NUTRITIVE EVALUATION OF RICE OFFAL IN DIETS FOR GROWING PULLETS AND LAYERS

BY

EMMANUEL AMODU OBEKA
B.Sc. (Agric.)
Ahmadu Bello University
Zaria, Nigeria.

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Department of Animal Science
Faculty of Agriculture
Ahmadu Bello University, Zaria

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.

Obeka

Emmanuel Amodu Obeka

CERTIFICATION

This thesis, "Nutritive evaluation of rice offal in diets for growing pullets and layers", by Emmanuel Amodu Obeka meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

Internal Examiners:

1. _____ Date: 3/3/86
Dr. A. O. Aduku
Chairman, Supervisory Committee
Department of Animal Science
Ahmadu Bello University, Zaria.

2. _____ Date: 3/3/86
Dr. P. C. Njoku
Member, Supervisory Committee
Department of Animal Science
Ahmadu Bello University, Zaria.

3. _____ Date: 3/3/86
Professor N. N. Umunna
Head, Dept. of Animal Science
Ahmadu Bello University, Zaria.

4. _____ Date: 3-iii-86
Professor G.E. Osuide
Dean, Postgraduate School
Ahmadu Bello University, Zaria.

DEDICATION

This work is dedicated to all those who helped me in one way or the other in my search for knowledge.

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diets in the rearing phase but given low-fibre diets in the laying phase took a relatively short time to attain 50% lay once egg laying had commenced.. Egg production was satisfactory on the diets with 0, 20 and 40% rice offal replacing maize. The feed consumed per dozen eggs increased from 1.64kg for birds continuously fed the control diets (in the growing and laying phases) to 5.54kg for birds fed the diet with 60% rice offal replacing maize. At 60% rice offal replacing maize in the diet, egg production was significantly ($P \leq 0.05$) low and the cost of producing one dozen eggs was twice that of the control diet. However, egg production was optimum on the diets with 40% rice offal replacing maize.

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INTRODUCTION

Reid (1970) predicted that by the year 2000 A.D., there will be insufficient grain for all forms of livestock production. The energy in poultry diets is derived mainly from cereals. Those grown in the tropics include maize, sorghum, rice, millet and to some extent wheat. Due to insufficient local production, there is a competition between man and poultry for food ingredients. It is morally unjustifiable to use grain for feeding poultry when human needs have not been met. As much as 70% of the running cost of a poultry enterprise is due to feeds. Feed cost is the most limiting factor in poultry production today. Dependence on alternative source of ingredients, especially when it encourages a shift of ingredients for which there is less competition, may help if the latter is sufficiently available.

The search for grain substitutes in animal feeds has been a subject of numerous cost-oriented studies. Tubers and roots are suitable substitutes due to their high energy content and relatively lower costs. Cassava in particular, is widely known as a rich caloric source. Cassava mixed with appropriate amounts of high protein feedstuffs produces cheaper feeds than if cereals alone are used.

To a great extent, by-products are cheaper to use in poultry feeds since there is little or no competition for

them. Large quantities of fibrous feed ingredients abound-one of the most important in Nigeria, being rice offal.

In Nigeria, there is a great potential for widescale rice production. Areas of particular importance are the Benue and Niger valleys. Rice offal , a rice milling by-product, holds promise as a suitable and cheap substitute for the cereal grain in poultry feeds. Poultry rate of growth and production appear to be largely unaffected by the source of the digested energy. The emphasis should now move away from what cannot be achieved with poor quality fibrous feed ingredients to what can be achieved with them through improved technical knowledge by judicious supplementation and feed preparation.

In this country, there is virtually a complete lack of research information with regard to the use of rice offal, as a partial replacement for maize in grower and layer diets.

