LAYING PERFORMANCE AND EGG QUALITY OF QUAIL *COTURNIX COTURNIX JAPONICA* FED SNAIL-MEAL-ENRICHED COMMERCIAL LAYERS DIET

BY

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DECLARATION

I hereby declare that this thesis is a record of my own research work. It has not been represented by me in any previous publication for a higher degree. All the sources of information are duly acknowledged by means of references.

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CERTIFICATION

This thesis entitled "LAYING PERFORMANCE AND EGG QUALITY OF QUAIL, *Coturnix coturnix japonica*, FED SNAIL-MEAL-ENRICHED COMMERCIAL LAYERS DIET" by MADU IBRAHIM KATSALLAH GADZAMA meets the regulations governing the award of degree of M.Sc Zoology of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

To these wonderful families

THE KATSALLAHS

THE WUDAHS

THE DZIKWIS

and

TO

MUMMY

for her support, understanding, patience and steadfast love.

ABSTRACT

Three experimental diets, formulated using different levels of inclusion of whole snail meal, *Limicolaria* sp were fed to laying Japanese quail, *Coturnix coturnix japonica,* for 56 days. This was done to determine the influence of the different diets on egg production and egg quality characteristics. Commercial layers mash served as the control diet.

Chemical analysis showed that the whole snail meal contained calcium (30.40%), ash(45.88%) and protein(16.08%). The control diet (17.5% CP) had the highest values of phosphorus, moisture, nitrogen-free extract, organic matter and metabolizable energy. These components varied inversely with increase in quantity of whole snail meal; diet 4 (23.5% CP) had the lowest values and diets 2 (19.5% CP) and 3 (21.5% CP) had intermediate values.

All the four treatment diets contained adequate energy and protein that supported egg production. The control diet gave the best feed conversion with lowest egg weight, egg shell thickness and Haugh unit, while diet 2 with the poorest feed conversion gave the highest egg number and yolk index. Eggs in diet 3 had the highest weight. Diet 4 had the lowest egg number and highest values of egg shell thickness and Haugh unit. The feed conversion and shape index were not influenced by the treatment diets.

This study shows that upto 2.0% (CP) whole snail meal may be included in 17.5 % (CP) layers diets of quails for higher egg production and up to 6.0% (CP) for improved egg weight and Haugh unit score.

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ABBREVIATIONS, SYMBOLS AND DEFINATIONS

^{O}C	-	Degree centigrade
CF	-	Crude fibre
cm	-	Centimeter
CP	-	Crude protein
DM	-	Dry matter
et al	-	and others
g	-	gram(s)
HNO_3	-	Nitric acid
i.e	-	that is
in	-	inches
Kcal	-	Kilocalorie(s)
Kg	-	Kilogramme(s)
ME	-	Metabolizable energy
ml	-	millilitre(s)
mm	-	millimeter(s)
N	-	Nitrogen
1N	-	One normality
NFE	-	Nitrogen free extract
P	-	Probability
%	-	Percent
+	-	addition
-	-	subtraction

< - less than

> - greater than

ad libitum at pleasure/will

Anon - Anonymous

Caput - per head

CHAPTER ONE

1.0 INTRODUCTION

The acute shortage of animal protein in the diets of Nigerians demands that efforts be directed to rearing animals that are prolific and have short generation intervals such as pigs, poultry and rabbits Olubajo(1976). Olubajo also estimated that more than 1.68 million tonnes of beef would be needed annually to raise animal protein intake in Nigeria to 25g per caput per day. This is hardly possible in view of the present stationary if not declining cattle production and the low productivity and small body size of indigenous livestock.

Although the problem of protein shortage can be appreciably alleviated by intake of vegetables and supplementation of cereals with legumes, animal proteins are better balanced in terms of essential amino acids. Watt and Merril (1979) reported that protein value of poultry animals both wild and domesticated was known to be higher than that of other animals.

The use of wildlife as a source of meat is not new. Prior to the domestication of the limited number of species that are now used for flesh food, bush meat had been man's main source of meat. In Nigeria, 19% of the total locally produced animal protein are of game meat (Charter, 1971). Although game meat is cherished by all and accepted as an alternative source of animal protein, little or no effort has been made by various governments or individuals to protect these game animals from extinction. Anon.(1972) reported that wildlife is being depleted even inside the protected areas, at an alarming rate. Many methods have been suggested for the preservation of these wildlife. Some of

these methods include: domestication (Talbot, *et al.*, 1965; Danney, 1968) and controlled animal cropping (Borgston , 1969; Westerskov, 1977; Mentis and Bigalke, 1980). The idea of domestication was based on the fact that wild animals are capable of adjusting to ecological and physiological changes while animal cropping involves the feeding of animals in their natural habitat when there is scarcity of food. Captive breeding of wild birds has increased dramatically in this century and production of the young often exceeds that of the same number of birds in their native habitat (Gee and Temple, 1978).

The Common Quail *Coturnix coturnix*, a member of the family *Phasianidae,* (Appendix I) is a bird of very wide distribution in the old world, being found almost throughout Europe and Africa and in the greater part of Asia (Hugh, 1963). It is a miniature partridge in appearance with a striped head and rather sandy colouration streaked with white. The shape is plump and rounded and the legs lack the spurs usual among game birds. In the male, the top of the head is black barred with brown,with a pale butt line down the centre of the crown and a broader one above each eye. The female has the black anchor mark on the throat and has the breast usually spotted with black (Hugh, 1963).

Quail rise not in coveys but singly and fly at a height of 1.5 to 4.6 meters from the ground. The food chiefly consists of grain and seeds but insects and their larvae are also eaten. All food is taken from the ground and the bird never perches on trees. The usual call of the quail is a very liquid wet- mi-lips and it is uttered both day and night. This is the call of the male, but there are other softer calls used by both sexes.

The quail breeds, as it lives, in open country in cultivation and standing crops, in hayfields and rough pastures. The nest is a hollow scraped in the ground and lined scantily with grass and a few leaves. The number of eggs is very variable, from three to ten or twelve. Eggs are broad ovals, a good deal pointed towards the small end.

There are over forty different species of quail in the world. The number of species kept domestically, commercially or as ornamentals are only twenty two. The most widely domesticated subgroup of the quail family are the *Coturnix* and *Colinus* species. The *Colinus* subgroup made of the Bobwhite quail have been bred as meat birds and have a body weight of 500 grams (Thear, 1987). Four species are well recognized in the Coturnix group,the European quail *Coturnix coturnix coturnix*, Usseri quail *Coturnix coturnix useriensis*, Japanese quail *Coturnix coturnix japonica* and African quail *Coturnix coturnix africana*. The Japanese quail is the most widely domesticated and has been bred for high egg and meat production (Anon, 1991).

The Japanese quail *Coturnix coturnix japonica*, native to Asia, were first recorded to be domesticated in the 11th century as a song bird (Cheng and Kimura, 1990). It was not until the early 20th century that Japanese quail were recognised as a food source. At that time they were utilized primarily for egg production. The value of Japanese quail as a research animal was realized in the middle of the 20th century, when favourable comparisms between the Japanese quail and other poultry species were recorded.

In Nigeria the Japanese quail was introduced in 1992. The National Veterinary Research Institute (NVRI), Vom, Nigeria, with the support of the Directorate for Food, Road and Rural Infrastructure (DFFRI) imported fertile eggs from the Republic of Benin.

Currently over one hundred thousand quail are produced annually for both meat and egg and for distribution to farmers as foundation stock for breeding (Haruna *et al.*, 1997).

The African land snail, of the family **Achatinidae** is endemic throughout Africa South of the Sahara and the genus *Achatina* comprises perhaps as many as eight valid species (Bequaet, 1950). The chief reason why man has deliberately introduced *Achatina* into new localities was doubtless in order to make use of it as a food source (Purcho, 1968). The garden snail, *Limicolaria* sp. belongs to the family Achatinidae (appendix II). It is relatively small in size compared to the Giant African Snail *Achatina fulica* Bowdich, which can reach a size of more than 30cm, with a shell length of more than 20cm. The garden snail is primarily found in gardens around houses and on farms. **Achatinidae** are widely regarded as pests because of the damage they inflict on commercial garden plants and crops. The **Achatinidae** indeed are all recognised as pests that cause considerable loss owing to their depredation in vegetable gardens. They are crespuscular in habit but may become active in the day time, when it is raining or overcast.

Natural enemies of the **Achatinidae** are planarians, beetles, ants, crabs, monitor lizards, toads and ground dwelling birds. These predators feed either on the eggs, or the snails themselves. Two carnivorous snails, *Edentulina affinis* and *Gonaxis kibweziensis*, with lengths 3.5cm and 2.0 cm respectively, specifically prey on the giant snail *Achatina fulica* Bowdich (Grzimek, 1972).

In the middle of the century, the achatinas, when dehydrated are reportedly used for poultry food (Rees, 1950). The domesticated duck has the reputation of being the

most avid consumer of snails (Panosmarti, 1952). It is possible, however that a reasonably fine meal can be made of the dehydrated snails and that this is incorporated into the regular poultry feed. Since chickens apparently do not readily eat the giant snails, a method of this sort would seem to be a plausible way in which snails could be fed to chickens. A portion of the *Achatina* shell could also be ground and used as an added source of calcium for animals (Scholes, 1945).

The lack of nutrient consistency in livestock feed adversely affects animal performance (Duncan, 1986). One of the primary sources of this lack of consistency is the variability associated with nutrient content of feed ingredients. Its high protein content vouches for the great value of snail meal as a source of animal protein in animal feed (Van Weel, 1948; Mead, 1950; Garnadi, 1951).

Of the domestic poultry, only the chicken and the duck can be regarded as truly annual reproducers. These two species have for long been subjected to selection for high egg production and as a result mature females of both species lay eggs irrespective of the season. Nutrition is undoubtedly the most important environmental factor governing the long term egg production record of a bird. Genetic difference has been demonstrated in the requirement of egg production stocks for different nutrients and especially for the level and type of protein in the feed (Harms *et al.*, 1966). Sustained egg laying requires energy from feed stuffs considerably above the maintenance requirement of a laying bird. Improvements in poultry rations have reflected an increasing appreciation of the basic relationship between energy intake and energy output of a laying hen, as well as a better understanding of the hen's need for physiologically essential nutrients.

Eggs contain many of the substances essential for human growth and development. Eggs furnish protein, calcium, phosphorus and iron as well as vitamins. The yolk is an excellent source of vitamin A and good source of vitamin D and riboflavin.

In addition to egg size, breeders are concerned with a number of egg quality traits. These are classified for convenience into exterior and interior quality groups. The former includes the shell characteristics of colour, texture, strength (resistance to breakage) and shape. The interior quality group include freedom from blood and meat spot, amount of thick albumen and proportion of albumen to yolk. The amount of thick albumen is used as an index of freshness (Cole and Ronning, 1977)

The food scientist generally defines quality in terms of those attributes of the products that determine marketability and consumer acceptability: such as: (i) Purity and safety (ii) Sensory properties (iii) Convenience (iv) Shelf life (v) functional performance (vi) nutritive values (Cole and Ronning, 1977). Egg is relatively high in cholesterol and saturated fatty acids. The fat soluble pigments are very important, in that they give the yolk its golden colour. These complex inorganic compounds known as carotenoids, are derived exclusively from the feed. The yolk colour is generally measured by a scoring system based on comparism with a set of arbitrary colour standards. Information on the physical quality parameters of fresh egg in the country is limited (Olomu, 1975; Ibe 1986 and Ayorinde, 1987).

