.9	43.43	42.9	43.1	40.01	40.01	7.3	NS
Total Protein Intake (g)	397.28	491.11	481.83	494	485.14	414.45	484.71	475.84	501.39	507.01	36.35	NS

%=percentage, SEM= Square error of means, LOS= Level of significance, NS= Not significant

Table 4.6.1: Egg Production Performance of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Level of Enzyme (%)	**0**	**0.01**	**SEM**	**LOS**
Age at first egg (days)	40.53	39.95	0.73	NS
Weight of first Egg (g)	7.87	7.59	0.46	NS
Average Egg Weight (g)	9.99	10.06	0.53	NS
Egg Number	42.76	43.12	5.53	NS
Egg Mass (g)	429.36	433.05	42.81	NS
Hen day production (%)	76.76	75.52	5.92	NS
Hen House Production (%)	74.47	73.59	5.55	NS
Average Mortality 6-20 Wks	2.21	1.47	0.42	NS

%= percentage, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

Table 4.6.2: Effect of Interaction on Egg Production Performance of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Level of RSC (%)	0	7.5	15	22.5	30	SEM	LOS
Age at first egg (days)	39.87[a]	39.00[a]	40.67[a]	40.00[a]	41.67[b]	0.68	*
Weight of first Egg (g)	7.17[c]	6.84[c]	8.06[b]	8.49[a]	8.11[b]	0.16	*
Average Egg Weight (g)	10.00	9.76	9.93	10.13	10.31	0.43	NS
Egg Number	37.75	42.82	45.56	45.50	43.10	3.53	NS
Egg Mass (g)	380.31	417.53	452.65	460.57	444.97	40.81	NS
Hen day production (%)	69.12	75.00	81.66	80.98	73.94	5.12	NS
Hen House Production (%)	68.50	74.96	75.03	77.05	74.63	3.55	NS
Average Mortality 6-20 Wks	3.02[c]	1.50[a]	1.00[a]	1.67[a]	2.00[b]	0.42	*

abc= means within rows differ significantly at P<0.05, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

The single effect of RSC inclusion indicated significant ($P<0.05$) variation in AFE, WFE and average mortality. AFE increased with increasing inclusion of RSC and birds not fed RSC based diets reached AFE faster though comparable with other inclusion levels except 30% with which it differed. The highest WFE was with 22.5% RSC inclusion rate and differed from other levels, while the least were in 0 and 7.5% inclusion rate. Mortality was lowest at 15% and was similar to 7.5 and 22.5% but differed from 30% which further differed from 0% inclusion rate.

4.11: Effect of the Interaction between Allzyme SSF® and RSC on Egg Production Performance of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 To 20 Weeks)

Egg production performance is outlined in Table 4.6.2. Age at first egg (AFE), Weight of first egg (WFE) and average mortality 6-20 weeks varied significantly ($p<0.05$) while all other parameters did not differ due to interaction between enzyme and RSC levels. The best (38.67, 40.00, 39.67 and 39.33 days) AFE were found in the enzyme supplemented groups with RSC 7.5 to 22.5% and 7.5% RSC without enzyme supplementation respectively. WFE were considerably lower in enzyme supplemented diets compared to zero supplemented diets. It ranged from 6.40g in 7.5% RSC and 0.01% enzyme to 8.60g in 22.5% RSC and 0.01% enzyme diets. Mortality rates were better in the enzyme supplemented diets while it was higher in the zero supplemented diets with values ranging from 0.67 (15% RSC and 0.01% enzyme) to 2.67 (30% RSC and 0.00% enzyme) with no definite trend across interaction levels.

Table 4.6.3: Effect of the Interaction between Allzyme SSF® and RSC on Egg Production Performance of Japanese Quails fed fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Level of Enzyme (%)	**0**					**0.01**						
Level of RSC (%)	**0**	**7.5**	**15**	**22.5**	**30**	**0**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Age at first egg (days)	39.67[a]	39.33[a]	41.33[b]	40.33[b]	42.00[c]	40.07[a]	38.67[a]	40.00[a]	39.67[a]	41.33[b]	0.53	*
Weight of first Egg (g)	7.13[c]	7.28[c]	8.36[a]	8.37[a]	8.23[b]	7.20[c]	6.40[d]	7.76[b]	8.60[a]	7.99[b]	0.16	*
Average Egg Weight (g)	9.95	9.88	9.90	9.98	10.25	10.05	9.63	9.96	10.28	10.37	0.43	NS
Egg Number	37.56	41.63	46.63	45.30	42.70	37.94	44.00	44.49	45.70	43.49	3.53	NS
Egg Mass (g)	378.42	411.58	462.25	453.09	441.44	382.20	423.47	443.05	468.05	448.49	40.81	NS
Hen day production (%)	68.78	74.36	83.62	82.76	74.29	69.47	75.64	79.70	79.20	73.58	5.12	NS
Hen House Production (%)	68.16	76.27	76.76	75.62	75.56	68.84	73.65	73.30	78.48	73.70	3.55	NS
Average Mortality 6-20 Wks	3.13[d]	1.67[b]	1.33[a]	2.33[c]	2.67[c]	3.03[d]	1.33[a]	0.67[a]	1.00[a]	1.33[a]	0.42	*

[abcd]= means within rows differ significantly at $P<0.05$, %= percentage, Wks= Weeks, SEM= Squre error of means, LOS= Level of significance, NS= Not significant.

4.12 Egg Quality Traits of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Tables 4.7 and 4.7.1 show the egg quality characteristics of Japanese quails fed the experimental diets. Across all internal and external egg quality characteristics, the supplementation or not of enzyme did not significantly (P>0.05) influence performance with the exception of egg specific gravity. The best egg specific gravity was obtained with enzyme supplementation and differed from its control.

The single effect of RSC inclusion showed significant (P<0.05) variations in egg weight, egg width and egg specific gravity on one hand and (P<0.01) in Albumen weight, Yolk height, yolk depth, shell thickness, shell weight and Haugh unit on the other hand. Egg weight, albumen weight and yolk depth increased linearly with increasing levels of RSC supplementation, egg width were better with 0 and 30% inclusion rates. Yolk height and shell thickness was highest with 22.5% inclusion. Shell weight showed better performance at 22.5 and 30% inclusion rates while Haugh unit were better at 0 – 15% inclusion rates but declined at higher inclusion rates (22.5 and 30%). Egg specific gravity was best without RSC inclusion rates and no apparent trend was observed within inclusion levels.

Table 4.7.1: Egg Quality Traits of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Level of Enzyme (%)	0.00	0.01	SEM	LOS
Egg Weight (g)	10.07	10.08	0.74	NS
Egg Length (mm)	3.15	3.17	0.42	NS
Egg Width (mm)	2.49	2.46	0.17	NS
Albumen Length (mm)	4.64	4.45	0.52	NS
Albumen Height (mm)	0.40	0.38	0.02	NS
Albumen thickness (mm)	1.64	1.64	0.57	NS
Albumen Weight (g)	5.55	5.47	0.28	NS
Yolk Height (mm)	0.88	0.87	0.06	NS
Yolk Depth (mm)	2.13	2.15	0.09	NS
Yolk Weight (g)	3.11	3.17	0.24	NS
Shell Thickness (mm)	0.69	0.69	0.05	NS
Shell Weight (g)	1.15	1.18	0.07	NS
Haugh Unit	60.24	60.33	0.69	NS
Egg Shape Index	0.79	0.79	0.20	NS
Egg Specific Gravity	1.09^{b}	1.10^{a}	0.00	*

%= percentage, mm= mili meter, SEM= Squre error of means, LOS= Level of significance, NS= Not significant.