This study was undertaken to examine the nutritive value of rice offal as a feed ingredient for growing egg-type pullets and layers and to determine suitable levels of inclusion in chick, grower and layer diets commensurate with economy and satisfactory performance. It was felt that such information, lacking to date, may be helpful in reducing both poultry feed cost and competition between man and livestock for grains. The carry-over effects of feeding high-fibre grower diets

on subsequent laying performance was also evaluated. Attempts were also made to find if there were anatomical modifications of the alimentary tract resulting from feeding high-fibre diets during the pullet growing period. Such findings may help in understanding the fundamental effects of using high-fibre diets for growing pullets and laying hens.

REVIEW OF LITERATURE

INGREDIENT DESCRIPTION

Rice by-products vary in composition depending on the methods of milling. However, rice husks, rice bran, rice polishing and broken rice are some of the more readily distinguishable fractions originating from rice mills.

According to Oyenuga (1968), rice milling process as carried out in Nigeria by the standard machine methods consisted of three stages:

a) removal of husks from paddy rice to produce brown rice

b) production of white rice by removing the brown coat and the germ. The brown coat, consisting mainly of the aleurone layer, and the germ constitute the bran. This by-product is rich in the B-vitamins, oils and protein and is a well-known feedstuff for all classes of domestic animals.

c) polishing of the white rice to give what is usually referred to as "polished rice".

Rice husk has little or no feeding value and is very high in ash, most of which is silica. Rice husk has generally been used as a source of roughage in complete ruminant diets.

Rice bran and rice polishings are valuable livestock and poultry feedstuffs. Both fractions contain about 56% of the crude protein, 56% of the fat and 58% of the mineral

content of brown rice (Oyenuga, 1968). Their protein also contains higher amounts of the essential amino acids. They also contain about 80% of the thiamine, 50% of the riboflavin, 65% of niacin, 62% of the Pantothenic acid and 50% of the pyridoxine found in the brown rice (Oyenuga, 1968).

Locally produced rice by-product is a mixture of rice husks, rice bran and rice polishings together with some broken grains. It is obtained from a one-stage milling process. This is the feedstuff used in the present research. It may be referred to as rice offal. Rice offal is high in fibre, but low in ether extract and protein. Rice offal has a similar nutrient composition with rice mill feed (Gohl, 1975) which contains approximately 60 per cent hulls, 35 percent bran and 5 percent polishings. Rice offal is often erroneously called rice bran.

Rice bran consists essentially of the bran fraction and contains about 14 to 18 percent ether extract (Gohl, 1975). Rancidity is a big problem in the storage of unextracted rice bran. The rancidity is caused by a lipolytic enzyme present in the bran (Shaheen et al., 1975). The enzyme becomes active when bran is separated from the rice, causing the free fatty acid content of the ether extract in the bran to increase rapidly (Kratzer and Payne, 1977). Rice bran is a good source of B-vitamins and is fairly palatable to farm animals. Table 1 shows

the nutrient composition of rice mill feed and rice bran from different sources.

The suitability of rice mill feed in animal feeds has been well established. In countries where the use of rice hulls as livestock feed is legally allowed, up to 75 percent of the hay can be replaced by rice mill feed with good results (Gohl, 1975).

Joshi and Khan (1983) replaced up to 70 percent of the wheat straw of a diet with rice hulls and did not notice any adverse effect on the palatability and performance in cattle. The digestibility of the dry matter and crude fibre was significantly reduced ($P<0.01$). This may be attributed to lignin and silica, whose contents are high in rice hulls namely 20% and 16% respectively (Singh, 1978) as quoted by Joshi and Khan (1983).

RICE BRAN IN POULTRY DIETS

According to a number of researchers (Pino, 1962; Maust et al., 1972) the inclusion of rice bran in diets has not provoked any adverse effect on growth rate, provided the rate of inclusion did not exceed 50%. Growth of chicks was reduced by 30% when rice bran was used at 60% of the diet to replace corn as an energy source in diets containing fish meal and soybean meal (Kratzer et al., 1974). There was no evidence of interference in the availability of trace minerals.