1.1 JUSTIFICATION OF STUDY

F.A.O (1968) reported that protein of animal origin contributed only 8.6g (16.63%) of an estimated 51.76g daily per capita protein intake of the average Nigerian and this has been found to be decreasing yearly. In view of this, the Federal Government of Nigeria had tried to offset the huge deficit in animal protein consumption by embarking on massive importation of chilled beef and chicken. For many obvious reasons, this policy could not be the long term solution to the problem. It is now very well known that very rapid increase in poultry products can be achieved in a short time compared to what is feasible in beef production (Adichie *et al.*, 1985).

In view of prevailing economic pressures, there is little prospect of increasing the number of cattle and sheep in Africa, because of tropical diseases like trypanosomiasis, rinderpest, enterities etc. In addition increased stocking of domestic livestock, especially cattle, sheep and goats, aggravates soil erosion, overgrazing and accelerates water depletion. These necessitate the search for alternative animal protein sources other than livestock.

In comparing birds, as alternative sources of protein, Ukoha *et al.*, (1992) reported that, the double spurred francolin *Francolinus bicalcaratus*, a pheasant of the same family as quail, has a higher value of protein and some mineral content than the corresponding parts of the domestic fowl *Gallus gallus domesticus*. Generally, the francolin meat was accepted as being more palatable with a higher meat quality than the domestic fowl (Onyenekwe, 1988).

Quail has been a table delicacy since olden times. It is a dual purpose bird for both meat and egg production. Because of low volume low weight and rapid regeneration rate, Japanese quails have been occupying a significant position in poultry production activities in thickly populated countries like Japan, Singapore, Hongkong (CARI, 1986). Today, millions of domesticated quail are reared in Japan, Indonesia, Thailand, Phillipines, Taiwan Malaysia as well as in Brazil and Chile. Similarly quail farming is also popular in Korea and Germany (Rath, 1994).

Quail farming is gaining popularity in Nigeria due to its advantages like convenience of management, requiring less space and feed requirement, short productive cycle and earlier returns than that of chicken farming(Haruna *et al.*, 1997).

The experience with quails over the years has shown that they are comparatively more resistant to a number of diseases and their egg have been found very useful for production of vaccines and in disease investigation. Quails offer opportunity for diversification and convenience of management as they do not demand routine vaccinations and medications, more birds can be grown per unit floor area and on a unit quantity of feed available and shorter reproductive cycle with earlier marketing age (CARI, 1990).

In Nigeria, in recent years, commercial feeds contain an average of 50% maize and 90% of the feeds are consumed by poultry.The once prosperous poultry industry has virtually collapsed due to shortage and high cost of feed ingredients particularly maize and fishmeal (Olayemi 1989). The predicament is however being aggravated by the ever-increasing demand for maize as both staple for man and as an industrial raw material.

The present high cost of fishmeal suggests that alternative high quality animal protein source be sought for poultry feed. Fishmeal has remained the standard against which most other protein feedstuff intended for inclusions in practical type diets have been compared, because of its high content of lysine, methionine and cystine as well as its contribution of some unidentified growth factors. It has the added advantage of good flavour and taste which enhances palatability and acceptability of diets (Fanimo, 1996).

In recent times there has been a shortage of fishmeal in the country and its cost has significantly increased relative to other protein concentrates. Fishmeal currently costs more than twice the cost of groundnut cake. Because of this high cost, the use of substitute protein concentrates to reduce the cost per unit finished diet is necessary, such substitute should have comparable nutritive value but cheaper than the conventional protein sources. For the expensive fishmeal, snail meal would seem a suitable substitute. The snail bodies are reported to contain about 60% protein on dry matter basis (Gohl, 1975) and with the possible exception of methionine, to be well balanced in amino acid content (Mead and Kemmerer, 1953).

Quail are especially well suited for studying the effect of age on nutritional requirements throughout an entire life span (Schwartz and Allen, 1981). They are choosen for this study because they adapt well to semi-purified diets and consume significantly less quantities of expensive ingredients than other animals. Due to their small body size and high metabolic rate, response to dietary modifications are obtained much sooner than with any other species.

Snails have been known to be good sources of metal ions. In studying the mineralization in the Giant African Land Snail *Archachatina marginata* Swainson, Mafulul (1988) found that, generally, calcium and phosphorus metals were more concentrated in the tissue, except in the shell where phosphorus was the lowest concentration, and zinc was next to calcium in concentration. In the tissues, the greatest concentration of individual metals were as follows: calcium in the shell, phosphorus in the liver, magnesium and iron in the kidney, sodium in the foot, potassium in the gonad and zinc in the visceral mass.

Mead (1961) measured the amounts of calcium, phosphorus, potassium and P_3O_5 (phosphate) in the foot and mantle of *Achatina fulica* and obtained the concentrations of 0.257, 3.67, 2.75 and 11.78 milligram percent respectively. The fat and protein content amounted to 0.75 and 60.95% respectively. Mead (1961) showed that the visceral mass has more mineral content than the foot and mantle. He reported that the very high percentage of phosphate (and therefore phosphorus) especially in the visceral mass, largely of the hepatopancreas or "Liver", greatly increases the value of snail flesh as both a feed and a fertilizer.

Hence it is believed that successful replacement of fishmeal with cheap snail meal will definitely help to reduce the cost of poultry feeds.

1.2 OBJECTIVES OF STUDY

This study has the following objectives:

i) To monitor egg production of the Japanese quail *Coturnix coturnix japonica* fed with snail-meal-enriched commercial feed;

ii) To determine the feed conversion (FC) of the birds for various compositions of feed;

iii) To evaluate the impact of the feed on the egg weight, shape index and external qualities of the egg: egg shell thickness and egg shell weight and

iv)To evaluate the impact of the feed on the internal qualities of the egg: albumen and yolk qualities.

The present work is designed to contribute to the existing knowledge on the utilization of snail as an additional source of animal protein supplement in poultry feeds.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 THE COTURNIX QUAIL

The coturnix quail is widely distributed in Europe, Africa and Asia, where it is noted as a migratory game bird. Several subspecies are recognized, the more important of which are the European *Coturnix coturnix coturnix* and the Asiatic or Japanese, *Coturnix coturnix japonica*. For several centuries in Japan a semi-domesticated strain has been raised as a pet, for meat and eggs, and as a singing bird.

Padgett and Ivey (1959a), Wilson *et al.*, (1959) recognized that this species had important advantages as a laboratory animal. Coturnids which live well in laboratory cages, are relatively inexpensive to maintain; 20 to 30 birds can be kept for the same cost as one chicken (UFAW 1967). A relatively large number of eggs may be obtained, up to 200 or more per coturnix hen. The short life cycle takes 16 to 17 days for incubation and 6 to 7 weeks from hatching until sexual maturity. At present the coturnix quail is being used in a number of areas of research. These include embryological, physiological, nutritional, genetic, endocrinology and even germfree and cancer studies.

2.2 QUAILS THAT OCCUR IN NIGERIA.

The following types of Quails found in Nigeria are classified and described by Bannerman (1952).

2.2.1 THE COMMON QUAIL *Coturnix coturnix*

The common quail has been known to visit West Africa in small numbers between October and April but does not remain to breed (Bannerman, 1952). In the vicinity of Lake Chad they are reported to be more plentiful in March and April than at any other time of the year. They have been reported in northern and southern Nigeria .

Its habits of rising with a quick whirr, dropping quickly again into cover after only a short flight, is a well-known characteristic of the species. As it rises often from one's feet, it utters a sharp twit-twit twit and skims away with rapid swerving flight just above the top of the grass. It is almost impossible to flush it a second time, no matter how closely marked.

The crown is black with buff tips to the feathers divided in the centre by a pale buff stripe. The cheeks and a streak over the eye are white. The back and wings are sandy brown irregularly marked with black and barred transversely with cream and buff. All the feathers of the mantle, scapulars and back have spear-shaped cream-coloured shaft specks. The centre of the chin and throat is black, below which is a white u-shaped patch bordered with rufous chestnut. The breast is cinnamon-buff and the belly white; the long brown flank feathers are light brown; the bill is dark brown. The wing measures 105-119mm.The total length of the bird is about 6 inches.

The female resembles the male on the upper parts but differs on the underside by having the throat entirely white and the breast with round or oblong black spots. Common quails are fond of groundnut and corn-growing areas, but sometimes they may be flushed in forest clearings.

2.2.2 HARLEQUIN QUAIL *Coturnix delegorguei delegorguei.*

This is a much darker bird than the common quail. The hens are practically indistinguishable in the field from common quail. The male has the upper parts dark brown instead of sandy brown. Three cream stripes, one down the centre, the other bordering the crown are more noticeable in the Harlequin than in the common quail. The bill is black legs and feet are dull pink. In flight, the white under-wing coverts are usually apparent.

The adult female closely resembles the female common quail, but the markings are blacker and there is no barring on the wings. A ring of black dots borders the throat; the under- side is pale chestnut.

The Harlequin, though resident in Africa is subject to periodic migratory movements which are as yet little understood, but are believed to be governed by the rainfall (Bannerman, 1952).

Harlequins are found in a greater part of Africa but not the forest region. They occur in the Lake Chad area and probably in the Bauchi Plateau.

2.2.3 AFRICAN BLUE QUAIL *Excalfactoria adansonii*

This diminutive bird is the smallest of all the quail family and measures only 5.5 inches in total length. It is conspicuously coloured. The entire upper parts of the male is blackish brown, strongly washed with slate-blue from the mantle to the rump, with the middle of the back blotched with black. The throat is black and separated from the breast by a white band. The female is brown in colour; barred below and partridge-like on the

upper part and is not so easily distinguished unless flushed with her brightly coloured mate. Unlike the male, she lacks the chestnut marks on the wing and tail and from the breast downwards is closely barred with black on a light brown ground colour.

The African blue quail flies a very short distance when flushed and lies very close to the ground, so that it is seldom seen. When the dew is on the grass, it is so reluctant to take wing that it may almost be caught by hand. It rises with a faint whirr of wings, flies swiftly and strongly and drops to the ground again, within fifty yards or so. It lives almost entirely on seeds but will eat small snails and insects. They are always found in pairs, otherwise they are not sociable. Single birds are occasionally flushed.

The nest is a hollow lined with dry grass and concealed under a tuft. Six to eight eggs are laid, yellowish-clay coloured without gloss and blunt at both ends. The quail has been found in roadside grass in marshy hollows where the grass is rank, in fadamas on the Bauchi Plateau, where the grass is short and in long grass by a stream.

2.2.4 LITTLE BUTTON-QUAIL *Turnix sylvatica lepurana.*

This tiny bird has often been likened to a miniature English Partridge. It has partridge-like plumage on the upper parts and rust-coloured breast with black spots on either side; a rather stout medium bill and bare yellowish flesh-coloured legs with no hind toes are easily observable characters. It is extraordinarily difficult to flush from cover and often escapes detection by hiding. When flushed the whirr of its wings is astonishingly loud and startling. No bird is more difficult to flush from cover, and its presence is most likely to be betrayed by its peculiar whistle or coo, like the sound of

wind passing through a pipe, which may be heard especially on moonlight nights. It has a curious whizzing flight and alights in an upright position with wings outstretched (Bannerman, 1952).

The terrain upon which the button quail may be found is old cultivation land, maritime plains, millet and maize especially when returning to the wild. Its food consists of insects, ants, grass seeds, millets etc.

The button quail lays three eggs in a slight depression in the soil which is lined scantily, with few grasses and plant roots. The eggs have a pale brown colour with ashy spots and blotches and heavier markings of brown and tawny evenly distributed over the shell. The button quail is found in localities in central and northern Nigeria .