Table 4.7.2: Effect of Interaction on Egg Quality Traits of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Level of RSC (%)	**0.00**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Egg Weight (g)	9.52^{b}	9.88^{b}	10.10^{a}	10.22^{a}	10.66^{a}	0.44	*
Egg Length (mm)	3.18	3.17	3.08	3.16	3.22	0.14	NS
Egg Width (mm)	2.56^{a}	2.43^{b}	2.43^{b}	2.44^{b}	2.52^{a}	0.06	*
Albumen Length (mm)	4.47	4.47	4.32	4.49	4.98	0.32	NS
Albumen Height (mm)	0.38	0.38	0.44	0.39	0.36	0.12	NS
Albumen thickness (mm)	1.59	1.61	1.62	1.57	1.81	0.57	NS
Albumen Weight (g)	5.17^{b}	5.42^{a}	5.49^{a}	5.69^{a}	5.80^{a}	0.28	**
Yolk Height (mm)	0.84^{c}	0.89^{b}	0.82^{d}	0.92^{a}	0.90^{b}	0.06	**
Yolk Depth (mm)	2.00^{b}	2.20^{ab}	2.16^{ab}	2.08^{b}	2.27^{a}	0.09	**
Yolk Weight (g)	3.02	3.08	3.11	3.09	3.42	0.34	NS
Shell Thickness (mm)	0.66^{e}	0.83^{b}	0.77^{d}	0.84^{a}	0.79^{c}	0.05	**
Shell Weight (g)	1.16^{b}	1.11^{d}	1.14^{c}	1.21^{a}	1.21^{a}	0.07	**
Haugh Unit	61.67^{a}	60.31^{a}	60.61^{a}	59.94^{b}	58.90^{b}	0.69	**
Egg Shape Index	0.81	0.78	0.80	0.78	0.79	0.17	NS
Egg Specific Gravity	1.11^{a}	1.09^{c}	1.10^{b}	1.10^{b}	1.09^{c}	0.00	*

^{abcd}= means within rows differ significantly (P<0.05, 0.01), %= percentage, mm= mili meter, SEM= Squre error of means, LOS= Level of significance, NS= Not significant.

4.13: Effect of the interaction between Allzyme SSF® and RSC on Egg Quality Traits of Japanese Quails fed RSC Based Diets with or without Allyzme SSF® Supplementation (6 to 20 Weeks)

Effect of interaction on egg quality parameters is described in Table 4.7.2. Egg length; Albumen thickness and ESI were not significantly influenced by interactions. Egg Weight and Width were significantly ($p<0.05$; 0.01) better in the zero enzyme RSC based diets than the enzyme supplemented RSC based diets. The highest weight and width 10.91g and 2.53mm were found in 0.01 Allzyme SSF® and 30% RSC diet. Albumen length was highest (5.06mm) with diet containing 30% RSC with no Allzyme SSF® supplement and was similar to 7.5% RSC with no Allzyme SSF® supplementation and 4.89mm obtained in diet containing 30% RSC with Allzyme SSF®, all other diets were similar and ranked lower. Albumen weight and Shell Weight were similar for all interactions but differed from diet containing 7.5% RSC with Allzyme SSF® which had significantly lower value (5.19g and 1.09g), the highest mean (5.80g and 1.25g) was obtained in 30% RSC and Allzyme SSF® containing diet.

Yolk height (mm) were significantly lower in the enzyme containing RSC diets compared to the non-enzyme containing diet with the exception of 15% RSC with no Allzyme SSF® diet which had the least (0.80mm) value. Yolk depth was comparatively similar for all diets but differed from diet containing 25% RSC without enzyme supplementation with the least value (2.02mm). Yolk Weight (g) did not indicate a clearly defined pattern of difference between enzyme levels however, diets with no enzyme supplementation had higher number of relatively higher weights than diets containing enzyme. Shell thickness varied across all dietary combinations, the highest value (0.87mm) was obtained in 22.5% RSC with Allzyme SSF® and the least (0.75) was obtained in 15% RSC with Allzyme SSF® diet. Haugh unit ranged from 57.98 (30% RSC with Allzyme SSF®) to 61.31 (7.5% RSC with Allzyme SSF®), while ESG was better with Allzyme SSF® containing diet with 1.10 (15 and 22.5% RSC with Allzyme SSF®) than without Allzyme SSF® supplementation.

Table 4.7.3: Effect of the Interaction between Allzyme SSF® and RSC on Egg Quality Traits of Japanese Quails fed RSC Based Diets with or without Allzyme SSF® Supplementation (6 to 20 Weeks)

Level of Enzyme (%)		**0**					**0.01**					
Level of RSC (%)	**0.00**	**7.5**	**15**	**22.5**	**30**	**0.00**	**7.5**	**15**	**22.5**	**30**	**SEM**	**LOS**
Egg Weight (g)	9.43^{b}	10.13^{a}	10.25^{a}	10.13^{a}	10.40^{a}	9.62^{b}	9.62^{b}	9.94^{b}	10.31^{a}	10.91^{a}	0.44	*
Egg Length (mm)	3.15	3.12	3.11	3.17	3.20	3.21	3.21	3.04	3.14	3.24	0.12	NS
Egg Width (mm)	2.53^{a}	2.48^{a}	2.47^{a}	2.44^{a}	2.51^{a}	2.52^{a}	2.37^{b}	2.38^{b}	2.43^{a}	2.53^{a}	0.07	*
Albumen Length (mm)	4.43^{b}	4.69^{a}	4.46^{b}	4.55^{b}	5.06^{a}	4.52^{b}	4.24^{b}	4.18^{b}	4.42^{b}	4.89^{a}	0.22	*
Albumen Height (mm)	0.38^{b}	0.32^{d}	0.46^{a}	0.42^{b}	0.40^{b}	0.39^{b}	0.43^{a}	0.41^{b}	0.36^{c}	0.31^{d}	0.02	**
Albumen thickness (mm)	1.57	1.68	1.61	1.54	1.78	1.60	1.53	1.62	1.59	1.84	0.57	NS
Albumen Weight (g)	5.12^{b}	5.64^{a}	5.48^{a}	5.74^{a}	5.79^{a}	5.22^{b}	5.19^{b}	5.49^{a}	5.63^{a}	5.80^{a}	0.28	**
Yolk Height (mm)	0.83^{b}	0.92^{b}	0.80^{f}	0.94^{a}	0.90^{c}	0.85^{b}	0.86^{d}	0.84^{e}	0.89^{c}	0.90^{c}	0.06	**
Yolk Depth (mm)	1.98^{b}	2.25^{a}	2.15^{a}	2.02^{b}	2.27^{a}	2.02^{b}	2.15^{a}	2.16^{a}	2.14^{a}	2.27^{a}	0.09	**
Yolk Weight (g)	2.99^{bc}	3.14^{a}	3.19^{a}	3.00^{b}	3.25^{a}	3.05^{b}	3.01^{b}	3.03^{b}	3.18^{a}	3.59^{a}	0.24	**
Shell Thickness (mm)	0.66^{d}	0.81^{c}	0.77^{f}	0.81^{c}	0.78^{e}	0.77^{c}	0.84^{b}	0.75^{g}	0.87^{a}	0.80^{d}	0.05	**
Shell Weight (g)	1.15^{a}	1.13^{a}	1.12^{a}	1.17^{a}	1.16^{a}	1.17^{a}	1.09^{b}	1.16^{a}	1.24^{a}	1.25^{a}	0.07	**
Haugh Unit	61.06^{a}	59.29^{b}	60.61^{a}	60.41^{a}	59.81^{b}	62.28^{a}	61.31^{a}	60.61^{a}	59.47^{b}	57.98^{c}	0.69	**
Egg Shape Index	0.80	0.81	0.80	0.77	0.79	0.82	0.74	0.80	0.79	0.78	0.04	NS
Egg Specific Gravity	1.10^{a}	1.09^{b}	1.09^{b}	1.09^{b}	1.09^{b}	1.10^{a}	1.09^{b}	1.10^{a}	1.10^{a}	1.09^{b}	0	*

^{abcdefg}= means within rows differ significantly at P<0.01; P<0.05, %= percentage, mm= mili meter, SEM= Square error of means, LOS= Level of significance, NS= Not significant.

CHAPTER FIVE

5.0 DISCUSSION

5.1: Proximate Composition of Roselle Seed Cake

Crude protein value of 25.38% observed for RSC in this study agrees with the findings of Isidahomen *et al*. (2006) and Kwari *et al*. (2011) that the seed cake of Roselle contains between 21.40-38.57% crude protein. Observed Ether Extract value of 5.78 % differed from the value 17.43% reported by Muhktar (2007). However, dry matter (%) of 91.80% agreed with the value reported by this author. Crude fibre (%) value of 10.20 obtained was slightly below that of 11.98% while Ash (%) of 8.03 was higher than 5.34 reported by Mukthar (2007). Also the Metabolizable energy value of 2885.00 Kcal/Kg obtained agreed with the range of 2880-3500 Kcal/Kg reported by various authors (Isidahomen *et al*., 2006; Muhktar, 2007; Diarra *et al.,* 2011 and Kwari *et al*., 2011). Variations in values obtained could be attributed to different sources of the seed and different post-harvest and storage conditions such as moisture content, temperature and humidity of store house etc. that the seeds might have undergone before procurement and handling by different investigators.