Table 1: Nutrient composition of rice bran and rice mill feed from different sources

Sources	Dry matter %					
	DM	CP	CF	Ash	EE	NFE
Rice bran (Philipines)	88.8	10.6	18.9	13.8	10.6	46.1
Rice bran (Iraq)	91.1	12.4	10.2	12.8	18.3	46.3
Rice mill feed (Nigeria)	89.0	7.6	36.6	11.3	7.6	36.9
Rice mill feed (Zimbabwe)	94.6	7.7	27.7	15.0	4.2	45.4

Source: B.O. Gohl, (1975).

Both autoclacing and parboiling have been found to improve its feeding value (Kratzer et al., 1974). Both methods bring about a marked improvement in growth, indicating a destruction of the growth-depressing factor in rice bran. Kratzer et al. (1974) observed that the pancreas of birds fed rice bran was significantly enlarged when compared to that of birds on the control diet. Rice bran also contains a lipase which is active after the rice is milled. It is this lipase activity that makes rice bran prone to rancidity on storage. Shaheen et al. (1975), Kratzer and Payne (1977) found that parboiling rice before it was milled, as is done commercially in some places, destroyed this lipase activity.

Piliang et al. (1982) found that pullets fed a diet with 81.5% rice bran laid significantly fewer eggs than pullets fed a standard layer diet. The progeny of the pullets fed 81.5% rice bran showed feather defects. Addition of zinc carbonate, $ZnCO_3$, to the maternal diet eliminated the feather defects. They also found that there was no significant difference in egg production between the control group and the high rice bran groups (79 to 81.5% rice bran) when the latter were supplemented with $ZnCO_3$. Several investigations have described successful laying hen diets containing 20 to 45% of rice bran or polishings (Panda and Gupta, 1965; Cuca and Avila, 1974). Din et al. (1979) fed 74% rice bran and observed 43.5% egg

production. A diet containing 74.7% of autoclaved rice bran resulted in 64.6% egg production which was not significantly different from the positive control diet. Majun and Payne (1977) included rice bran in layer diets at 0, 300 and 600g/kg in place of wheat and soybean meal. Inclusion of 600g/kg non-autoclaved rice bran caused an adverse effect on egg production, shell thickness and egg yolk colour. Autoclaving the rice bran (120^{o}C for 20 minutes) prior to mixing of diets overcame the deleterious effects. Fading of yolk colour due to rice bran inclusion in the diet suggests that the bran contains some factor which causes changes within the lipid fraction. Whereas, Kratzer et al. (1974) noticed pancreatic enlargement in chicks fed rice bran, Majun and Payne (1977) did not notice such effects with layers. They concluded that 30% inclusion of rice bran in layer diets had no adverse effects on the performance other than on yolk colour.

Deolanker and Singh (1979) fed isonitrogenous diets (22% protein) based on maize and groundnut oil meal without or with untreated, autoclaved or dehydrated rice bran to broiler chickens from 10 days to 49 days of age. The rice bran replaced 50, 75 or 100% of the maize respectively. Body weights were more significantly reduced with 100% autoclaved rice bran than with all other treatments. Body weights were more significantly

greater without rice bran and with 50% untreated and dry heated rice bran than with all other treatments. Feed efficiency was significantly higher with 50% dry heated rice bran than with all other treatments except 75% autoclaved, 75% and 100% untreated rice bran. Feed efficiency of the 100% autoclaved rice bran group was significantly lower than that with all other treatments. Trypsin activity as a percentage of that of the diet without rice bran was highest, 184% with 100% autoclaved rice bran and was lowest, 81% with the 100% untreated rice bran diet.

ENERGY AND NUTRIENT AVAILABILITY FROM RICE BRAN AND OTHER FIBRE SOURCES

Deolanker and Singh (1979) found that the metabolizable energy of the maize diet and the 100% replacement by untreated, autoclaved or dry heated rice bran diets did not differ significantly and was between 2754.37 to 2783.02 Kcal/kg. That of the autoclaved rice bran was significantly lower than that of untreated rice bran, 2625.49 to 2773.47 Kcal/kg.