2.2.5 QUAIL-PLOVER OR BUSH-LARK QUAIL *Ortyxelos meiffrenii.*

This is an extremely small bird masquerading as a game-bird, but far removed from that group in every other aspect; it has the appearance of a bush lark which has been crossed with a quail (Bannerman, 1952). The general colour of the upper parks, including the crown, is sandy rufous and the feathers of the mantle and back are edged with cream. The wing is prettily patterned black, white and sandbuff; the throat is white and the rest of the under parts is white. It has a yellowish bill and feet and legs are flesh-coloured. They are monomorphic.

The quail-plover flies with jerky undulations, often rising a long way from the ground, when it looks like a bob-tailed, broad-winged lark. When on ground, it is very secretive, concealing itself in grass, through which it can thread its way very rapidly, running in

a crouching attitude; sometimes it will attempt to elude discovery by crouching until almost trodden upon. Quail plover breeds in the winter months soon after the new year. The nest being a tiny scoop in light open bush made in firm sand near the foot of some herb, with a few bits of leaves and stalks as lining. Eggs are stone-coloured with underlying inky-purple and surface spots and blotches of black. The clutch size is two. It is found mostly in the extreme northwest of Nigeria.

2.3 IMPORTANCE OF QUAIL

Two species of quail have been domesticated.They are (i) the Japanese quail *Coturnix coturnix japonica* which has been divergently selected for egg production on one hand and meat yield on the other, and (ii) the bob white, *Colinus virginianus,* in America.

Literature abound on the Japanese quail because the benefits of using it as a research animal lie in the ease of handling and low maintenance cost. Japanese quail have been used as a model for poultry genetic research, because they are less expensive than chickens and turkeys and show genetic variation for growth traits in most populations (Wilson *et al.*, 1961; Marks, 1990). More recently, they have been produced commercially in North America and have enjoyed increasing popularity as a form of poultry meat and eggs (CARI,1990).

2.4 NUTRITION OF QUAILS.

The earliest studies on the food habits of Japanese quail, *Coturnix coturnix*

japonica, in their natural habitat conducted by Taka-Tsukasa (1935), Standford (1957), Toshchi (1959) and Whetherbee (1961) have discussed the dietary preferences of quail. In general, in the wild, the quail prefers diets relatively high in protein in order to thrive and reproduce efficiently. Quail farmers in Japan have long been aware that domesticated species also require a higher level of protein in their diets than domesticated fowls (Howes, 1964).

The dietary protein requirement of quail is influenced by metabolized energy content and the ingredients used to formulate purified or conventional diets. The earlier investigators raised their quail flocks essentially on turkey starter diets, containing about 25-28% crude protein (Woodard *et al.*, 1965; NAS 1969; Wilson, 1972). A dietary crude protein level of 24-25% is needed in starter diet for quail. An initial level of 28-32% crude protein gave an initial better growth (Lee *et al.*, 1977).

Studying the carcass composition of Japanese quails, Hardy (1981) confirmed that carcass of highest fat content was obtained in quail receiving high protein diet and established that the results indicated that more than 24% protein was needed in the diet for maximum growth rate. According to Howes (1965), protein levels from 16 - 28% in purified diets containing 2700Kcal per Kg metabolizable energy did not significantly influence the body weights of quail hens. The data indicated that purified diets based on isolated soybean protein and starch can be fed to *Coturnix* quail to get optimum egg production, fertility and hatchability. The optimal level of dietary protein is less than 20%, possibly as low as 16%, if the metabolizable energy level of the diet is about 2700 Kcal/Kg. The estimate of the protein requirement of egg laying Japanese quail varies

from 15-25% of the diet (Vohra,1971; Vohra and Roudy bush 1971; Begim and Insko 1972; Kumar *et al.*, 1978; Yamane *et al.*, 1979; Allen and Young, 1980).

In random bred quail, sexual maturity was reached very rapidly and less adversely affected by feed restriction than chickens, which require a longer growing period prior to maturity. Alternatively, due to their early age at sexual maturity, quail may exhibit accelerated growth following early feed restriction in order to obtain the minimum body weight required for sexual maturity (Sabine *et al.*, 1995).

From studies, critical information about nutrition of Coturnix quails is scarce as it is for most related species. It has been inferred that Coturnix quails require high protein diets. Commercial game diet containing some 28% crude protein are frequently used. Since the turnover of game rations in the food supply store is usually small, the likelihood of toxic fungus is greatly increased, especially in hot and humid areas Wilson *et al.*, (1961) used turkey starter diets for Coturnix quails.

Howes (1962) has demonstrated that for coturnids, high protein diets are not required for growth but are needed largely for laying. A diet containing 18% protein gave as much growth as did one containing 36%, but feed efficiency was reduced. He also found that coturnids compared with domestic fowl ,*Gallus gallus domesticus*, are somewhat more sensitive to high quantities of dietary fat. Howes (1962) tentatively recommended that supplementary light and high quality diets be used with caution to avoid mortality caused by prolapse of the oviduct and reduce the number of small and often useless eggs.

2.5 FERTILITY AND EGG PRODUCTION.

The early sexual maturity of coturnids is remarkable. Females have been known to lay as early as 38 days of age; and most birds in full lay by 50 days, if conditions are optimal. Male sexual maturity is similar to that of the female, at least as far as spermatogenesis is concerned (Padgett and Ivey, 1959b, 1960). However, fertility of young males is not so high as that of older birds.

The effect of light on egg-production is pronounced (Arrington *et al.*, 1962). Increasing day-length or long days stimulate laying. Decreasing day-length definitely inhibits egg-production. In practice a day-length of 14 hours seems to be satisfactory for sustained laying. Hens under satisfactory conditions will continue to lay while moulting. A total number of 200 eggs per hen could reasonably be expected per year under good conditions with possibility of 260 eggs or more under optimal conditions (UFAW, 1967). The incubation period of coturnix quail ranges between 16 and 18 days.

2.6 SNAIL MEAL AS A SOURCE OF PROTEIN

In many parts of central West Africa, giant snails *Achatina fulica* provide one of the major single source of protein in the diet of humans (Mead, 1961). Local people eat giant snails which have been put in boiling water or on hot coals, removed from the shell, freed of the soft visceral mass, chopped and combined with some starchy dish such as cassava and palm oil to form their standard meal of fufu. The human consumption of land snails has been practiced since the very earliest times and even during the height of the Roman Empire (Taylor, 1900). The demand for the edible helicine snails has been

so great that heliculture or snail farming, especially in parts of Europe, is today a very sizeable industry (Mead, 1961).

As a pest, one of the major methods of control of *Achatina* is through human use as food for poultry and livestock, fish bait and Fertilizer. Experiments were conducted to determine snail composition and value of snail meal as a protein source for broiler and layer chickens. There are undocumented reports of the African Giant Snail being fed to chickens and ducks. However, the nutritional value as determined under controlled experimental conditions is probably unknown.

According to Creswell and Kompiang, (1981), snail meal made from the bodies of the African Giant Snail, *Achatina fulica* Bowdich when analysed for chemical composition and nutritional value for broiler chicken, contained approximately 60% protein, 2.0% calcium, 0.8% phosphorus, 4.35% lysine, 1.0% methionine and 0.6% cystine on dry matter basis. Metabolizable Energy (ME) was 3400Kcal/Kg dry matter. The analysis for gross and amino acid composition suggests that snail meal is a source of high levels of protein and essential amino acids for chickens.

Snail meal has been known to contain low amount of vitamin A and reasonably high amount of vitamin B. A series of tests have established the fact that snail meal is not a good source of vitamin A or carotene. The shell consists of 99.8% calcium carbonate and 1.1% silicate (Mead, 1961).

2.7 AMINO ACID ASSAY OF SNAIL MEAL.

The discovery of a very high protein content in snail meal has aroused interest

in the quantity of the amino acid make-up of this protein (Appendix III). Preliminary amino acid assays revealed the significant fact that the essential amino acid lysine was present in dehydrated, pulverized snails to the extend of 1.33 times that of whole chicken egg (Mead and Kemmerer, 1953; Anon.1953) and 4.35% dry sample (Creswell and Kompiang, 1981).

The consistent deficiency of lysine in the common sources of plant protein used as food supplement, such as cotton seed meal, makes this discovery all the more important. Other amino acids were sufficiently high in concentration, compared with whole egg, to increase considerably the estimates of the value of snail meal as a poultry and livestock supplemental feed (Mead, 1961).

2.8 MEDICINAL VALUE OF *Achatina fulica Bowdich.*

The Giant African Snail was presumed to have great medicinal properties. Taylor (1900) not only discussed the possible curative powers of snails in ridding the body of tuberculosis but recommended a method of puncturing the snail shell "to enable the patient suck the oozing liquor".

The use of helicine snails in medicine has been traced by Cadart (1955) from the earliest times right to the present where it was reported that the mucus of *Helix pomatia* favoured the action of penicillin. The curative substance extracted from the snails is said to be "Ishimoto Negligin" which is orthocalcium phosphate. This is perhaps the medicinal substance which the Institute of Medicine in Japan was reportedly extracting from the giant snails (Pangga 1949). This chemical is claimed to cure kidney disease, tuberculosis,

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anaemia, diabetes, asthma, urtricaria, to relieve constipation and hemorrhoids, to prevent influenza,and to perpetuate beauty and clear skin. Tazawa *et al.*, (1934) especially urged the cultivation of *Achatina fulica* and made numerous recommendations for increasing production and simplifying the task of raising the snails.

There is little written on the presumed toxic nature of the giant snails as a food item. There remains the indisputable fact that other species of *Achatina* are eaten by choice in great quantity and with impunity in West Africa. Both Van Weel (1948) and Mead (1961) have sampled the slime with no harmful effects. The evidence that snails are poisonous is therefore entirely circumstantial.

2.9 FEED FORMULATION AND EVALUATION

The energy in poultry diets is derived mainly from cereals. Those available in the tropics include maize, millet, sorghum, rice and to some extent wheat. Dietary energy and protein interact because (i) protein provides part of the dietary energy, (ii) energy is needed for protein turnover and deposition, and (iii) body protein is part of the stored energy of the body (Boorman, 1980).

The different types of oil that have been or can be used to increase the energy in poultry diets include palm oil, groundnut oil, melon seed oil and palm kernel oil. The vegetable sources of protein include groundnut meal, or copra meal. Potential sources of protein include cowpea, bambaranut and palm-kernel meal. The animal sources are chiefly fishmeal, blood meal, milk powder and to some extend meat and bone meal.

The minerals needed in formulating a feed can be supplied as micro-nutrients feed additive. Vitamins are given in synthetic forms. These are as effective as those from natural sources and are often preferred for their standard quality, guranteed potency, stability and full biological availability. Synthetic vitamins are supplied singly or as low potency pre-mixes in combination with active ingredients like minerals, antibiotics and others (Oluyemi and Robert, 1985).

The feed requirements of birds are largely determined by the anatomy and capabilities of the digestive tract. These determine what type of feeds can be ingested and digested into the nutrients required to sustain the body and the form in which these nutrients will be delivered to the circulatory system. Alterations and impairments within the digestive system may affect feed utilization and subsequently growth (Waibel and Devegowda, 1982).

In formulating poultry feed, Oluyemi and Robert (1985) remarked that only the levels of the feed ingredients that are compatible with efficiency are used. According to Waibel and Devegowda (1982), linear programming has been an extremely important tool in modern ration formulation. This is because it allows the imputing of many nutritional requirements and feeding ingredients with minimum and maximun restrictions and quickly produces a least cost formulation which meets those specifications.