5.2: Growth Performance of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation (2-6 Weeks)

The range of 141.71g – 149.66g for final body weight at the sixth week obtained in this study agrees with the findings of Sezer and Tarhan (2005) and Ngele *et al*. (2011) who reported a range of 134.50g to 154.80g for all sexes of white, brown and wild quails fed 24% CP diet at 36 days of age. However, it fell below the range of 152.26g – 159.45g reported by Eleftherios *et al*. (2010) and 167.6g reported for Italian quails (Almeida *et al*., 2002). However, the range obtained was comparatively higher than the value of 101.40g for Japanese quail in the same experiment at 35 days old. Final weight were also comparatively higher than the range of 98.15 - 140.59g reported for Quails (2-6 weeks) fed enzyme supplemented diet (Makinde, 2012), however differences in mean response to dietary treatments due to test ingredient interactions obtained agreed with the findings of the same author. Differences in experimental setup, diet composition and source of experimental animals may be chiefly responsible for observed variations. Higher final weight and consequently average daily weight gain (g/day) observed in birds fed diets 4 and 5 was associated with higher levels of test material supplementation (22.50% RSC+0.01% Enzyme and 30.00% RSC+0.01% Enzyme) whereas such levels of RSC without exogenous enzyme supplementation had the least value in these traits along with the control group. This agrees with reports on the impact of exogenous enzyme supplementation on growth performance of farm animals in general. Such impact as cited includes but is not limited to improvement of the nutritive value of feed stuffs (Munir and Maqsood, 2013); reduction in the variability in nutritive value between feedstuffs and improving the accuracy of feed formulations (Pariza and Cook, 2010). The observation in this experiment is at variance with the negative response of dietary feeding of graded levels of Roselle seed in broiler chicks reported by Mukthar (2007) this may be due principally to the effect of enzyme supplementation not the specie of animal used.

Although no significant differences were noted in feed cost, feed:gain, feed-cost:gain, protein intake and protein efficiency ratio (PER), numerically higher means were found in all RSC based diets with or without enzyme supplementation supporting the assertion of Mukhtar and Bakheit (2012) who reported that the addition of Xylam enzyme to 15% roselle seed based diet improved feed intake compared to broiler chicks fed the seed without enzyme supplementation. However, they all compared with the control diet. This summation did not agree with the findings of Mukthar (2007) who reported decrease in feed intake, weight gain and feed conversion with the increase of Roselle seed in the diets but agreed with reports of Kwari *et al*. (2010) who reported no adverse effects of feeding raw roselle seed on feed intake, growth and feed conversion of cockerels and Kwari *et al*. (2011) who replaced soybean meal with raw roselle seed meal at 0.0, 25.0, 50.0, 75.0, and 100.0% in broiler diets and reported a decreased performance (feed intake, weight gain, and feed conversion ratio) only above 50.0% replacement.

Mortality ratio during the first four weeks did not follow a particular trend though it showed differences. However, these differences could not be attributed to the presence or absence of RSC in the diets when they were compared without interaction effects. Interaction effects showed reduction in mortality rate by enzyme supplementation with increasing RSC levels up to 22.5% and the average mortality at 30% RSC with enzyme supplementation was lower than that of 22.5% RSC without enzyme supplementation this may be due to the action of the enzyme deactivating residual antinutritional factors that might have remained in RSC after processing. This completely agreed with the findings of Mukthar (2007) who stated that increasing levels of Roselle seed in the diet did not influence mortality rate in broiler chicks and Damang and Guluwa (2009) who included up to 30% raw roselle seed meal in the diet of broiler chickens and reported no adverse effects on the performance of the birds during starter or finisher phase.

5.3: Nutrient Retention Performance of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation

From the observation in table 4.3.2, the best performance in all retention traits were noticed with the diets containing RSC without Allzyme® supplementation between levels 15% and

22.5% while the least were obtained in RSC based diets at 30% with Allzyme® and 7.5% without Allzyme®, this apparently does not follow any known literature pattern. It would have been expected that the presence of the exogenous enzyme will enhance retention better than without it (Slominski, 2006), however, unaccounted for factors could have been responsible for this observation. However, studies on interaction showed better impact of enzyme supplementation on nutrient retention and this agreed with the observation of Makinde (2012) that better retention existed with enzyme supplemented diets containing two major fibre sources as test ingredients. Further studies on the interaction between exogenous enzyme and RSC may serve to give clearer light.

5.4: Carcass Characteristics of Japanese Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation

Carcass Weight range of 69% - 78% despite the variability in live weight between diets containing the test ingredients and the control agreed with the findings of Eleftherios *et al*. (2010) who reported a range of 57.70% - 78.37% as carcass dressing % when Japanese quails were fed Mannan oligosaccharides and calcium propionate as feed additives. Values ranging from 65.20% - 77.00% have been reported by El-Fiky, 1991; Kosba *et al*., (2001) and cited by Aboul-Seoud (2008). Carlson *et al*., (1975) reported that the most important factors affecting dressing percentage are breed, body size, and age at slaughter, sex, and nutrition during the growing period, time of fattening and the processing procedures. However, there was no difference in live weight due to factor interaction as reported by Makinde, (2012). A clear trend of higher carcass proportion due to interaction between Allzyme SSF® and RSC was established in this study compared to the absence of enzyme in the diets. This observation agrees with the findings of Mukhtar and Bakheit (2012).

Significant ($p<0.01$) differences in the proportion of thigh, breast and back to carcass weight (%) among dietary treatments did not agree with the findings of Eleftherios *et al*. (2010), though ranges were similar for these parameters. Most literature reports however, presents studies on cut parts on weight basis, which makes it difficult to find basis for comparison. However, it is observed that the primal cuts such as breast, thigh and back of treatments containing the test ingredients were better than those observed for the control diet Also, those diets containing RSC and Allzyme SSF® had better primal cuts than diets with no Allzyme SSF®. Other cut up parts such as wings and neck and organs namely liver, kidney, heart and gizzard+proventriculus with lungs varied with no particular pattern between the control and the test diets, even among interaction levels.

Intestinal length was measured because of the fibre level of roselle seed. It is expected to increase with the increasing level of RSC supplementation. There was no apparent trend. However, l intestines were significantly longer in quails fed supplemented or unsupplemented RSC compared to the control. This is in consonance with the plethora of reports that fibre content of diets is related to length of intestine and also the longer the small intestine, the larger the area available for nutrient absorption to the animal, hence better utilization is ensured. These observations may support the assertions of Montagne *et al.* (2003) who indicated that some fibre sources when used in adequate quantities may enhance intestinal development and hence, some productivity indicators. Praes *et al*. (2011) in an interactive study between varying protein and dietary fibre levels concluded that diet with no fibre addition encouraged the best intestinal development parameter results in the duodenum; while in the jejunum and ileum, diets with the addition of fiber resulted in better intestinal development. Diets containing RSC and Allzyme SSF® were better for this trait compared to non-enzyme containing diet, this was in agreement with the findings of Makinde (2012) that significant differences existed due to interaction effect and addition of enzyme; apparently, this may be due to the effect of the enzyme on general nutrient utilization including but not limited to better fibre utilization which enhances growth and hence intestinal development and not necessarily due to raw fibre effect on the length of the small intestine.

5.5: Performance of Laying Quails Fed RSC Based Diets with and without Allzyme SSF® Supplementation

The range of 17.19g – 21.95g for average daily feed intake were comparably lower than the report of 20.94g - 27.30g (Makinde, 2012) but closer to the observations of Tuleun *et al*. (2013) who reported 14.01 to 22.15 for varying protein levels, while Bawa *et al*. (2011) reported higher (23.58 – 28.87) values than these. Variations in feed intake among these studies may be attributed to differences in the prevailing maximum ambient temperatures and relative humidity at the various locations and also the type of feeder and form of offered feeds. However, it is noteworthy that increasing RSC level did not adversely affect feed intake in this study and egg laying performance were commensurate with feed intake parameters.

Although there was no significant difference observed among dietary treatments for feed:Gain, the range of 4.94 to 6.01 were better than 6.07 – 8.45 reported by Makinde (2012). Also observation of significant differences in Feed:Gain by this author varied with what was observed in this study, pointing to the fact that birds fed RSC based diets ate less to produce more eggs.