Majun and Payne (1977) using laying birds got 3081.37 Kcal/kg as their metabolizable energy value for rice bran. Deolanker and Singh (1979) calculated mineral availability from rice bran diets using 45 Ca and 59 Fe and thyroid activity using 131 I. Calcium distribution in the kidney, liver, blood and femur was

apparent that extra bulk is largely due to increased feacal excretion of bacteria. Cabbage and bran have thus been found to increase feacal weight, feacal nitrogen excretion and the excretion of bacteria in man (Steven and Cummings, 1981). The nitrogen content of bacterial fraction was approximately 6%. independent of diet. Therefore the increased output of bacteria accounted for the greater N excretion associated with the intake of fibre. Bacteria made up of feacal weight on a dry matter basis and since they contain 80% water, the increase in bacterial dry weight recorded implied an increase in the overall water content of the stool. Hence dietary fibre seems to increase feacal weight, feacal nitrogen and feacal water through the same mechanism, namely increased microbial proliferation. It seems likely that a part of the energy released by fibre digestion could be accounted for in the same way. Generally, crude fibre decreases the apparent digestibility of dry matter, energy and crude protein in diets of monogastric animals (Kornegay, 1978). For one reason or the other, dietary fibre, given at certain levels may have some beneficial effects on single-stomached animals.

UTILIZATION OF DIETARY FIBRE BY CHICKENS

There has been an increased interest in the subject of fibre nutrition in recent times. Two major factors led to this development, namely: increasing cost of cereal grain because of competition between livestock and man and

the availability in large quantities of fibrous industrial by-products whose use for livestock feeding does not provoke competition with man.

Fibrous feedstuffs are relatively unpalatable as human foods and are less expensive than low-fibre cereal grains. Furthermore, the fibre content of a feedstuf is probably the single most important determinant of nutritive value, ie. it largely determines the proportion of chemically available nutrients which can be utilised by the animal. An important goal of nutrition research is to find simple ways of determining the true nutritive value. It is important therefore, to have a clear understanding of what dietary fibre is and the part it plays in livestock (Poultry) nutrition. Trowell et al. (1976) described dietary fibre as the sum of lignin and the polysaccharides that are not digested by the endogenous secretion of the digestive tract. These include cellulose and a range of so-called non-cellulosic polysaccharides, the most predominant being the hemi-cellulose.

FOWL GUT MICROFLORA AND POULTRY NUTRITION

Interest in the microflora of the fowl dates back to the last century and despite the impetus given to such studies by the observation of growth stimulation by dietary antibiotics and other chemotherapeutic substances, information on the subject remains rather scanty. The slow pace of research work in this direction is mainly due to technical problems. The methods available

to the microbiologist for the enumeration of microflora are subject to a variety of errors. Studies on mixed populations of microflora are further complicated by interactions between host and microflora.

In the bird, certain peculiarities in the structure of the gut must be taken into account in any study of the establishment of a microflora and its possible nutritional significance. The crop, for example which is an outgrowth of the oesophagus, forms a sac in which feed may be retained or not, according to the state of fasting of the bird (Halnan, 1949). It, thus, offers a site for possible microbial fermentation before the feed undergoes the major processes of digestion. The small and large intestines are short relative to those of mammals. The bile duct enters distally to the duodenum. At the junction of the small and large intestines are two ceaca in which according to Barnes and Shrimpton (1957), the greatest number of microflora organisms occur.