The most reliable assessment of the feed quality is on the basis of its effect on the performance of the bird. However, these effects can be predicted to some extent from the chemical analysis of the diet. The efficiency of feed utilization of the bird is partly genetically determined as the faster growing or the more prolific birds are also more efficient (Oluyemi and Robert, 1985).

2.10 PROTEIN QUALITY

The quality of a dietary protein is the extent to which its essential amino acid pattern coincides with the needs of the animal. Theoretically, the poorer a protein is, the more of it that is needed to satisfy the needs for particular nitrogen retention. Therefore maximum nitrogen retention is achievable with a poorer dietary protein but more of the protein will be needed and the rate of increase in nitrogen retention per unit intake of the protein will be less than that of a better protein source (Buttery and Lindsay, 1980). Wethli, *et al.*,(1975) showed that young chicks did not achieve maximum weight gain when receiving proteins of poor quality, even if enough of such protein were included in the diet of the chick to satisfy the requirement for the limiting amino acid expressed as a proportion of the diet.

2.11 GROWTH AND PROTEIN UTILIZATION IN BIRDS

Growth in birds has been widely investigated (Huxley, 1932; Laird, 1965; Lilja, 1983). Many studies concentrated on the development of the gastro-intestinal tract (G.I.T) during the post hatching growth period (Katanbat *et al.*, 1988: Nitsan *et al.*, 1991). In all these it was shown that the G.I.T has a major role in inducing growth during the early post hatching period. During this period the G.I.T segments increase in size much more rapidly than the whole body.

A lot of work has been done on poultry nutrition but more effort has been in the area of nutrition of the chicken. Very little work has been done on turkey nutrition and duck and quail nutrition (Sekoni, 1994). Yacowitz *et al.*, (1952) found that all-vegetable

diet containing 25% protein caused a greater decline in hatchability than a similar diet containing 16% protein. However, they did not study the effect of high levels of protein on growth and viability of chicks that were hatched.

Studies conducted by Fairbairn (1952), Elgood (1964) and Button (1967) found francolins to be principally ommivores. Onyenekwe (1988) found that the francolin is equipped with principal enzymes such as carbohydrases, lipases and protease to digest its multivaried food item. This equips the bird for the digestion of all the major food components fed to most birds. Fairbairn (1952) has reported that francolin chicks when fed on termites and egg remained under nourished. This may be due to high protein and low carbohydrate of the these feeds leading to low caloric intake and nutritional imbalance.

The concept of the energy:protein ratio was developed as a simple means to balance the protein and energy contents of broiler and hen diets (Combs and Romoser, 1955). According to Friedman (1977), the nutritional quality of a protein depends on the proportion of its essential amino acids, their physiological availability and the specific requirement of the animal. It is generally accepted today that the usefulness of feeds as sources of protein depends primarily on the total concentration of the protein and the distribution of the amino acids making up the proteins.

2.12 EGG QUALITY

Friedman (1977) remarked that the nutritional quality of a protein depends on the proportion of its amino acids, especially the essential amino acids, their physiological

availability and the specific requirement of the consumer in as much as all the generally recognised amino acids occur as components of tissue and proteins. Allen and Young (1980) reported sufficiently high amounts and composition of amino acid in quail egg (Appendix IV).

Eggs ranked only with cow milk in being the most economically produced animal protein and contain more nutrients than any other animal source.Apart from egg size, consumer acceptance of eggs also depends on egg quality parameters such as Haugh units, yolk colour, storage stability and, in particular, sensory stability (Jiang *et al.*, 1991). Interior egg quality has been recognized as a major criterion for effective assessment of egg quality control (Doyon *et al.*, 1986). Variables like Haugh unit, albumen height, Yolk and shell qualities are some of the parameters most commonly used to measure egg quality (Haugh, 1937; Cherry *et al.*, 1978 and Benoff and Renden, (1983). The Haugh unit is a measure of albumen quality (Card and Neshein, 1973). The yolk index is a measure of the standing up quality of the yolk and has been found to decline with age of the bird.

In comparing the effects of different dietary protein levels on the egg performance of four-month-old, eight-month-old and twelve-month-old female Japanese quail, Schwartz and Allen (1981) found that the requirements for protein to maximize egg production, egg yield and egg yield per feed were 15.0%, 15.0% and 14.8% respectively. The four-month-old quails gave a higher percent egg production.

The shell proper contains 95% calcium carbonate and small amounts of magnesium, phosphorus and other inorganic materials (Cole and Ronning, 1977). Factors

influencing egg shell quality have been investigated by numerous researchers. Egg shell quality is a very important aspect when considering phosphorus requirement for laying hens. Phosphorus is a critical nutrient in laying hen diets. Numerous studies on dietary phosphorus requirement have been reported. Said *et al.*, (1984) suggested that 0.5% total phosphorus, with dicalcium phosphate used as the inorganic sources gives the best results as measured by egg production egg shell quality. Other reports suggest 0.4 or 0.45% total phosphorus to be adequate for egg production, shell quality and feed efficiency (Damron, *et al.*, 1974;Andrews and Berg, 1977;Hamilton and Sibbald, 1977;Edwards and Suso, 1981). Many techniques and devices have been used to measure egg shell quality and their relationship with other factors have been reviewed (Tyler, 1961; Hunton, 1969; Hammerle, 1969). The measurements are useful for studying egg shell quality since they are highly correlated with the shell characteristics of thickness, whole egg specific gravity (Wells, 1967) and egg shell weight (Tung *et al.*, 1968) which are thought to account for a large percentage of the variance of shell quality (Frank *et al.*, 1964). Soundness of the shell (freedom from cracks) is essential to prevent loss of contents and to minimize contamination and spoilage by microbes. Shell strength is of importance in the handling and marketing of eggs. Highly negative correlations have been established between percentage of cracked eggs and percentage shell and shell weight (Abdallah *et al.*, 1993).

In studying the zinc requirement of laying Japanese quail, Shukla *et al.*, (1993) reported that egg mass, egg production, feed conversion efficiency and body weight are affected by different dietary levels of zinc.

Sundaram (1989) compared the egg production efficiencies of domestic fowl, ducks and Japanese quail and reported from practical farm experience that quail were at least equal to and possibly better than, ducks in this respect. Both quail and ducks were shown to be more efficient converters of feed to eggs than domestic fowl by producing twice as much egg mass per kilogramme body weight (Tikk and Tikk, 1991).

CHAPTER THREE

MATERIALS AND METHODS

3.1 CONSTRUCTION AND PREPARATION OF CAGES

A row of eight small colony units were constructed from wire mesh and wood, with each unit space measuring 55 x 68 cm and 66cm high. The floor of the cages was covered with newspaper, as absorbent. Each cage unit was provided with a water drinker and a tubular feeder constructed from aluminium (Plate I A,B)

3.2 COLLECTION AND IDENTIFICATION OF SNAILS

Batches of garden snails *Limicolaria* sp. (Plate II A) were hand-picked after rainfall from surrounding gardens and vegetation of the University quarters. The snails were identified by the brown parallel streaks on a yellow-brown background, along the length of the shell, which spread into purple-brown towards the edge of the shell. The shell is thin and cone-shaped. The snail's body is grey with prominent longitudinal brown stripes. Snails collected were within the weight range of 4.6 to 13.5 grams.

3.3 PREPARATION OF SNAIL MEAL

Batches of freshly collected garden snails were boiled in water for 3 to 5 minutes to loosen the soft tissues from the shell. The shells were then separated from the soft tissues by hand. The soft tissues were chopped up using a chopping board and sharp knife. The chopped soft tissue was dried in a force-draught oven at 60^{o}C and ground up to a texture of commercial layer's mash using a mortar and pestle. (See Plate II B for dried soft tissue of snail). The shells were air dried and ground using a grinder and mixed with the ground soft tissue to form whole-snail meal (Plate IIC).

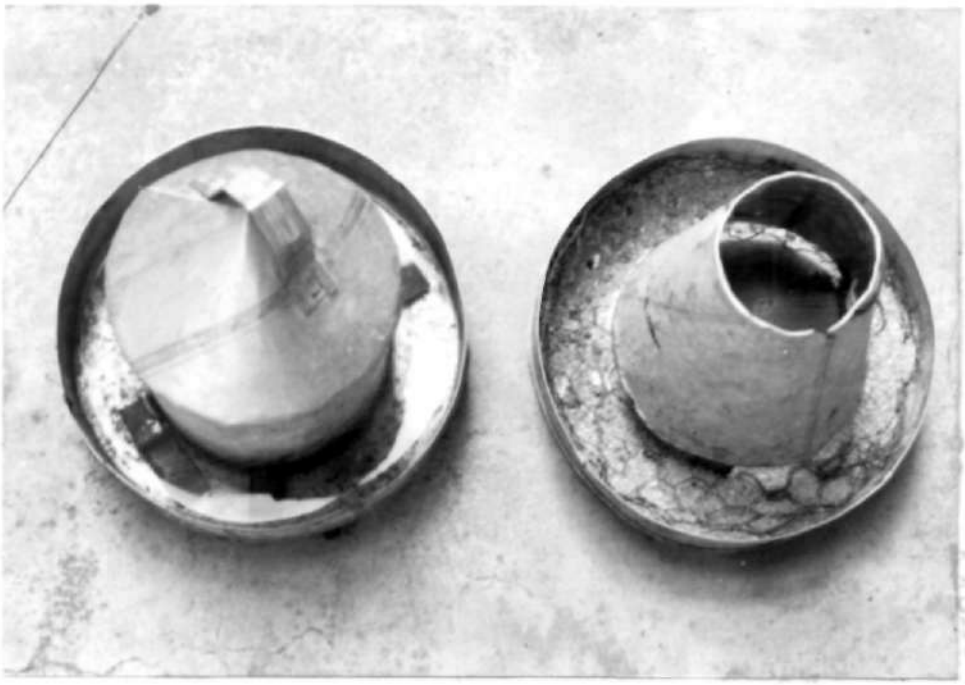


PLATE I. A: Water drinker. B: Tubular feeder fitted with wire mesh.

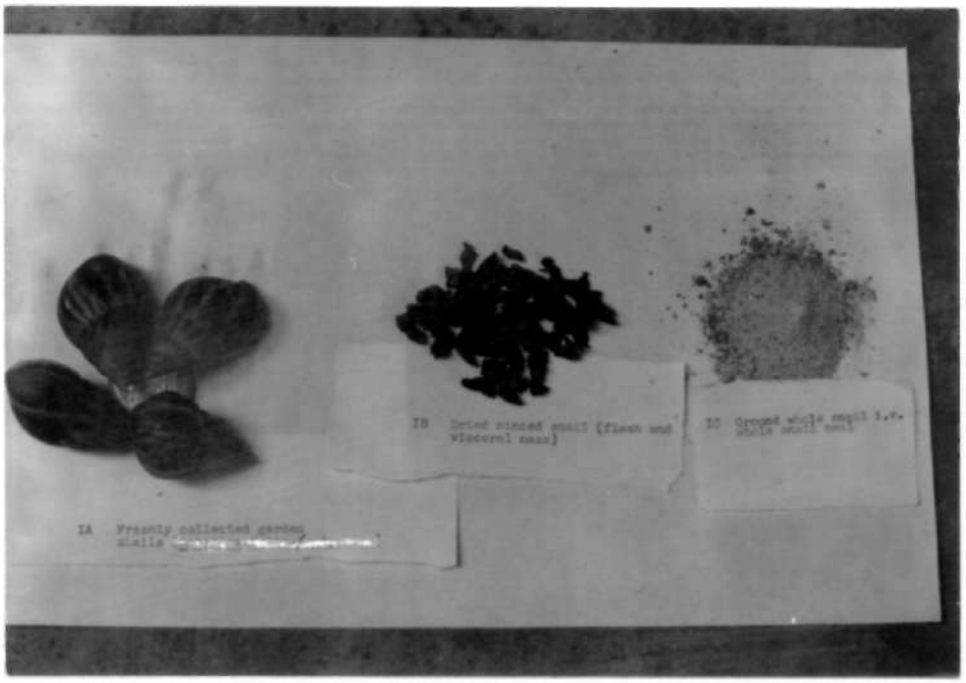


PLATE II. A: Freshly collected garden snails *Limicolaria* sp. B: Dried minced soft tissues; C: Processed whole snail meal.