Feed cost/dozen egg (N) ranged from 37.30 to 44.80. There values were higher than 30.75 - 37.81 reported by Makinde (2012) and also observation of no difference was at variance with this author's report probably due to the fact that he used fibrous feed stuffs which were cheaper than seed cakes as test ingredient. However all RSC based diets in this study compared favorably with the control in this regard. It is therefore important to consider this parameter in the light of the statement that the best ration from the biological point of view is determined by the highest yield per unit feed consumed regardless of the amount of feed consumed. This confirms the report of Oruwari *et al*. (2003) and Fanimo *et al*. (2007) who suggested that the unit cost of feed used in producing a dozen or crate of egg should be given more importance rather than the least cost diet. There was no clear trend between diets due to interaction of test ingredients.

5.6: Egg Production Performance of Laying Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation

Age at first egg (AFE) is adjudged best as the bird that comes into lay earliest. AFE range of 38.69 days – 42 days were within range reported in literature for Japanese quails. Sezer (2007) who had reported mean value of 39.7 days and a range of 25-69 days. Similarly Mizutani (2003) had stated that the average normal data for Age at sexual maturity (ASM) was 38 to 42 days of age in Japanese quails. The importance of early sexual maturity in any farm animal is that it has a longer reproductive life and hence ability to produce more offsprings. The effect of the interaction between Allzyme SSF® supplementation and RSC as opposed to its lack is clearly indicated in the early sexual maturity of birds fed diets containing both ingredients.

The range of Average egg weight (g) of 9.64 to 10.37 in the present study was higher than a range of 9.07 to 9.14 reported by Ngele *et al*. (2011) but compared favourably well with the result of Babangida and Ubosi (2006) who recorded 9.51g egg weight when quails were fed 20% CP diet which was not significantly different from birds fed 22% CP (10.13g). This shows that at 20% CP, egg weight of quails is not compromised.

The observed egg number of 37.56 to 45.60 agreed with the findings of Havenstein *et al.* (1988 as cited in Aboul-Seoud, 2006) that average egg production ranged between 37.60 and 57.70 eggs during the first 60 days of production but differed from the records of 58.12 and 62.82 eggs reported by (Abdel-Mounsef, 2005).

Egg mass or total egg weight (g) is an assessment of egg weight produced during short periods of the production curve. The range of 378.42g to 468.05g obtained in this study agreed with the findings of Abdel-Mounsef (2005) who reported estimates between 451.20 and 469.30g. The observed superiority of the RSC based diets with or without Allzyme® supplementation over control diet may be a pointer to the suitability of RSC as an unconventional feed stuff for egg production in quails.

Though Hen day production (%) (HDP) did not differ across treatments, yet it was observed that values obtained for diets containing RSC with or without Allzyme SSF® supplementation were numerically superior to the control diet. The value for HDP which fell between 68.78 and 78.48 were lower than the findings 73.04 to 92.18% reported by Akpodiete (2008) for chickens when he replaced palm kernel cake for maize in layer diets with different levels of enzyme supplementation. However, it fell within the range of 69.67 to 86.33 reported by Tuleun *et al*. (2013) for quails fed varying levels of dietary protein. Observations of dietary differences in this parameter were in consonance with the observation of these authors.

Hen House Production (%) (HHP) differed and showed the superiority of RSC based diets with or without Allzyme SSF® supplementation over the control diets as also evidenced in the mortality ratio where the control diet had the highest mortality accounting for reduction in HHP. The range of 68.16 to 83.62 agreed with the report of 69.00 to 81.67 % reported by

Tuleun *et al.* (2013). However, this difference was not observed on the interaction table for this characteristic.

Makinde (2012) reported comparable performance between the control and the test ingredient based diets for these traits though there were no significant differences. It can thus be inferred that as long as the unconventional feedstuff does not significantly influence mortality compared to the control diet, HHP and HDP are not likely to differ and so such ingredients can conveniently replace conventional feed ingredients.

An overview of the dietary treatments showed that the diet containing 22.5% RSC and 0.01% Allzyme SSF® supplementation was superior in most egg production traits measured. This and previous observations however, did not support the findings of Kwari *et al.* (2011) that 12% of dietary Roselle seed (raw or processed) did not significantly influence egg production characteristics in chickens.

5.7: Egg Quality characteristics of Laying Quails Fed RSC Based Diets with or without Allzyme SSF® Supplementation

Observed 9.43 – 10.91 range for egg weight (g) were higher than the values 8.25 – 9.78 reported by Tuleun *et al*. (2013). Also the significant differences obtained were not in agreement with the observation of no difference reported (Akpodiete, 2008 and Tuleun *et al*., 2013). However, this may just be a partial evaluation of RSC based diets on egg weight parameter in Japanese quails as differences in experimental compositions and designs in comparable literatures do not furnish exact bases for comparison. Ranges (2.37 – 2.53) of egg width observed were comparatively higher than the range 2.11 - 2.18 (Tuleun *et al*., 2013) while significant difference observed in this study agreed with the findings of the same author.

Albumen height obtained in this study were higher than 0.24 – 0.27 reported by Tuleun *et al*. (2013). Variations in egg quality parameters (internal and external) are influenced by plethora of factors, hence comparing observed results with previous studies may not prove or disprove much, however thickness of albumen is indicative of viscosity and freshness of the egg. Albumen weight and yolk weight ranges of 5.12g – 5.80g and 2.99g - 3.59g in this study were comparatively higher than the values of 4.84g – 5.11g and 3.11g - 3.26g reported by Makinde (2012) and observed significant ($p<0.05$) difference across treatment with better performance in RSC based diets were at variance with the observation of Makinde (2012) who reported no significant dietary effect on egg quality traits. Observations on shell thickness (0.25 to 0.37 mm) were higher than the range 0.24 – 0.28 reported by Makinde (2012) and Tuleun *et al*. (2013). Observed differences were in consonance with Tuleun *et al*. (2013) but differed from the summation of Makinde (2012). Haugh Unit (HU) ranges of 57.38 to 61.31 were comparatively lower than 69.83 to 70.11 reported by Makinde (2012). As an indicator of egg freshness, HU values obtained in this result were low but significant dietary influences existed contradicting the report of no significance by Makinde (2012).

Range of egg shell index (ESI) 0.74 – 0.81 was similar to the report of 0.76 – 0.79 by Tuleun *et al*. (2013) and also the absence of significant ($p>0.05$) differences were in accord with the observation of this author and Akpodiete (2008) who reported no difference in ESI for pullets fed varying levels of enzyme supplemented palm kernel cake based diets as replacement for maize.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

An experiment was conducted to evaluate the growth and laying performance of Japanese quails fed roselle (*Hibiscus sabdariffa* L) seed cake based diets with or without Allzyme SSF® supplementation by allotting 540 day old and 270 six-week old quails in a completely randomized design (CRD) using a 5 x 2 factorial with 3 replicates arrangement. Proximate analysis of the mechanically extracted RSC was carried out and values obtained were used in determining the calculated analysis of feed compounded. Feeding trials were grouped into two phases as growth (2 to 6 Weeks of age) and egg laying trial (6 to 20 Weeks of age).

The birds were weighed and fed the control diets shown in Tables 3.1 and 3.2 during a two-week adjustment period before experimental trial. Proximate composition of RSC, growth performance, digestibility trial and carcass characteristics indicators were measured at the growth phase while reproductive, egg production with economics of production and egg quality measures were monitored at the egg phase.

Data obtained from the study were subjected to Analysis of Variance and significant differences among treatment means were compared using the Duncan Multiple Range Test. Obtained results showed proximate composition of RSC with dry matter (%) of 93.68; crude protein (%) was 25.38, ether extract (%) 5.78, crude fibre (%) 10.20, ash (%) 8.03 and nitrogen free extract (%) 50.61. Metabolizable energy (ME) was determined as 2885.00Kcal/Kg.

At the growth phase, higher final weight and consequently average daily weight gain (g/day) observed in birds fed diets 9 and 10 was associated with higher levels of test material supplementation (22.50% RSC+0.01% Enzyme and 30.00% RSC+0.01% Enzyme) whereas such levels of RSC without exogenous enzyme supplementation had the least value in these traits along with the control group. No significant differences were noted in feed cost, feed: gain, feed-cost: gain, protein intake and protein efficiency ratio (PER).