VOLATILE FATTY ACID (VFA) PRODUCTION IN THE DIGESTIVE TRACT OF FOWL

The ceaca are a site of major fermentative activity. Fermentation by the ceacal flora has been recognised for many years (Beattie and Shrimpton, 1958), and recently by Annison *et al.* (1968). The role of the ceaca in the digestive processes of the fowl is generally considered to be of little importance, largely because ceacectomy

has no apparent effect on growth rate and performance. There is, however, some evidence that removal of the ceaca leads to much lower digestibility co-efficients for the crude fibre of wheat and maize (Halnan, 1949) and more recently, Thornburn and Wilcox (1965) have shown that ceacectomy of young cockerels is followed by a reduction in droppings dry matter and overall feed digestibility. Cellulose digestibility in a given bird was reduced but the effect was not always evident between one bird and another, a finding explained on the basis of differences in the ceacal flora of individual birds. The spectrum of volatile fatty acids (VFA) present in the portal blood is similar to that in ceacal contents (Annison et al. 1968). This indicates that absorption of fermentation products has taken place and that the liver is receiving a continous supply of these acids. The absence of all the acids, except acetic and formic from peripheral blood (Annison et al. 1968) shows that they are taken up and metabolized by the liver, while the presence of a high level of acetate in the peripheral blood indicates either that the liver is unable to handle all the acetate derived exogenously from the digestive tract or there is a significant endogenous contribution to the level of circulating acetate. All metabolic processes proceeding via acetyl COA are potential contributors.to endogenous acetate formation. It was clearly shown that these processes were, indeed, the

major source of blood acetate by the fact that blood acetate level of germ-free birds was similar to that of conventional ones (Annison et al., 1968).

The role of acetate in the overall metabolism of the fowl has been studied by isotope dilution techniques which showed that total acetate entry rates were about 16 and 9g/hour respectively in fed and starved (48 hours) birds, acetate accounting for 11 and 6% respectively, of total energy production (Annison et al., 1968). These entry rates indicate acetate absorbed from the alimentary tract accounts for only about 25% of total entry in the fed bird. This emphasis the greater importance of endogenous acetate production. However, it is possible that the extent of VFA production in the ceaca may be modified under different dietary regimes or by alterations in the ceacal microflora. Exogenously derived acetate may then become of greater importance as an energy source to the bird.

VITAMIN SYNTHESIS IN THE GASTRO-INTESTINAL TRACT OF FOWL

The caeca offer favourable conditions for the microbial synthesis of the B-complex vitamins. Ceacectomy effectively reduces this synthesis to a low level but does not completely eliminate it (Coates, 1962). Other parts of the digestive tract seem to be involved in vitamin synthesis to some extent.

RESPONSE OF GROWING PULLETS TO HIGH-FIBRE DIETS

Dietary fibre has been incorporated in experimental diets of monogastric animals for many years. It has been known to promote constant passage of materials through the alimentary tract. Davis and Briggs (1947) as quoted by Thompson and Weber (1981) reported that the addition of fibre to the diets of chicks stimulated growth. However, the non-essentiality of dietary fibre for chicks was shown by feeding chemically defined liquid diets which produced normal growth (Lang and Briggs, 1976). Recent experiments showed mixed results of fibre on growth. Cellulose, solka-floc and wheat straw resulted in depressed growth while wheat bran and magonex (a wood hemicellulose extract) stimulated growth (Dvorak and Bray, 1978; Bayer et al., 1978; Kondra et al., 1974; Hedge, et al., 1978).

Kondra et al. (1974) fed a high fibre diet (19.6% fibre) to meat-and egg-type chickens during the last 6 week of their period and found a significant reduction in feed consumptions, exclusive of the added fibre, per hen-day in both strains. There was also a reduction in body weight gain per bird, but there was no effect on feed efficiency. The addition of fibre also resulted in a significant increase in weight (and size) of the various parts of the alimentary tract in both strains. Mortality during the growing period was not affected by the high-fibre

diet. It was concluded that chickens were capable of a high degree of anatomical and physiological adaptation to compensate for variation in nutrient concentration of their diet. Such adaptation during the growing phase was shown to have some beneficial effects on breeding period performance.