3.4 FEED

Two 25kg bags of commercial layers' mash (Nagarta brand) were purchased for use as control diet and in formulating the other diets. The feed was thoroughly mixed to ensure uniformity prior to chemical analysis.

3.5 CHEMICAL ANALYSIS

Proximate chemical composition of the whole snail meal and the commercial layers' mash was carried out for crude nitrogen and protein content, crude fibre, ash, fat, phosphorus and calcium.

The crude nitrogen content was determined using the micro Kjeldahl technique as described by Krishna and Ranjhan(1980) in which organic matter is digested by heating in concentrated sulphuric acid. Protein content was determined indirectly by using the empirical factor of 6.25 to convert nitrogen to protein. Therefore crude protein = N x 6.25, where N is nitrogen (%). Factor 6.25 is based on the fact that protein contains 16% nitrogen.

The method of determining water content and dry matter described by Krishna and Ranjhan, (1980) was also used. The dry matter generally is the constant weight a sample attains when heated at 100^{o}C for two hours. The weight loss after drying was considered to be the water content while the final weight of the sample after drying constituted the dry matter.

Crude fibre was determined on moisture-free basis as that fraction remaining after digestion with standard solutions of sulphuric acid and sodium hydroxide by the

Weende's method, as described by Krishna and Ranjhan (1980).

The ash content was determined by weighing 5 grams of sample in a crucible and charring on a low flame. The crucible was then kept in a muffle furnance and the temperature was allowed to rise to 600^{O}C and left for 2 hours. The total ash (%) was calculated as:

$$\frac{\textit{weight of ash } x\ 100}{\textit{weight of sample on dry matter basis}}$$

Fat was extracted by reflux distillation with petroleum ether (boiling point 40^{O}C - 60^{O}C) over a period of eight hours using the Soxhlelt method as described by Krishna and Rahjhan (1980). The total fat was expressed as the weight of crude fat divided by weight of dried material taken, expressed in percentage.

The wet ashing method described by Harris (1970) was used for the determination of calcium content. The organic matter of the sample was oxidised with concentrated nitric acid and perchloric acid. The acids were partially removed by volatilisation and the soluble mineral constituents remained dissolved in nitric acid. Any silica present was dehydrated and made insoluble. The dry ashing method was used for the determination of phosphorus. Finely ground and oven-dry sample (10.5g) was placed in a porcelain crucible in a muffle furnace for 6-8 hours at a temperature of 450^{O}C. The sample was cooled on top of an asbestos sheet and 5ml 1N HNO_3 solution was added. This was evaporated to dryness on a steam bath under ventilation. The atomic absorption

spectrophotometer analysis was used to analyse the mineral elements.

3.6 DIET FORMULATION

Three experimental diets were formulated by adding graded levels of whole snail meal to layers' mash (17.5% CP). All diet formulations were based on determined levels of protein in the whole snail meal (i.e 16.08%CP).

Diet 1 was the control diet (i.e the 17.5% CP): commercial layers' mash.

Diet 2 - 124.4 grams, representing 2% CP. whole snail meal was added to 1000 grams commercial feed giving a CP level of 19.5% CP level

Diet 3 - 248.8 grams, representing 4% CP, whole snail meal was added to 1000 grams commercial feed. This gave a total of 21.5% CP level.

Diet 4 - 373.1 grams (6.0% CP) whole snail meal was added to 1000 grams weight of commercial feed, giving a CP level of 23.5%. The detailed method of formulation is shown in Appendix V.

3.1 DETERMINATION OF METABOLIZABLE ENERGY (ME)

The metabolizable energy of the control and formulated diets was calculated using the formula by Winberg (1971). The detailed calculation is shown in Appendix VI.

3.8 COLLECTION OF BIRDS

Quail hens (Plate III) at the point-of-lay purchased from The National Veterinary Research Institute Vom, Plateau State, were transported in cardboard boxes to the

Department of Biological Sciences, Ahmadu Bello University, Zaria. The birds were housed in prepared cages in the post-graduate laboratory of the Department.

The sex of the quails was ascertained by the grey and black-speckled breast and whitish throat and by examining the vent. Vent inspection was done by grasping the head and neck between the thumb and forefinger, with the body cradled in the palm of the hand. This exposed the ventral area to full view, showing considerably enlarged bluish coloured vent with a horizontal slit. These are the distinguishing features of female quails. The male quail is distinguished by its even coloured brown breast with only a few speckles and by a ball-like protrusion above the vent.

3.9 EXPERIMENTAL DESIGN

Forty quail hens were labelled, using leg tags, with the numbers one to forty. The Fisher and Yates' statistical table (cited in Murdoch and Barnes, 1973) was used to arranged these numbers in random order. The first treatment (i.e control) was assigned ten birds; the other 3 treatments were also assigned ten birds each. Each treatment was replicated by splitting each group of ten birds into two groups of five birds each. A sixteen-hour lighting period per day was provided.

3.10 FEEDING EXPERIMENT

Thirty to forty-day-old quail hens were used. The first fourteen days of arrival were used for acclimatization of birds to cages and ambient conditions. During this period, birds were fed *ad libitum* on the control diet and water . Food wastage was reduced by fitting wire mesh over the food (Plate IB).



PLATE III: Forty-day-old Japanese quail *Coturnix coturnix japonica* hens.

The first three days of feeding the quails on the treatment diets were regarded as a period of acclimatization to respective diets. During this period no measurement of any parameter was taken. Effectively, at the start of recording, birds were 42-43 days old and had attained 85% lay. Each treatment group was fed in the morning of each day, with 320 grams of their respective diets for a period of 56 days. Feed refused by birds was freed of birds' droppings and weighed using a Mettler balance before feeding each day.

Availability of water was ensured by draining and refilling water drinkers each morning. Water drinkers and feeders were washed and disinfected using Dettol antiseptic once a week.

3.11 MEASUREMENTS.

3.11.1 EGG PRODUCTION (EP).

Eggs were collected everyday before 9-00 am. The number of eggs laid daily by each group, in each treatment was recorded. Egg production (EP) was calculated as shown below:

$$EP(\%) = \frac{\text{total number of egg per day/treatment}}{\text{number of birds per treatment}} \times 100$$

3.11.2 DETERMINATION OF EGG QUALITY

All of the eggs collected each day per treatment were weighed using a top loading Mettler Balance to the nearest 0.1g and average egg weight determined. An egg whose weight was closest to the average weight per treatment was isolated. The length and maximimun width of each isolated egg was measured, using 12cm Vernier calipers, to the

nearest 0.1cm. The shape Index (SI) of each egg was calculated as the proportion of the maximum width to the length:

$$SI = \frac{\text{Egg width (cm)}}{\text{Egg length (cm)}}$$

Each egg was broken carefully along the equator using a sharp knife (care being taken to keep the yolk and albumen intact) and placed on a flat white tile to determine the internal quality traits..

The inner thick albumen height was measured using 12cm Vernier calipers, to the nearest 0.1cm and recorded in millimeters. The Haugh Unit (HU) of each egg was calculated from the height of the albumen and egg weight using the Haugh Unit formula modified by Eisen *et al.*, (1962):

$$HU = 100\log (H - 1.7W^{-37} + 7.57)$$

where: H is the height of the inner thick albumen in millimeters. W is the weight of the egg in grams.

The yolk height and width/diameter were measured using 12 cm Vernier calipers, to the nearest 0.1cm. The dimensions obtained were used to calculate the Yolk Index (YI) of each egg using the formula by-sharp and Powell (1930).

$$YI = \frac{\text{Yolk height (cm)}}{\text{Yolk width (cm)}}$$

The egg shell thickness of isolated eggs from each treatment was measured using a 0-12cm Micrometer Screw gauge, with a ball anvil, to the nearest 0.01mm.

Measurements were taken at three points around the equator of the egg shell, with the shell membrane partially removed at these points. The shell thickness was determined by taking the average of the three measurements.

The shell from each of the isolated eggs was washed in tap water with the shell membrane intact and left to dry at room temperature for 24 hours. This was then weighed using a top loading Mettler Balance to determine the egg shell weight.

The weight of the food refused by birds which was determined earlier was used to calculate the average feed intake per bird, per day, for each treatment. The Feed Conversion (FC) was determined as follows:

$$FC = \frac{\text{Feed intake gram/bird/day.}}{\text{whole egg weight gram/egg/day.}}$$

3.12 STATISTICAL ANALYSIS.

To determine whether there were any significant differences between the diets, the data for egg production, egg weight, Haught unit, feed conversion, shape index and yolk index were subjected to analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) (Duncan, 1955)

Pearsons correlation coefficient was used to compare the characteristics of the eggs by treatments.

$SAS^{(R)}$ soft ware (1998 Edition) was used to analyse the data.

CHAPTER FOUR

RESULTS

4.1 CHEMICAL ANALYSIS.

4.1.1 WHOLE SNAIL MEAL

The chemical composition of whole snail meal is presented in Table 4.1. The value obtained for ash was the highest (45.84%) and for phosphorus the lowest (0.34%), on dry matter basis. The level of calcium was quite high (30.40%) and in fact, not much lower than the ash content. The other components had intermediate values.

4.1.2 EXPERIMENTAL DIETS.

Table 4.2 shows the chemical composition of the control diet and the other three experimental diets. The table presents the values obtained for the crude protein, mineral content (calcium and phosphorus), moisture content, dry matter, ash, crude fibre, ether extract, calculated nitrogen free extract, carbohydrate and organic matter and metabolizable energy contents of the diets.

CRUDE PROTEIN (CP)

The protein level in the control diet was 17.51%. The determined values of crude protein content of the other three treatment diets, containing snail meal were approximately the same as their calculated values. (See Table 4.2).

TABLE 4.1 COMPOSITION OF WHOLE SNAIL MEAL

Components	Percentage
Crude Protein (N x 6.25)	16.08
Moisture	2.22
Dry Matter	97.88
Ash	45.88
Crude Fibre	0.95
Ether Extract	2.01
Calcium	30.40
Phosphorus	0.34

CALCIUM AND PHOSPHORUS

It was found that the calciun level of diets 2, 3, and 4, containing different amounts of whole snail meal was consistently higher than the calcium level in the control diet. Calcium was found to constitute 3.0% in the control diet and 8.9% in diet. The control diet had the highest phosphorus level of 3.4% and diet 4 had the lowest value of 0.41%. The level of phosphorus decreased with an increase in the quantity of whole snail meal included in the diets.

MOISTURE CONTENT

The moisture content in all the diets was found to decrease slightly with increased inclusion of the snail meal. The highest value of 6.45% was recorded in the control diet and the lowest value of 5.54% in diet 4.

DRY MATTER (DM)

The highest value of 94.46% was recorded in diet 4, with the control diet having the lowest value of 93.55%. It was observed that DM increased with increased inclusion of whole snail meal.