Mortality percentage during the first four weeks did not follow a particular trend though it showed differences. However, these differences could not be attributed to the presence or absence of RSC in the diets when they were compared without interaction effects. Interaction effects showed reduction in mortality rate by enzyme supplementation with increasing RSC levels up to 22.5% and the average mortality at 30% RSC with enzyme supplementation was lower than that of 22.5% RSC without enzyme supplementation.

Nutrient retention was observed to be better in diets with RSC but no enzyme compared to its converse, while carcass characteristics studies indicated higher carcass proportion due to interaction between Allzyme SSF® and RSC compared to the absence of enzyme in the diets. Also longer intestines were confined to RSC containing diets with or without enzyme supplementation, while the least was observed on the control diet.

Egg laying phase revealed that in Feed cost/dozen egg (₦), all RSC based diets in this study compared favorably with the control; early age at sexual maturity was favoured by diets containing both RSC and enzyme, average egg weight, egg number and egg mass, HDP and HHP and mortality ratio showed better performance of diets containing RSC compared to the control group.

Egg quality characteristics showed comparable to superior performance of RSC containing diets to the control diets, no definite impact of the presence or absence of supplemented enzyme could be established in the study though interaction effects were established.

Generally, it was observed that enzyme supplementation did not create great disparity in performance, but the single effects of RSC without supplementation were comparable to those supplemented. It shows therefore that RSC could be used safely in Quail nutrition. However interaction studies indicate sublime synergistic effect from the combination of both RSC and enzyme on all performance indices.

6.2 Conclusions

From this study, the following conclusions are drawn:

There exist practical merits for the replacement of groundnut cake with mechanically crushed RSC in the nutrition of Japanese quails as evidenced by the comparable to superior performance of birds fed diets containing RSC for growth, nutrient retention and carcass traits. Enzyme supplementation also revealed synergistic effect for most studied traits at the growth phase.

Age at sexual maturity and other egg production characteristics, feed intake parameters and economics of egg production were superior in performance for RSC with or without enzyme supplementation than the control group, however, significant interactive effect were established between RSC and enzyme supplement.

The feeding of RSC with or without enzyme supplementation had no adverse effect on survivability at the growing and laying phase. Egg quality characteristics were comparable across dietary groups and no adverse effect of RSC substitution for maize was established on internal egg quality.

Mechanically crushed RSC can be safely fed with or without enzyme supplementation to Japanese quails to reduce cost of production and improve their productivity.

The best level of RSC supplementation based on observed performances was at 22.50% inclusion.

6.3 Recommendations

RSC inclusion at 22.50% with enzyme supplementation is recommended as the best factor combination for Japanese quail nutrition for growth, egg production and egg quality performance.

Contribution to Knowledge

This study has established that RSC could be used successfully with or without enzyme supplementation as both protein and energy source replacement for conventional feed stuffs in order to reduce cost of production without compromising productivity in Japanese quail farming.

REFERENCES

Abdel-Mounsef, N.A. (2005). Non genetic factors affecting some productive traits in Japanese quail. M.Sc. Thesis Faculty of Agriculture, Al-Azhar University Cairo, Egypt.

Aboul-Seoud, D.I.M. (2008). Divergent selection for growth and egg production traits in Japanese quail. Ph.D thesis submitted in the Faculty of Agriculture, Animal Production Department, Al-Azhar University Cairo, Egypt.

Abu El, G., Mohammed, A.Y., Mohammed, A. and Asma, A.A. (2008). Effect of soaking, sprouting and cooking on chemical composition, bioavailability of minerals and in vitro protein digestibility of Roselle (*Hibiscus sabdariffa* L.) seed. *Pakistan Journal of Nutrition*, 7(1): 50-56.

Abu-Tarboush, H.M., Ahmed, S.A.B. and Al Kahtani, H.A. (1997). Some nutritional and functional properties of Karkade (*Hibiscus sabdariffa*) seed products. *Cereal Chemistry,* 74(3): 352-355. http://dx.doi.org/10.1094/CCHEM.1997.74.3.352.

Abu-Tarboush, H.M. and Ahmed, S.A.B. (1996). "Studies on karkade (*Hibiscus sabdariffa*): Protease inhibitors, phytate, in vitro protein digestibility and gossypol content". *Food Chemistry* 56(1): 15-19.

Acamovic, T. and Stewart, C.S. (2000). Plant phenolic compounds and GIT micro-organisms. In: Tannins in Livestock and Human Nutrition. *Proceedings of an International Workshop,* Adelaide Australia, Page 127-129.

Adebiyi, O.A., Ologhobo, A.D., Adu, O.A. and Olasehinde, T.O. (2010). Evaluation of the nutritional potentials of physically treated cowpea seed hulls in poultry feed. *Emirate Journal of Food Agriculture*, 22: 232-239.

Adeniji, A.A. and Balogun, O.O. (2002). Utilization of flavour treated blood-rumen content mixture in the diets of laying hens. *Nigerian Journal of Animal Production*, 29 (1): 34-39.

Adeola, O. and Olukosi, O.A. (2008). Opportunities and challenges in the use of alternative feedstuffs in poultry production. *Nigerian Poultry Science Journal*, 5(4): 147-155.

Adigun, J.A. (2003). Effect of Intra-row spacing and weed control on growth and yield of Roselle (*Hibiscus sabdariffa*) in Southwest Nigeria. *Asset Series A.* 3(2): 91-98.

AFRIS, (2004). Animal feed resources information system. On line source http://www.fao.org/ag/aga/AGAP/FRG/AFRIS/DEFAU LT.HTM. accessed 12/10/2014.

Akanya, H.O., Oyeleke, S.B., Jigam, A.A. and Lawal, F.F. (1997). Analysis of sorrel drink. *Nigerian Journal of Biochemistry,* 12:77-79.

Akpodiete, O.J., Eruvbetine, D. and Gagiyovwe, E.E. (2008). Effect of Enzyme supplementation on palm kernel based diets on broiler chicken Performance. *Nigerian Poultry Science Journal,* 4: 39-46.

Aletor, V.A. (1993). Cyanide in gari 1: Distribution of total, bound and free hydrocyanide acid in commercial gari, and the effect of fermentation time on residual cyanide content. *International Journal of Food Science and Nutrition*, 44: 281-287.

Almeida, R.G., de-Nascimento Junior, D., do-Euclides, V.P.B., Macedo, M.C.M., Regazzi, A. J., Brancio, P. A., Fonseca, D. M. da., Oliveira, M. P., (2002). Animal production of mixed pastures under three stocking rates in the Brazilian Savannah. *Revire Brasille Zootec*hnology, 31(2):852-857.

Altinel, A., Gunes, H., Kirmizibayrak, T., Corekci, S.G. and Bilal, T. (1996). The studies on egg quality characteristics of Japanese quails *Veteriner Fakultesi Dergisi Istanbul.* 22: 203-213.

Alu, S.E. (2012). Nutrient digestibility and serum biochemistry of laying quails *(Cortunix cortunix japonica*) fed sugarcane scrapping meal-based diets supplemented with exogenous enzyme. IOSR *Journal of Agriculture and Veterinary Science,* 1(5): 29-35. ISSN: 2319-2380, ISBN: 2319-2372.

Alu, S.E., Kaankuka, F.G. and Oluremi, O.I.A. (2009). Effects of Nutrase Xyla® enzyme supplementation on nutrient digestibility by weaner pigs fed low or high fibre diets. *Production Agriculture and Technology Journal,* 5(2): 327-334.

Al-Wandawi, H., Al-Shaikhly, K. and Abdul-Rahman, M. (1984). Roselle seed: A new protein source. *Journal of Agricultural and Food Chemistry*, 32: 510-512.

Angel, R., Saylor, W. W., Mitchell, A. D., Powers, W. and Applegate, T.J. (2006). Effect of dietary phosphorus, phytase and 25-hydroxycholecalciferol on broiler chicken bone mineralization, litter phosphorus, and processing yields. *Poultry Science,* 85: 1200-1211.

Anon,(1991). Little known animals with promising economic future (Micro-livestock). *Board of Science and Technology for International Development,* National Academy Press, Washington D.C. Page 147-155.

Ao, T., Pierce, J.L., Hoskins, B., Paul, M., Pescatore, A.J., Cantor, A.H., Ford, M.J. and King, W.D. (2010). Allzyme SSF® increased AMEn of the corn-soy diet and improved performance of broilers. *Poultry Science*, 85: 1200-1211.

AOAC. (1990). The official method of analysis. Association of Official Analytical Chemists, 13th Edition. Washington, DC.