The feeding of a diet containing 20.2% spruce wood flour to growing birds had no adverse effect and a slight growth increase was reported at 28 weeks of age (Ewing, 1947). Reid et al. (1961) as reported by Nelson (1972) found that limitation of the dietary intake of pullets from 9 weeks to age to maturity delayed sexual maturity and reduced growth rate. They used direct restriction of intake and also the addition of bentonite and wood flour to obtain this effect.

RESPONSE OF LAYING HENS TO HIGH-FIBRE DIETS

Deaton et al. (1973) observed that the weights of gizzards of floor and cage-reared broilers differed significantly. Those reared on the floor had heavier gizzards. Addition of 30g ground pine shavings/kg to the diet of the cage-reared broilers eliminated the gizzard weight difference (Kubena et al., 1974). This findings suggests that the consumption of litter results in the difference in gizzard weight through significant change in the alimentary tract. Subsequently, caged laying hens were fed on diets containing 15, 30 or 60g ground pine shavings/kg of the diet (Deaton et al., 1977).

As dietary fibre increased, gizzard weight increased, but there was no effect on body weight, egg production, egg weight, efficiency of feed conversion, liver, fat or shell breaking strength. Body fat tended to be lower when pine shavings were fed. As a result of these earlier findings on the use of fibrous feedstuffs in layer diets, Deaton et al. (1979) evaluated the effect of replacing soybean meal. They found that the increased dietary fibre resulted in a significant increase in gizzard weight and gut length. Feed efficiency decreased but egg production, egg weight, shell breaking strength and mortality were notieffected. Nelsoni(1972) investigated the effect of restricting the energy intake of the laying hen on egg production and efficiency of energy utilization. He used both direct restriction and restriction by dilution of the diet using wood dust (1.36, 22.7 and 31.8% wood dust) as the diluent. Light and medium breeds of layers were used. Percentage egg production was markedly affected by diets ($P<0.01$) and breeds ($P<0.05$). At the 13.6% level of dilution, the light hybrids had a lower production than when fed the concentrated diet ad lib. while the medium hybrids gave a higher percentage production on the 13.6% level of dilution than the concentrated diet. Production at the 22.7% level of dilution was fairly consistently below that at the 13.6% level dilution and that at the 31.8%

level of dilution was always, markedly below production at the 13.6% level. The total egg weight data showed the same general patterns as the values for the percentage egg production. Smith and Keen (1971), worked on sugar beet pulp as a replacement for maize in diets for broilers and laying pullets and found that if the level exceeded 30% of the total laying diet, performance of both types of birds were adversely affected.

The carry-over effects of feeding high-fibre diets to birds during growing period were increase rate of lay and body weight gain (Kondra et al. 1974). However, the feeding of a high fibre grower diet followed by low-fibre laying diet resulted in an increased feed efficiency, but this does not hold for birds fed high-fibre growing and laying diets. The high-fibre diets (20% wheat straw) fed during the laying period reduced rate of lay and feed efficiency but did not affect the weight, quality, fertility or hatchability of the eggs.

DIETARY FIBRE AND FEED INTAKE

Savoury and Gentle (1976) noticed increased feed intake with increased dietary fibre in Japanese quail (Coturnix coturnix japonica), but found no obvious effect on rate of passage. Nelson (1972) reported an increase in the total feed intake with increase in

dietary fibre in growing and laying diets. Poultry, like other animals, are greatly affected by the level of energy in their diet. Baungardt (1969) suggested that at low densities, physical capacity and distention of the digestive organs limit feed and nutrient intake. At these energy levels, the energy "needs" of the bird are not satisfied even though a transient "satisfaction" due to a distended digestive tract occurs. Hunger returns as soon as the digesta pass down the gut.