ASH CONTENT

The control diet had the lowest ash content of 11.28%. Ash content was found to increase with increase in the quantity of the whole snail meal in the treatment diets. Ash content of diet 4 was highest (29.31%) (Table 4.2).

TABLE 4.2: CHEMICAL COMPOSITION OF THE CONTROL AND EXPERIMENTAL DIETS

Component	Diet 1	Diet 2	Diet 3	Diet 4
Crude protein (%)	17.51	19.52	21.50	23.48
Calcium (%)	3.02	5.21	8.30	8.91
Phosphorus (%)	3.40	0.54	4.42	0.41
Moisture (%)	6.45	6.13	5.68	5.54
Dry matter (%)	93.55	93.87	94.32	94.46
Ash (%)	11.28	19.43	23.71	29.31
Crude fibre (%)	7.89	8.46	9.31	10.12
Ether extract (%)	7.54	8.38	10.48	11.94
*Nitrogen Free Extract(%)	49.33	38.08	29.32	19.61
*Calculated Carbohydrate(%)	57.22	46.54	38.63	29.73
*Calculated Organic matter(%)	82.27	74.44	70.61	65.15
Calculated ME:				
Kcal/100gram	328.30	295.42	283.88	266.86
Kcal/Kg	3283	2954	2839	2669

All values are based on dry matter
*Detailed calculation shown in Appendices VII, VIII and IX
ME = Metabolizable Energy.

CRUDE FIBRE.

The crude fibre content of the three treatment diets was only very slightly higher than that of the control. However, the highest value was recorded in diet 4, 8.12%. This value was slightly higher than the values recorded for diet 3 (8.09%) and diet 2 (8.04%).

ETHER EXTRACT - Crude fat.

The crude fat was observed to increase with increased inclusion of whole snail meal. Diet 4 which had the highest level of the snail meal had the highest value of 11.94% and the control diet had the lowest value of 7.54%.

NITROGEN FREE EXTRACT (NFE)

The control diet had the highest NFE value of 49.33%, the next highest diet 2(38.08%) while diet 4 had the lowest value (19.61%).

ORGANIC MATTER

The organic matter in the diets varied considerably. The control diet had the highest value of 82.27% whereas the lowest value of 65.15% was observed in diet 4.

METABOLIZABLE ENERGY (ME)

It was observed that the higher the level of whole snail meal inclusion, the lower the ME, expressed in Kcal/kg. The control had the highest value of 3283 Kcal/kg, while diet 4 had the lowest value of 2669Kcal/kg.

4.3 EGG QUALITY PARAMETERS.

All the eggs sampled (Plate IV) and analyzed were normal with no incidence of blood and meat spots. The shell was clean, unbroken and appeared normal. The yolk outline was well defined and free of defects. Throughout the eight-week period of the experiment, only one death was recorded among the birds fed on diet 3 (21.5% CP), representing 10% mortality.

Table 4.3 shows the mean values of the egg characteristics during the period of study. The number of eggs collected daily varied from five to ten with a mean of 8.08± 0.028. The egg shell thickness gave a mean value of 0.20mm ± 0.00. A mean Haugh unit value of 91.50± 0.35 was obtained. The feed conversion, shape index and yolk index were found to vary considerably, showing mean values of 2.71 ± 0.104, 0.82 ± 0.007 and 0.52 ± .007, respectively. The rate of egg production had a mean value of 75.00% ± 0.79.

The general characteristics of the eggs from quails fed on the different diets are shown in Table 4.4. The egg number, egg weight, Haugh unit, yolk index and egg production were significantly related to diets ($P<0.05$), with the egg shell thickness being most significant ($P<0.01$). The feed conversion and shape index were statistically independent of dietary treatments with their respective lowest and highest values observed in the control diet. The difference between the feed conversion and shape index of the diets was not significant (Table 4.4). Feed conversion was numerically highest for birds fed on diet 2; the eggs from these birds had the lowest mean shape index.



PLATE IV: Eggs of Japanese quail

TABLE 4.3 Mean Production Values of Variables

Egg Charateristics	Mean	Standard deviation	Correlation of value	Minimum	Maximum
No of Eggs	8.0804 ±0.0688	1.0299	12.7462	5.0000	10.0000
Egg weight(g)	9.2835 ±0.0279	0.4188	4.5110	8.1000	10.4000
Egg shell thickness(mm)	0.2002 ±0.0015	0.0217	10.8601	0.1100	0.2900
Haugh Unit	91.4951 ±0.3509	5.2514	5.7396	81.9000	99.5000
Feed conversion	2.7089 ±0.1043	1.5611	57.6266	1.6700	25.5000
Shape Index	0.8186 ±0.0065	0.0970	11.8548	0.6300	1.1300
Yolk Index	0.5180 ±0.0072	0.1074	20.7281	0.3000	0.8200
Egg Production	82.0699 ±0.7923	11.8584	14.4491	50.000	111.000
Other variables	-				
Days	28.5000 ±1.0824	16.1994	56.8401	1.0000	56.0000
Weeks	4.5000 ±0.1534	2.2964	51.0315	1.0000	8.0000
Diets	2.5000 ±0.0749	1.1205	44.8215	1.0000	4.0000

TABLE 4.4 Effects of different dietary tretments on egg production performance and egg quality traits

Variables	Control	Diet 2	Diet 3	Diet 4	S.E	Level of Sgni
Protein level (%)	17.5	19.5	21.5	23.5	-	-
No of eggs	8.179^{ab}	8.411^{a}	7.893^{b}	7.839^{b}	±0.13	*
Egg weight (g)	8.998^{d}	9.143^{c}	9.629^{a}	9.359^{b}	±0.00	*
Egg shell thickness (mm)	0.182^{d}	0.199^{c}	0.204^{b}	0.215^{a}	±0.93	**
Haugh unit	89.195^{b}	91.763^{a}	92.255^{a}	92.768^{a}	±3.50	*
Feed conversion (feed/g/ egg)	2.576^{a}	2.950^{a}	2.614^{a}	2.696^{a}	±0.30	NS
Shape Index	0.828^{a}	0.801^{a}	0.821^{a}	0.824^{a}	±0.00	NS
Yolk Index	0.525^{ab}	0.560^{a}	0.502^{b}	0.485^{b}	±0.00	*
Egg Production	81.786^{ab}	84.107^{a}	83.994^{a}	78.293^{b}	±17.47	*
Mortality	0.000	0.000	1.000	0.000	-	-

All Values represent means
SE - Standard error
NS - not significant (P>0.05)
* - significant (P<0.05)
** - highly significant (P<0.01)
a,b,c,d-Means within rows with the same letter are not significantly different at 5% level of probability using DMRT.

The egg shell thickness and egg weight were considerably lower in the control diet and diet 2. Higher values of these characteristics were obtained in diet 3, with diet 4 having the highest values. The egg shell thickness and egg weight differ significantly between the diets (Table 4.4). Highest values of number of eggs, Yolk index and egg production were obtained in birds fed on diet 2, with lowest values of these characteristics in diet 4. The egg number and yolk index of the birds fed the control diet were not significantly different from those of birds fed other diets. There was significant difference in the egg number and Yolk index between diets 2 and 3; 2 and, 4. There was no significant difference for these characteristics between the control diet and other diets and diets 3 and 4. (Table 4.4)

The differences between the values of the Haugh unit for the three treatment diets were significant although higher Haugh unit values were obtained with higher levels of snail meal inclusion. The Haugh unit of the control differed significantly from that of the treatment diets.

Table 4.5 shows the weekly variation of egg charactristics. Only the Haugh unit and Yolk index did not differ significantly between weeks. Though not significant statistically, higher values of Haugh unit and yolk index were recorded in week 6 and week 5 respectively. The highest number of eggs was recorded in week 2, with the lowest value in week 8. Maximum egg production and egg weight were reached in week 6 and week 7 respectively, their respective minimum values were obtained in weeks 8 and 2. The first and second weeks showed lower values for egg shell thickness and feed conversion. Higher values of these characteristics were observed in week 3 and week 5 (Table 4.5). Weeks 2 and 7 gave highest and lowest numerical values of shape index respectively.

TABLE 4.5: Weekly Variation of egg quality Parameters

Week	No of egg	egg weight(g)	egg shell thickness (mm)	Haugh Unit	Feed conversion	shape index	yolk index	egg production
1	7.64^{abc}	9.311^{b}	0.173^{f}	91.079^{a}	2.169^{b}	0.831^{a}	$0,502^{a}$	79.43^{ab}
2	8.464^{a}	8.982^{c}	0.195^{e}	90.589^{a}	2.484^{b}	0.850^{a}	0.534^{a}	84.643^{a}
3	8.107^{ab}_{c}	9.071^{c}	0.209^{a}	92.050^{a}	2.862^{ab}	0.835^{a}	0.519^{a}	82.571^{a}
4	8.250^{ab}	9.307^{b}	0.206^{b}	91.393^{a}	2.765^{ab}	0.833^{a}	0.512^{a}	84.821^{a}
5	8.107^{ab}_{c}	9.407^{ab}	0.208^{a}	90.296^{a}	2.762^{ab}	0.818^{ab}	0.536^{a}	83.357^{a}
6	8.393^{a}	9.304^{b}	0.204^{c}	92.254^{a}	3.528^{a}	0.810^{ab}	0.523^{a}	86.107^{a}
7	7.786^{bc}	9.479^{a}	0.204^{c}	92.107^{a}	2.553^{b}	0.773^{b}	0.497^{a}	79.893^{ab}
8	7.571^{c}	9.407^{ab}	0.202^{d}	92.143^{a}	2.547^{b}	0.799^{ab}	0.520^{a}	75.524^{b}
SE	±0.19	±0.01	±1.31	±4.95	±0.43	±0.00	±0.00	±24.70
Level of significant	*	*	*	NS	*	*	NS	*

All values represent means

S.E.Standard Error
NS Not significant (P>.0.05)
* = Significant (P<0.05)
a,b,c = Means Within columns with the same letter are not significantly different at 5% level of probability using DMRT.

Table 4.6: Evidence for Interaction between egg chracteristics

Egg characteristics	Egg Number	Egg Weight	Egg Shell Thickness	Haugh Unit	Feed Conversion	Shape Index	Yolk Index	Egg Production
Egg Number	1.00000							
Egg Weight	-0.30257**	1.00000						
Egg Shell Thickness	-0.07272+	0.25202**	1.00000					
Haugh Unit	0.11805+	0.10330+	0.20933*	1.00000				
Feed Conversion	0.07801+	-0.08017+	0.09989+	-0.00598+	1.00000			
Shape Index	0.06531+	-0.05145+	-0.03389+	0.01221+	-0.02733	1.00000		
Yolk Index	0.05216+	-0.05769+	-0.06709+	-0.05313+	0.07873+	- 0.122031+	1.00000	
Egg Production	0.89566**	-0.18653*	0.00726+	0.07818+	0.07663+	0.06933+	0.04674+	1.00000

Pearson correlation coefficients/ Prob > Ho: Rho= O/N = 224

* - significant (P<0.05)
** - Highly significant (P<0.01)
+ - Not significant (P>0.05)

Table 4.6 shows the relationship between the egg characteristics. The number of eggs was related to the egg weights and egg production. The egg weight was related to both the rate of egg production and egg shell thickness.Furthermore egg shell thickness was related to the Haugh unit.

The pearson correlation coefficient showed a positive correlation between the egg number and egg production but negative correlation between egg number and egg weight. It also showed positive correlation between egg weight and egg shell thickness but negative correlation between egg weight and egg production. In addition, positive correlation was also found between egg shell thickness and Haugh unit.