Applegate, T.J., Joern, B.C., Nussbaum-Wagler, D.L. and Angel, R. (2003). Water-soluble phosphorus in fresh broiler litter is dependent upon phosphorus concentration fed but not on fungal phytase supplementation. *Poultry Science*, 82: 1024-1029.

Ari, M.M. and Ayanwale, B.A. (2012). Nutrient retention and serum profile of broilers fed fermented African Locust Beans (*Parkia filicoide*). *Asian Journal of Agricultural Research,* 6(3): 129-136. DOI: 10.3923/ajar.

Ari, M.M., Ayanwale, B.A., Adama, T.Z. and Olatunji, E.A. (2012). Effects of different fermentation methods on the proximate composition, amino acid profile and some antinutritional factors (ANFs) in Soybeans (*Glycine Max*). *Fermentation Technology and Bioengineering,* 2: 6-13.

Ari, M.M., Ogah, D.M., Hassan, I.D., Musa-Azara, I.S., Yusuf, N.D. and Alu, S.E. (2013). Effects of utilization of crushed, boiled and fermented Roselle Seeds (*Hibiscus sabdariffa*) on the Performance of broiler chickens. *British Biotechnology Journal,* 4(1): 4-11. www.sciencedomain.org

Aruna, M.B., Isidahormen, C.E., Girgiri, Y.A. and Olawole, A. (2007). Performance and heamatological parameters of rabbits fed graded levels of sorrel seed (*Hibiscus sabdariffa*) meal as a replacement for groundnut cake. *Research Journal of Animal Science*, 1(3): 111-113.

Atteh, J.O. (2002). Versatility of Nutrase xyla® as a feed additive for monogastric animals. Paper presented at the 4th Annual seminar of Bio – Ingredient Limited.

Babangida, S. and Ubosi, C.O. (2006). Effects of dietary protein levels on the performance of laying Japanese quails (*Coturnix coturnix japanica*) in a semi-arid environment. *Nigerian Journal of Animal Production*, 33(1): 45-52.

Bacon, W.L. and Nestor, K.E. (1983). Divergent selection for body weight and yolk precursor in *Coturnix coturnix japonica*. 4–Correlated responses in carcass composition and carcass yield of progeny during growth. *Poultry Science*, 62: 537 – 544.

Bakheit, M.H.E. (1993). The nutritional value of Roselle meal (*Hibiscus sabdariffa*) in laying hens diets. M.Sc Thesis submitted to the Faculty of Animal Production University of Khartoum.

Bawa, G.S., Lombin, L.H., Karsin, P., Musa, U., Payi, U.E. and Shamaki, D. (2011). Responses of Japanese quails to varying dietary protein levels in the Tropics. *Nigerian Journal of Animal Production*, 38(1): 43-54.

Bawa, G.S., Lombi, L.H., Shamaki, D., Karsin, P. and Musa, U. (2012b). Protein requirement of Japanese quail (*Cortunix cortunix japonica*) chicks in Nigeria. *Nigerian Journal of Animal Production*, 39(1): 153-160.

Bawa, G.S., Alayande, L.A. and Ogundipe, S.O. (2012c). Effect of Maxigrain® supplementation on the utilization of brewers dried grain and maize offal-based diets for broiler chickens. *Nigerian Journal of Animal Science*, (12): 29-40.

Brenes, A., Rotter, B.A., Marquardt, R.R. and Guenter, W. (1993). The nutritional value of raw, autoclaved and dehulledpeas (*Pisum sativum*) in chicken diets as effected by enzyme supplementation, *Canadian Journal of Animal Science*, 73: 605-614.

Carlson, C.W., Mariom, W.W., Miller, B F. and Goodwin, T.L. (1975). Factors affecting poultry meat yield. *North Central Region Research Poultry*, No. 266 Bulletin 630. South Dakota State University, Brookings, S. D.

Choct, M. (2006). Enzymes for the feed industry: Past, present and future. *Worlds Poultry Science Journal,* 62(1): 5-16.

Choct, M., Hughes, R.J., Wang, J., Bedford, M.R., Morgan, A.J. and Annison, G. (1995). Feed enzymes eliminate the anti-nutritive effect by NSP and modify fermentation in broilers. *Proceedings Australian Poultry Science Symposium*, 7: 121-125.

Dafwang, I.I. (1990). Poultry Production in Nigeria: A paper presented at a workshop organized by the college of Agriculture, Lafia, Nigeria.

Damang, P.J. and Guluwa, L.Y. (2009). Effects of graded levels of roselle (*Hibiscus sabdariffa*) seeds on the growth performance of broiler chickens. In: B.I. Umoh, A.B.I. Udedibie, I.P. Solomon, O.L. Obasi, B.I. Okon and E.J. Udoh (eds). Animal Agriculture in Nigeria and the Global Food Challenges. *Proceedings of the 34th Annual Conference of Nigerian Society of Animal Production,* University of Uyo, Akwa Ibon State, Nigeria. Page 150-152.

Dashak, D.A. and Nwanegbo, V. (2002). Chemical composition of the seeds and calyxes of (*Hibiscus sabdariffa*) grown in Jos North Local Government Area of Plateau states. *Journal of Natural Sciences*, 5: 328 - 341.

Deshpande, S.S., Salunkhe, D.K., Oyewole, O.B., Azam-Ali, S., Battock, M. and Bressani, R. (2000). Fermented grain legumes, seeds and nuts. A global perspective. FAO Rome, Italy, *Agricultural Services Bulletin*, 142: 1-53.

Diarra S.S., Kwari I.D., Girgiri, Y.A., Saleh, B. and Igwebuike, J.U. (2011). The use of sorrel (*Hibiscuss sabdariffa*) seed as a feed ingredient for poultry: A review. *Research Opinions in Animal and Veterinary Sciences,* 1(9): 573-577.

Edache, J.A., Musa, U., Haruna, E.S., Esilonu, J.O., Jibrin, I., Okpala, E.J. and Dogo, I.G. (2005). Replacement value of guinea corn for maize in practical diets fed to quail chicks. *Animal Science International,* 2(2): 311-313.

El-Adawy, T.A. and Khalil, A.H. (1994). Characteristics of roselle seeds as a new source of protein and lipid. *Journal of Agricultural and Food Chemistry*, 42: 1896-1900.

Eleftherios, M.B., Efterpi, V.C. and Panagiota, C.F. (2010). Effect of dietary supplementation of mannan oligosaccharides and acidifier calcium propionate on the performance and carcass quality of Japanese Quail (Coturnix japonica). *International Journal of Poultry Science*, 9(3): 264-272.

El-Fiky, F.A. (1991). Genetic studies on some economic traits in Japanese quail. A Ph.D thesis submitted to the Animal Production Department, Faculty of Agriculture, Al-Azhar University. Cairo, Egypt, Page 154.

Fanimo, A.O., Adebayo, A.S., Oduguwa, O.O. and Biobaku, W.O. (2007). Feeding value of cashew nut testa for broiler chickens. *Nigerian Journal of Animal Production*, 34: 83-93.

FAO. (2008). Meat consumption report.www.fao.org/background.html.

Funk, E.M. (1948). The relation of yolk index determined in natural position to the yolk. A study of egg quality traits in Japanese quail index as determined after separating the yolk from albumen. *Poultry Science,* 27: 376-380.

Garwood, V.A. and Diehl, R.C.J. (1987). Body volume and density of live cortunix quail and associated genetic relationship. *Poultry Science,* 66(8): 1269.

Ghazi, S., Rooke, J.A., Galbraith, H. and Bedford, M.R. (2002). The potential for the improvement of the nutritive value of soybean meal by different proteases in broiler chicks and broiler cockerels. *British Poultry Science*, 43(1): 70-74.

Gobley, L.S. (1956). An introduction to the botany of tropical crops. Longmans, Green and Co. London, Page 72.

Gomez, S., Scheideler, S.E. and Wyatt, C. (1999). Effects of enzyme supplementation to corn-soybean rations with different energy densities on laying hen performance, *Poultry Science,* 78:103.

Gonzalez, M. (1995). Influence of age on physical traits of Japanese quail (*Coturnix coturnix japonica*) eggs. *Annual Zootehnical*, 44: 307-312.

Graham, K.K., Kerley, M.S., Firman, J.D. and Allee, G.L. (2002). The effect of enzyme treatment of soybean meal on oligosaccharide disappearance and chick growth performance. *Poultry Science,* 81: 1014-1019.

Hansawasdi, C. and Kawabata, J. (2000). Alpha-Amylase inhibitors from roselle (*Hibiscus sabdariffa* Linn.) tea. *Bioscience Biotechnology and Biochemistry,* 64 (5): 1041-1043.

Havenstein, G.B., Nestor, K.E. and Bacon, W.L. (1988). Comparison of pedigreed and non-pedigreed random bred control systems for use with artificial selection in the Japanese quail. *Poultry Science*, 67: 357-366.

Heiman, V. and Carver, J.S. (1936). The albumen index as a physical measurement of observed egg quality. *Poultry Science,* 15: 141-148.

Iposu, S.O., Onwuka, C.F.I. and Eruvbetine, D. (1994). The relationship between selected egg quality trait and egg size. *Nigerian Journal of Animal Production,* 21 (1and2): 156-160.

Isidahomen, C.E., Kwari, I.D., Adejumo, E.O. and Igwebuike, J.U. (2006). Proximate composition, tannin content and amino-acid profile of differently processed sorrel (*Hibiscus sabdariffa*) seeds. *Journal of Research in Bioscience,* 2: 37-40.

Jaroni, D., Scheideler, S.E., Beck, M.M., and Wyatt, C. (1999). The effect of dietary wheat middling's and enzyme supplementation 2: Apparent nutrient digestibility, digestive tract size, gut viscosity, and gut morphology in two strains of leghorn hens. *Poultry Science*, 8: 1664-1674.

Jovanović R., Dujić, D. and Glamočić, D. (2000). Domestic animal feed, Novi Sad, Stylos. Page 102-103.

Kalyane, V.L. (1986). "Nutritional quality of Hibiscus seed protein". *International Journal of Tropical Agriculture,* 4 (3): 280-282.

Kinsella, J.E. (1987). Sea foods and human health and diseases. Marcel Dekker Inc. New York and Basel. Page 346-362.

Klasing, K.C. (1998). Comparative Avian Nutrition. CAB International, Wallingford, UK. Page 243.

Kocher, A., Choct, M., Porte, M.D. and Broz, J. (2002). Effect of feed enzymes on nutritive value of soybean meal fed to broilers. *British Poultry Science,* 43(1): 54-63.

Kocher, A., Choct, M., Ross, G., Broz, J. and Chung, T.K. (2003). Effects of enzyme combinations on apparent metabolizable energy of corn-soybean meal based diets in broilers. *Journal of Applied Poultry Research,* 12: 275-283.

Kosba, M.A., Bahie El-Deen, M. and Shalan, H.M. (2001). Long-term selection for body weight in Japanese quail under Egyptian conditions. 3. Correlated responses of egg production traits. *Egypti*an *Poultry Science*, 23: 961-975.

Kostova, Z., Gerzilov, V. and Kutsev, T. (1993). Morphological characteristics and chemical composition of Japanese quail eggs. Higher Institute of Agriculture Plovdiv, Scientific works, XXXVIII, 3:193-196.

Kul, S. and Seker, I. (2004). Phenotypic correlation between some external and internal egg quality traits in the Japanese quails. *International Journal Poultry Science*, 3:400-405.

Kul-Kumar, A., Akhtar, S.M.H., Verma, S.B., Mandal, K.G., Mani Mohan, Kumar, A. and Mohan, M. (2000). Influence of age, body weight, egg weight, clutch size and pause on egg production in Japanese quails. *Indian Journal of Animal Health*, 39(2): 82-84.

Kwari I.D., Abdulrazaq O., Raji, J., Igwebuike, U. and Kibon, A. (2010). Response of growing cockerels to diets containing differently processed sorrel (*Hibiscus sabdariffa*) seed meal. *International Journal of Science*, 1(2): 183-190.

Kwari, I.D., Igwebuike, J.U., Mohammed, I.D. and Diarra, S.S. (2011). Growth, haematology and serum chemistry of broiler chickens fed raw or differently processed sorrel (*Hibiscus sabdariffa*) seed meal in a semi-arid environment. *International Journal of Science and Nature*. 2(1): 22-27. ISSN 2229–6441.

Leytem, A.B., Plumstead, P.W., Maguire, R.O., Kwanyuen, P. and Brake. J. (2007). What aspect of dietary modification in broilers controls litter water-soluble phosphorus: dietary phosphorus, phytase, or calcium? *Journal of Environmental Quality*, 36:453-463.

Liener, I.E. (1975). Endogenous toxic factors in oil seed residues. In: Halliday, D. (Ed.) *Proceedings of the Conference on Animal Feeds of Tropical and Sub-tropical Origin*. Tropical Products Institute, London, UK. Page 179-188.

Lobo, P. (2000). Enzyme to cut animal waste. *Feed Management*. 51:15–16.

Makinde, O.J. (2012). Comparison of the supplemental effects of Maxigrain® enzyme in palm kernel meal and brewer's dried grain based diets on the performance of Japanese quails. A MSc. Thesis submitted to the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria. Page 72.

Marquardt, R.R., Brenes, A. Zhiqun, Z. and Boros, D. (1996). Use of enzymes to improve nutrient availability in poultry feedstuffs. *Animal Feed Science and Technology,* 60: 321–330.

Marsman, G.J.P., Gruppen, H., Van Der Poel, A.F.B., Kwakkel, R.P., Verstegen, W.M.A. and Voragen, A.G.J. (1997). The effect of thermal processing and enzyme treatments of soybean meal on growth performance, ileal nutrient digestibility, and chime characteristics of broiler chicks. *Poultry Science*, 78:864-872.

McClean, K. (1973). Roselle (*Hibiscus sabdariffa* L.) as a cultivated edible plant. UNDP, FAO Project SUD/70/543, Sudan Food Research Center, Khartoum North. Page 1.

McDonald, P., Edwards, R.A. and Greenhalgh, J.F.D. (1995). Animal nutrition. 5th edition. Longman Publication. Page 221–235.

Mizutani, M. (2003). The Japanese quail. In: Laboratory Animal Research Station, Nippon Institute for Biological Science, Kobuchizawa, Yamanashi, Japan, Page 408-0041.

Mohammed, H.B., El Fadil, A. and El Zubeir-Salah K.J. (1994). The nutritional value of roselle seed meal in laying hen diets. *Journal of the Science of Food and Agriculture,* 65(2): 199–200.

Montagne, L., Pluske, J.R. and Hampson, D.J. (2003). A review of interactions between dietary fibre and intestinal mucosa and their consequences on digestive health in young non-ruminant animals. *Animal Feed Science and Technology*, 108: 95-117.

Morton, J. (1987). Roselle. In: Fruits of warm climate. Julia F. Morton. Page 281-286. Miami, Florida. ISBN: 0-9610184-1-0.

Mukhtar, A.M. (2007). The effect of feeding Rosella (*Hibiscus sabdariffa*) seed on broiler chick's performance. *Research Journal of Animal and Veterinary Sciences*, 2: 21-23.

Mukhtar, A.M. and Bakheit, A. (2012). Effect of feeding diets containing roselle seeds (*Hibiscus sabdariffa*) with or without enzymes supplementation on broilers performance, carcass traits and serum constituents. *Egyptian Poultry Science*, 33(1): 17-27.

Munir, K. and Maqsood, S. (2013). A review on role of exogenous enzyme supplementation in poultry production. *Emirate Journal of Food and Agriculture*, 25(1): 66-80. Doi: 10.9755/ejfa.v25i1.9138 http://www.ejfa.info.

Musa- Azara, S.I., Ogah, D.M., Yakubu, A., Ari, M.M. and Hassan, D.I. (2013). Effects of Hibiscus calyx extracts on the blood chemistry of broiler chickens. *Egyptian Poultry Science*, 33(1): 309-312. ISSN: 1110-5623.

Newman, K. (2013). Mechanisms of Enzymes in Poultry Production. http://en.engormix.com/MA-poultry-industry/articles/p0.htm

Ngele, M.B., Egbo, M.L. and Jonathan, J. (2011). Performance of Japanese quails (*Cortunix cortunix japonica*) fed varying levels of spent sorghum residue based diets. *Continental Journal of Animal and Veterinary Research,* 3(1): 16-21. ISSN: 2141 – 405X.

NRC. (1991). National Research Council. Quail. In: Micro livestock – Little known small animal with a promising future. Nation Academy Press. Washington DC. Page 147-155.