An analysis of variance to ascertain the effect of "week*diet" interaction on egg parameters revealed no effect on egg number,feed convertion and egg production, but significant effect on egg weight,egg shell thickness, Haugh unit, shape index and yolk index (see Appendix X, a-h, for ANOVA tables).

CHAPTER FIVE

DISCUSSION

5.1 CHEMICAL ANALYSIS

For many nutrients that are required by animals, there are direct chemical procedures for establishing how potent feedstuffs are in these nutrients (Cramptom and Harris, 1969). The proximate analysis is probably the most generally used chemical method for describing feedstuffs. Chemical analysis guide feed producers in the formulation and compounding of balanced rations for livestock. The proximate composition of the whole snail meal of *Limicolaria* sp. used in this study is similar to that found in *Achatina fulica* Bowdich, as reported by Creswell and Kompiang (1981).

The 16.08% protein content of the whole snail meal was adequate to support egg laying in Japanese quails. In determining the potentials of the snail meal in feeding broilers, Creswell and Kompiang (1981) observed significant improvements in weight gain due to the snail-meal because of the apparent nutritional adequacy of the basal diet. Creswell and Habibie (1981) reported that snail meal prepared from only the flesh of the snail(60.9% CP) and fed to laying hens, resulted in egg production and egg weight within the range of values obtained using commercial layer diet. The relatively low values of protein, crude fibre and ether extract and high percentage of ash in the whole snail meal suggest that the meal contained very low organic material but was rich in minerals. Low organic material in feeds is known to be responsible for low moisture content, which is ordinarily considered to be held in organic material. The low organic content was therefore responsible for the low moisture content of the whole snail meal. Higher

moisture content in feed increases the susceptibility of feed to spoilage in storage, in which growth of fungi may result in stale feed. The inclusion of whole snail meal, therefore, reduces the chances of feed spoilage due to its low moisture content. The addition of the whole snail meal produced a feedstuff that was high in calcium but low in phosphorus. The value of calcium obtained, in this work, using the garden snail was slightly lower than the 31.1% obtained by Creswell and Kompiang (1981) in the Giant African Snail, *Achatina fulica* Bowdich. This could be due to the comparatively thin shell of the garden snail. Mafulul (1988) also found that calcium and phosphorus were more concentrated in the tissue of the Giant Land Snail, *Archachatina marginata* Swainson, than were all other minerals. In the shell however, phosphorus had the lowest value while zinc was next to calcium in concentration.

The improvement in Haugh unit, egg weight, egg shell thickness, Yolk index and higher egg production (except in diet 4) was as a result of whole snail meal inclusion. This is the evidence of the good feeding value of the meal. Mead (1961) stated that removal of slime by boiling in water is essential to get rid of toxic and unpalatable factors in snail. Boiling is now considered a normal step in the preparation of snail meal, not for this reason alone but because boiling enables easy separation of the soft tissues from the shell (Creswell and Kompiang, 1981).

The proximate composition of the treatment diets revealed that the higher amount of moisture, crude fibre, fat and nitrogen free extract of the control diet might have been due to the high carbohydrate content. This is evident in the high amount of metabolizable energy, calculated carbohydrate and low ash content of the control diet.

Alhough the fat content of diets 2,3 and 4 was higher than that of the control diet, the low nitrogen free extract and carbohydrate content resulted in relatively lower metabolizable energy in these diets. This shows that addition of snail meal enriched the diets in protein, crude fibre, fats, mineral contents and at the same time, caused a decline in the levels of carbohydrate and moisture content.

5.2. LAYING PERFORMANCE AND EGG QUALITY

The protein levels of all the four diets used in this study supported good laying performance and most probably contained the amino acid required for laying. The range of protein levels of these four diets fall within the estimates of the protein requirement of egg-laying Japanese quail which vary from 15-25% of the diet, according to Vohra and Roudybush 1971; Begim and Insko, 1972; Kumar *et al.*, 1978; Yamane *et al.*, 1979 and Allen and Young, 1980. Egg production as obtained in all the diets was higher than the values of 67.8% and 72.1% at 18% and 20%, dietary protein, reported by Schwartz and Allen (1980). The relatively higher egg production in this study could be attributed to the better feed conversion by the quail hens. Creswell and Habibie (1981) obtained egg production values ranging from 72.6 - 79.8% at 20% protein level. Schwartz and Allen (1980) suggested that high egg production could be as a result of the high metabolic rate response of Japanese quails to dietary modifications compared to other species and laying chickens.

The improvement of laying performance with increase in the quantity of protein observed in the quails fed on diets 2 and 3, agrees with the result obtained by Howes

(1965). Howes reported that the optimal level of dietary protein is less than 20%, possibly as low as 16%, if the metabolizable energy level of the diet is about 2700 Kcal/Kg. In a similar report, Allen and Young (1980) observed a high level of egg production (88.3% and 92.6%) in laying Japanese quails fed 17.23% and 19.6% protein levels, respectively. The lower egg production in quails fed on diet 4 could probably be due to the fact that the protein content was higher than 20% and because of the relatively low energy content of the diet. The higher level of protein in diet 4 resulted in larger eggs with virtually no increase in egg production. Salah *et al.*,(1992) also reported that quail hens fed on 21 and 24% protein diets laid significantly heavier eggs with no increase in egg production. With respect to egg production, it appeared that the control diet and diet 4 were inferior to diets 2 and 3. Wilson *et al.*, (1980) reported that egg production decreased when the dietary level of phosphorous was increased above 0.41%. The high phosphorus content of the control diet in this study (3.4%) might have been the cause of relatively lower egg production of 81.7% compared to 84.1% in diet 2. With the exception of its probable effect on egg shell thickness and weight, the increased calcium content of diets 3 and 4 (over the control diet) appeared to have no effect on the other egg quality parameters. It also appeared to have no effect on egg production and feed conversion. This agrees with the results of the studies conducted by Watkins *et al.*, (1977), Kuhl *et al.*, (1977), Miller and Sunde (1975) and Brister *et al.*, (1980). The increase in egg production in quail hens fed on diet 2 is contrary to the findings of Scott *et al.*, (1971) who reported that a calcium level of 5.0% in chicken layer diet is excessive and might have resulted in the decreased egg production and feed consumption

that he observed. This study found diet 2 with 5.2% calcium to give the highest egg production. The difference in the finding of this study and that of Scott *et al.*, (1971) may be explained by subtle physiological differences between the chicken hens and quails used in these studies. The inverse relationship between egg production and egg weight in the treatment diets may be explained by the biological phenomenon that higher clutch sizes result in reduced egg weight (Gill, 1990).

The result of this study shows egg weight values similar to the values obtained by Howes (1965). Howes reported that quail eggs weighing about 9.0g were obtained when quail hens were fed on diet containing protein levels of 16-28% (ME = 2700Kcal/Kg). In this study eggs that weighed 9.6g and 9.4g were obtained from quails fed diets 3 and 4, respectively. These higher egg weight values might be as a result of the 21.5% and 23.5% protein contents of these diets. It can therefore be deduced that, addition of whole snail meal apparently increased the egg weight due to an increase in the protein content of the diets. The higher egg weight obtained in quails fed on diet 4 might have resulted in the low numbers of egg obtained. The increased egg weight and egg shell thickness with higher quantity of whole snail meal suggests that increased egg weight was related to the egg shell thickness due to the high calcium content of the treatment diets.

Eggs of quails fed diets 3 and 4 had thicker egg shells than those fed the control diet and diet 2. The thick egg shells must have resulted from the high percentage of minerals, especially calcium, in diets 3 and 4 arising from their higher whole snail meal content. The thickness of egg shell is used as the major criterion in assessing egg shell

quality. Therefore, shells of eggs from diets 3 and 4 were of superior quality to egg shells from the control diet and diet 2. Roland (1980) remarked that a laying hen should consume 3.75g calcium per day to ensure maximum egg shell quality. This is higher than the value recommended for laying hens by NRC(1984). The relatively thin egg shells of the eggs from the control diet in this study could mean that laying Japanese quails need higher dietary calcium than laying chickens. Edwards (1980) reported that obvious reasons for thin egg shell are i) the egg doesn't stay long enough in the shell gland of the hen to allow sufficient calcification of the egg, ii) layer diet being too low in calcium or vitamin D, iii) the diet may contain too much phosphorus. The probable reason for the thin shell of eggs from quail hens fed the control diet could be the high phosphorus level in the diet. The first week of the experiment recorded the lowest value of egg shell thickness. This could be attributed to slow response of birds to the respective treatment diets. This is substantiated by the improvement observed in subsequent weeks.

The relatively high Haugh unit values of diet 2, 3 and 4 indicate that the inclusion of whole snail meal improved the thick albumen quality of the eggs laid by birds fed on these diets. These eggs would therefore have longer storage potential than the eggs that were laid by quails fed the control diet. Hurnik *et al.*,(1978) found that the lower the albumen quality at oviposition, the more rapid its decline during storage. Also associated with the decline during storage is a loss in weight due to the evaporation of water (Romanoff and Romanoff,1949). The amount of thick albumen is used as an index of freshness (Cole and Ronning 1977), therefore fresh eggs have significantly greater albumen height than stored eggs (Benton and Brake,1996). Hall and Vanwagenem (1936) remarked that a good firm albumen is essential for high hatchability of eggs. The trend

towards high Haugh unit value with increased quantity of whole snail meal substaintiates its significant effects in the different diets, in this study. The numerically lower Haugh unit values from eggs of quails fed the control diet signifies that better Haugh unit score could be obtained by increasing the protein content of layers diet up to 23.5%. The Haugh unit values in this study fall within the range of values of 80.1 to 93.9 reported by Creswell and Habibie (1981), in chicken eggs.

Even though the shape index had no relationship with the diets, its value is likely to be of commercial interest in that the shape of an egg can influence the way it is set in a conventional incubator. Long and large round eggs (i.e low shape index) are undesirable because they pack badly, while extremes in both directions (i.e high shape index) tend to give poor hatchability (Landauer, 1937). Even though there was no relationship between the shape index and yolk index, diet 2, with the lowest shape index value had the highest yolk index. The weekly variation of the shape and yolk indices indicates a corresponding increase and decrease of these parameters. It can be assumed that the shape of an egg might in a way influence the width and probably depth of the yolk.

The variation in the yolk index, as a measure of standing-up quality of the yolk, might have been caused by the effects of the treatment diets. The yolk indices obtained in this study were higher than the values reported by Francis (1997) in laying chicken. Imai(1981) reported that the yolk index of fresh quail eggs is almost the same as that of chicken eggs. This indicates higher egg yolk quality from the eggs of quails in this study. That the yolk index of eggs of quails fed diet 2 was the highest could be as a result of better feed conversion by these birds. Creswell and Kompiang (1981) reported increased yolk pigmentation in eggs from laying chickens fed snail meal than those fed conventional layer's diet. This is an indication of higher quality yolk.

The calculated metabolizable energy (ME) values of the diets used in this study were within the range of 2700 to 2900 Kcal/Kg, recommended for laying quails (Howes, 1965; Vohra and Roudybush, 1971; Begim and Insko, 1972). The high ME value of the control diet was due to high percentage of carbohydrate in this diet. The low ME value in diet 4 was due to low carbohydrate content. Different ME showed no influence on the feed conversion (FC) in the different diets. This was due to the fact that there was no relationship between the feed conversion and diets, and other egg quality traits. From the calculated ME, no apparent reasons could be adduced for the varied FC and lower egg production of birds fed the control diet and diet 4. This presumed that maximal utilization of feed, at highest protein level, was quite similar for all diets. Nevertheless, the FC values obtained in this study were higher than values of 2.24 - 2.72 g (feed/gram/egg) reported by Creswell and Habibie (1981), in laying chickens.