Ojebiyi, O.O., Emiola, I.A., Rafiu, T.A., Hamzat, R.A. and Ademowo, I.O. (2009). Growth, haematological and serum biochemical responses of broiler chickens fed graded levels of kola (*Cola acuminata*) husk meal. *Tropical Journal of Animal Science*, 11: 110-120

Ojokoh, A.O., Adetuyi, F.C., Akinyosoye, F.O. and Oyetayo, V.O. (2002). Roselle (*Hibiscus sabdariffa*) calyx diet and histopathological changes in liver of albino rats. *Pakistan Journal of Nutrition*, 5(2): 110-113.

Okon, B.I., Obi, M.B., and Ayuk, A.A. (2007). Performance of quails (*Coturnix coturnix japonica*) fed graded levels of boiled sun dried taro cocoyam (*Colocosia esculenta*) as a replacement for maize. *Proceedings of the 32nd Annual Conference of the Nigerian Society of Animal Production,* 32: 320-322.

Olomu, J.M. (2011). Availability of amino acids. In: Monogastric Animal Nutrition Principles and Practice, Page 52.

Oluyemi, J.A. and Roberts, F.A (2000). Poultry production in warm wet climates. Macmillan Publishers Limited, London, Page 196.

Omole, A.J., Obi, O.O., Ogunleke, O.O., Odejide, J.O., Awe, O.A. and Popoola, Y.A. (2011). Performance and nutrient digestibility of broiler finishers fed diets containing exogenous Hamecozyme. *Proceedings of the 16th Annual Conference of the Animal Science Association of Nigerian,* 16: 399-401.

Oruwari, B.M., Aniebo, A.O. and Nkanta, D.M. (2003). Effect of replacing maize with cassava Brewers' dried yeast blend (Cassa-yeast) on performance of broiler chicks and feed cost in southern Nigeria. *Nigerian Journal of Animal Production*, 30(2): 169-178.

Pariza, M.W. and Cook, M. (2010). Determining the safety of enzymes used in animal feed. *Registered Toxicology and Pharmacology*, 56: 332–342.

Penn, C.J., Mullins, G.L., Zelazny, L.W., Warren, J.G. and McGrath, J.M. (2004). Surface runoff losses of phosphorus from Virginia soils amended with turkey manure using phytase and high available phosphorus corn diets. *Journal of Environmental Quality*, 33: 143-1439.

Persia, M.E., Dehority, B.A. and Lilburn, M.S. (1999). Cecal bacterial concentrations in turkey hens fed corn or wheat based diets with and without supplemental enzymes. *Poultry Science*, 78: 1-16.

Poultry Adviser. (1992). A new estimate of egg shell quality: Shell weight indirectly from egg weight and specific gravity. *Poultry Adviser,* 29(9): 53-54.

Praes, M.F.F.M., Pereira, A.A., Sgavioli, S., Duarte, K.F., Alva, J.C.R., Domingues, C.H., Puzzoti, M.M. and Junqueira, O.M. (2011). Small intestine development of laying hens fed different fiber sources diets and crude protein levels. *Poultry Science,* 85(2): 45-50.

Rao, P.U. (1996). "Nutrient composition and biological evaluation of mesta (*Hibiscus sabdariffa*) seeds". *Plant Foods for Human Nutrition,* 49(1): 27-34.

Romanoff, A.L. and Romanoff, A.J. (1959). The avian egg. In: Genechev, A. (2012). Quality and composition of Japanese quail eggs (*Coturnix Japonica*). *Trakia Journal of Sciences*, 10(2): 91-101.

Salawu, I.S., Orunmuyi, M. and Okezie, O. (2007). The use of hotelling T^2 Statistic in comparing the egg weight of quail, brown strain of the commercial chickens and duck. *Asian Journal of Animal Sciences*, 1(1): 53-56.

SAS, (2008). Statistical Analysis System, Computer Software, Version 9.0. Statistics SAS Institute Inc, SAS Circle. Cary, North Carolina, U.S.A.

Sauveur, B. (1988). Reproduction des colailles et production d'oeufs; INRA Paris. Page 385.

Sezer, M. (2007). Genetic parameters estimated for sexual maturity and weekly live weights of Japanese quail (*Coturnix coturnix Japonica*). *Asian-Australian Journal of Animal Science,* 20(1): 19-24.

Sezer, M. and Tarhan, S. (2005). Model parameters of growth curves of three meat-type lines of Japanese quail. *Czechslovakia Journal of Animal Science*, 50(1): 22–30.

Sheppy, C. (2003). The current feed enzyme market and likely trends. In: M.R. Bedford and G.G. Partridge (Edition). Enzymes in Farm Animal Nutrition CABI Publishing Wallingford, Oxon, UK. Page 1-10.

Shwart, R.W. and Allen, W.K. (1981). The effect of ageing on protein requirement of mature female Japanese quail for egg production. *Japanese Poultry Science*, 60(2): 342-346.

Slominski, B.A. (2014). Recent Advances in Enzymes for Poultry Diets. 2011 *Poultry Science* 90 :2013–2023 doi: 10.3382/ps.2011-01372

Slominski, B.A., Meng, X., Campbell, L.D., Guenter, W. and Jones, O. (2006). The use of enzyme technology for improved energy utilization from full-fat oil seeds. Part II: Flaxseed. *Poultry Science,* 85: 1031-1037.

Steel, R.G.D. and Torrie, J.H. (1988). Principles and practice of statistics. A Biometric Approach *2nd edition McGraw-Hill book co. Inc. New York.*

Swain, B.K., Naik, P.K., Chakurkar, E.B. and Singh, N.P. (2013). Effect of feeding brewers' dried grain on the performance of Japanese quail layers. *Indian Journal of Animal Nutrition,* 30(2): 210-213.

Tindal, H.D. (1986). Vegetable in the tropics. Macmillan Edition Ltd. *Hampshire,* Page 268 – 269.

Tomaz-Jinez, M., Cortes-Cuevas, A., Avila-Gonzales, E., Casaubon-Huguenin, M. and Salcsdo, E.R. (1998). Effect of high levels of roselle seeds (*Hibiscus sabdariffa*) on broiler performance and hepatic function. *Veterinarian-Mexico EneroMarzo*, 29(1): 27-34.

Tounkara, F., Amadou, I., Le Guo-Wei. and Shi Yong-Hui. (2011). Effect of boiling on the physicochemical properties of Roselle seeds (*Hibiscus sabdariffa* L.) cultivated in Mali. *African Journal of Biotechnology*, 10(79): 18160-18166. DOI: 10.5897/AJB11.022.

Tsai, P.J., McIntosh, J., Pearce, P., Camden, B. and Jordan, B.R. (2002). Anthocyanin and antioxidant capacity in Roselle (H. sabdariffa L.) extract. *Food Research International,* 35: 351-356.

Tuleun, C.D., Adenkola, A.Y. and Yenle, F.G. (2013). Performance and erythrocyte osmotic membrane stability of laying Japanese quails (*Coturnix coturnix japonica*) fed varying dietary protein levels in the hot-humid tropics. *Agriculture and Biology Journal of North America*, 4(1): 6-13. doi:10.5251/abjna.2013.4.1.6.13.

Viveros, A., Brenes, A., Pizarro, M. and Castano. M. (1994). Effect of enzyme supplementation of a diet based on barley and autoclave treatment on apparent digestibility, growth performance and gut morphology of broilers. *Animal Feed Science Technology*, 48: 237-251.

Volgarev, M.N. and Waggle, D.H. (1992). Introduction in "New protein foods in human health: Nutrition prevention and therapy" Fred, H., Steinke Doyle, H., Waggle and Michel, N. Volgarev, (editors), Page 1-8. CRC Press Inc. Boca Raton and London.

Wilson, W., Ursnia, O., Abbott, K. and Abplanalp, H. (1961). Evaluation of Cournix (Japanese quail) as pilot animal for poultry breeding. *Poultry Science*, 40: 651-657.

Yagoub, A.A. and Abdalla, A.A. (2007). Effect of domestic processing methods on chemical, in vitro digestibility of protein and starch and functional properties of bambara groundnut (Voandzeia subterranea) seed. *Research Journal of Agriculture and Biological Sciences*, 3: 24-34.

Zanella, I., Sakomura, N.K., Silversides, F.G., Fqueirdo, A. and Pack, M. (1999). Effect of enzyme supplementation of broiler diets based on corn and soybeans. *Poultry Science*, 78: 561-568.