5.3 CONCLUSIONS AND RECOMMENDATIONS

5.3.1. CONCLUSIONS

The significance of this research lies in the fact that whole snail meal was successfully incorporated in diet for laying quails and adequately supported laying of eggs of higher quality than those from the conventional commercial layers diet.

The study indicates that:

- The garden snail may be used as source of good quality protein which could easily be processed and incorporated into poultry feed rations.
- Up to 2.0% (CP) whole snail meal can be included in layer diets of Japanese quail for higher egg production;
- Diet 4 (23.5% CP) can be recommended when eggs with high weight, thicker shells

and longer storage potential are required.

- Diet 2 (19.5% CP) gave the best range of the egg characteristics of commercial interest.

5.3.2. RECOMMENDATIONS

It is recommended that:

- the garden snail be used as a source of protein in the production of poultry layers feed.
- fish meal or plant protein sources can be used to compliment the whole snail meal in poultry feed production.
- poultry feed producers should formulate and produce Quail Layer's Feed, with higher calcium and protein content than the available layers mash. This will help enhance layer quail performance.

Further studies should be carried out to determine:

- the fertility and hatchability of eggs from layer Japanese quails fed graded levels of whole snail meal.
- the growth performance of day-old quail chicks fed whole snail meal.
- other potential areas of utilization of the garden snail.

Finally, the physicochemical changes in the quail egg white during storage should be studied. This will help in the effective utilization of quail eggs.

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APPENDIX I

Classification of Coturnix Quail

KINGDOM - Animalia

PHYLUM - Chordata

CLASS - Aves

SUBCLASS - Neonithes

ORDER - Galliformes

FAMILY - Phasianidae

GENUS - *Coturnix*

SPECIES - *coturnix joponica*

APPENDIX II

Classification of the garden snail, *Limicolaria* sp.

KINGDOM - Animalia

PHYLUM - Mollusca

CLASS - Gastropoda

SUBCLASS - Stylommatophora

ORDER - Achatinacea

FAMILY - Achatinidae

GENUS - *Limicolaria*

APPENDIX III

Amino Acid Concentration in Snail meal[1, 2], *Achatina fulica* Bowdich.

Amino Acid	% Dry Sample
Lysine	4.35
Histidine	1.43
Arginine	4.88
Aspartic acid	5.98
Threonine	2.76
Serine	2.96
Glutamic acid	8.16
Proline	2.79
Glycine	3.82
Alanine	3.31
Cystine	0.60
Valine	3.07
Methionine	1.00
Isoleucine	2.64
Leucine	4.62
Tyrosine	2.44
Phenylalanine	2.62

[1]Total percent nitrogen recovered was 94.3

[2]Ammonia was 1.31% of dry sample weight.

Adapted from: Creswell and Kompiang, (1980).

APPENDIX IV

Estimated amino acid requirement of adult female Japanese quail for crude protein and amino acid composition of the quail egg.

Amino Acid	Requirement (% of diet)	Composition (mg/g egg)
Arginine	1.13	20.4
Histidine	0.38	15.0
Isoleucine	0.81	20.2
Leucine	1.28	32.2
Lysine	0.86	27.3
Methionine	0.37	11.7
Methionine plus cystine	0.68	19.3
Phenylalanine	0.70	17.8
Phenylalanine plus tyrosine	1.25	32.6
Threonine	0.67	19.0
Tryptophan	0.17	-
Valine	0.83	21.8

Culled from: Allen and Young (1980)

APPENDIX V

Detailed calculations of diet formulation

Determined CP of whole snail meal = 16.08%

therefore, 100 grams whole snail meal gives 16.08% CP.

(a) Diet 2 (19.52% CP)

If 100g gives 16.08% CP

Xg gives 2.0% CP

$$X = \frac{2.0\% \text{ CP} \times 100\text{g}}{16.08\% \text{ CP}}$$

$$X = 12.438\text{g}$$

This shows that 12.438g of 100g whole snail meal gives 2.0% CP

In other to add 2.0% CP whole snail meal to 1.0Kg of layers mash; Thus

12.438g gives 2.0% CP in 100g

X gives 2.0% CP in 1000g

$$\text{Therefore } X = \frac{12.438\text{g} \times 0.02 \text{ CP} \times 1000\text{g}}{0.02 \text{ CP} \times 100\text{g}}$$

$$X = 124.38\text{g}$$

This implies that 124.38g of whole snail meal is needed to increase the CP of every 1000g layer's mash by 2.0%.

(b) Diet 3 (21.50% CP)

100g whole snail meal gives 16.08% CP

X " " " " 4.0% CP

$$\text{Therefore, } X = \frac{100\text{g} \times 4.0\% \text{ CP}}{16.08\% \text{ CP}}$$

$$X = 24.874\text{g}$$

24.875g of 100g whole snail meal represent 4.0% CP.

Thus 248.75g of 1000g whole snail meal gives 4.0% CP.

248.75g whole snail meal is needed to increase the CP of every 1000g layers mash by 4.0%.

(c) Diet 4 (23.48% CP)

100g gives 16.08% CP

X gives 6.0% CP

Therefore, X = 37.313g

In 1000g whole snail meal, 373.13g represents 6.0% CP which is

needed to increase the CP of 100g layers mash by 6.0%.

APPENDIX VI

Calculation of metabolizable energy (ME), Using the formula by Winberg (1971)

Percentage carbohydrate x 4 - a

" fat x 9 - b

" fibre x 4 - c

Calorific value of sample = a + b + c

ME = calorific value of sample expressed in

Kcal/100g = (a + b + c)

(a) Diet 1 ME = 57.22 x 4 + 7.54 x 9 + 7.89 x 4
= 328.3 Kcal. /100g
= 3283 Kcal. /Kg

(b) Diet 2 ME = 46.54 x 4 + 8.38 x 9 + 8.46 x 3
= 295.42 Kcal. /100g
= 2954 Kcal./Kg

(c) Diet 3 ME = 38.63 x 4 + 10.48 x 9 + 9.31 x 4
= 286 . 08 Kcal/100g
= 2861 Kcal/Kg

(d) Diet 4 ME = 29.73 x 4 + 11.94 x 9 + 10.12 x 4
= 266 . 86 Kcal/100g
= 2669 Kcal/Kg.

APPENDIX VII

Calculation of Nitrogen free extract (NFE)

When the sum of the percentages of ash, crude protein (CP) ether extract (EE), crude fibre (CF) is subtracted from the dry matter (DM), the difference is the NFE which represents soluble carbohydrates NFE = DM - % (ash + CP + EE + CF)

(a) Control diet:

$$NFE = 93.55 - (11.28 + 17.51 + 7.54 + 7.89)$$

$$= 49.33$$

(b) Diet 2:

$$NFE - 93.87 - (19.43 + 19.52 + 8.38 + 8.46)$$

$$= 38.08$$

(c) Diet 3:

$$NFE = 94.32 - (23.71 + 21.50 + 10 .48 + 9.31)$$

$$= 29.32$$

(d)

$$NFE = 94.46 - (29.31 + 23.48 + 11.94 + 10.12)$$

$$= 19.61$$

APPENDIX VIII

Calculating Quantity of carbohydrate in treatment diets

Percentage carbohydrate in each diet is given by:

Total carbohydrate = soluble carbohydrate + Insoluble carbohydrate = (NFE + CF.) %

(a) Diet I - % Carbohydrate = 49.33 + 7.89 = 57.22%

(b) Diet 2 % Carbohydrate = 38.08 + 8.46 = 46.54%

(c) Diet 3 % Carbohydrate = 29.32 + 9.31 = 38.63%

(d) Diet 4 % Carbohydrate = 19.61 + 10.12 = 29.73%

APPENDIX IX

Total organic matter in different diets

Organic matter = 100 - % moisture + ash) OR

= (DM - ash)%

(a) Diet 1 Organic matter (%) = 93.55 - 11.28

= 82.27%

(b) Diet 2 Organic matter = 93.87 - 19.43

= 74.44%

(c) Diet 3 Organic matter = 94.32 - 23.71

= 70.61%

(d) Diet 4 Organic matter = 94.46 - 29.31

= 65.15%

APPENDIX X

ANOVA TABLES FOR (EGG CHARACTERISTICS)

a. Dependent Variable: Egg Number (EN)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	55.05	1.00	1.01*	0.47
WEEK	7	17.77	2.54	2.56*	0.02
DIET	3	11.88	3.96	3.99*	0.01
WEEK * DIET	21	16.05	0.76	0.77NS	0.75
ERROR	137	135.80	0.99		
Corrected Total	223	236.55			

* Significant (P < 0.01)
** Highly significant (P > 0.01)
NS Not significant (P > 0.05)
DF Degree of freedom

b. Dependent Variable: EGG WEIGHT (gm) (EW)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	11.16	0.20	5.69*	0.00
WEEK	7	5.77	0.82	23.11*	0.00
DIET	3	12.57	4.19	117.45**	0.00
WEEK * DIET	21	4.72	0.22	6.30*	0.00
ERROR	137	4.89	0.04		
Corrected Total	223	39.11			

c. Dependent Variable: EGG SHELL THICKNESS (mm) EST)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	0.04	0.00	99.09**	0.00
WEEK	7	0.03	0.00	279.79**	0.00
DIET	3	0.03	0.01	1525.03***	0.00
WEEK * DIET	21	0.01	0.00	46.57*	0.00
ERROR	137	0.00	0.00		
Corrected Total	223	0.11			

d. Dependent Variable: HAUGH UNIT (HU)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	1250.35	0.00	99.09**	0.00
WEEK	7	117.21	0.00	279.79**	0.00
DIET	3	423.44	0.01	1525.03***	0.00
WEEK * DIET	21	766.75	0.00	46.57*	0.00
ERROR	137	3592.06	0.00		
Corrected Total	223	6149.80			

e. Dependent Variable: FEED CONVERSION (FC)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	142.56	2.59	1-14*	0.27
WEEK	7	30.60	4.37	1-92*	0.07
DIET	3	4.74	1.58	0.69NS	0.56
WEEK * DIET	21	53.74	2.56	1-12NS	0.33
ERROR	137	311.79	2.28		
Corrected Total	543.43	543.43			

F. Dependent Variable: SHAPE INDEX (SI)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	0.69	0.01	1-63*	0.01
WEEK	7	0.12	0.02	2-16*	0.04
DIET	3	0.02	0.01	1-02NS	0.39
WEEK * DIET	21	0.21	0.01	1.32*	0.17
ERROR	137	1.06	0.01		
Corrected Total	223	2.10			

g. Dependent Variable: YOLK INDEX (YI)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	0.60	0.01	0.95^{NS}	0.58
WEEK	7	0.04	0.01	0.46^{NS}	0.86
DIET	3	0.18	0.06	5.20^{*}	0.00
WEEK * DIET	21	0.18	0.01	$0-75^{*}$	0.78
ERROR	137	1-57	0.01		
Corrected Total	223	2.57			

h. Dependent Variable: EGG PRODUCTION(EP)

Source	DF	Sum of Squares	Mean Square	F-value	Pr > F
DAYS	55	8238.09	149.78	1.15^{*}	0-26
WEEK	7	2404.60	343.51	2.63^{*}	0.01
DIET	3	1201.44	400.48	3.06^{*}	0.03
WEEK * DIET	21	1607.98	76.57	0.59^{NS}	0.92
ERROR	137	17906.36	130.70		
Corrected Total	223	31358.47			