On the basis of Hill's (1962) experiments, it has been generally accepted that medium-size laying hens are capable of adjusting their feed intake to the varying energy contents of their diet so that their metabolizable energy intake is a constant. The economic application of this suggestion is important, since the level of energy not only affects the daily feed intake, but also the cost of the diet. Higher energy diets cost most and reduce feed intake. The daily cost of feeding is least when the arithmetical product of cost per ton and daily feed intake is minimised. This happens with diet which is "least cost per calorie". However, it must be pointed out that not all metabolizable calories are equal in terms of producing weight gain or in effect on feed utilization (Summers, 1974). Fat calories are more efficiently utilized than carbohydrate calories and unsaturated fats to some extent more so than saturated fats. Such factors will affect feed intake with practical diets.

EFFICIENCY OF UTILIZATION OF METABOLIZABLE ENERGY INTAKE BY LAYING HENS

Various attempts have been made to apportion the quantity of metabolizable energy between the birds requirements for maintenance and for production. One of the earliest attempts was carried out by Byerly (1941) as quoted by Filmer (1974). He postulated that feed intake was determined by 3 factors:

a) maintenance requirement which was proportional to the metabolic body weight ($W^{0.653}$).

b) increments in body weight gain (w). Energy requirements for this were assumed to be strictly proportional to the gain in weight irrespective of the type of tissue actually being laid down.

c) egg output E.

Byerly's Equation:

$M = 1.517W^{0.653} + 3.265w + 3.292\ E$ where

M = ME intake (Kcal/bird day)

W = Body weight (g)

w = Body weight gain (g/bird day)

E = Egg output (g/bird day)

Morris (1972) pointed out that the gross energy efficiency has roughly doubled in the past two and a half decades since Byerly's work. Gross energy efficiency is simply the weight of egg output per Kcal of ME consumed.

However, net efficiency of energy utilization has not changed. Net efficiency of energy utilization refers to the quantity of energy required per unit metabolic body weight, per unit of growth and per unit of egg output. It refers to the co-efficients derived by Byerly from his original data.

The improvements in gross efficiency noted are due to genetic improvements in egg output coupled with a general reduction in body weight (and therefore in maintenance requirements). There is little evidence to show that the levels of energy and indeed of any nutrient required per unit of output or per unit of metabolic body weights has altered.

EXPERIMENTAL PROCEDURE

MATERIALS AND METHODS

Two experiments were conducted to study the feeding value of rice offal in diets for growing pullets and layers. Warren laying strain was used.

Experiment I: Growth experiment

Objectives:

a) To evaluate the nutritional potential of rice offal as feedstuff for pullet chicks.

b) To determine suitable levels of inclusion in chick and grower diets without precipitating adverse effect on growth.

Procedure:

1000, 4-week old Warren pullet chicks were assigned to five dietary treatments in a completely randomised design. Each treatment was replicated two times with 100 chicks in a replicate. The chikcs were reared on concrete floor littered with wood shavings. Equal and adequate number of feed and water troughs were provided in each pen to ensure ad lib. feeding and drinking. The composition of the diets used in experiment I are presented in Tables 2 and 3. Rice offal was used to replace maize in the maize-groundnut meal based control diet (Diet 1 or 0%) at 20% (Diet 2); 40% (Diet 3); 60% (Diet 4); and 80% (Diet 5) respectively. All the diets were isonitrogenous. At the age of eight weeks, the diets were changed from chick mash (20% protein) to grower mash (16% protein).

Table 2: Experimental Chick Diets fed from week 5 to 8.

	D I E T S				
% Rice offal replacing maize	0%	20%	40%	60%	80%
Ingredients					
Maize	62.60	50.10	37.60	25.00	12.50
Groundnut cake	33.30	34.00	34.60	35.00	36.00
Rice offals	-	11.80	23.70	35.90	47.40
Bone meal	3.00	3.00	3.00	3.00	3.00
Vitamin/Mineral Premix[a]	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25
L-Lysine HCl	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Crude protein %	19.99	20.01	20.00	19.90	20.04
Crude fibre %	5.56	9.81	14.09	18.46	22.64
Ether Extract %	4.37	4.59	4.80	5.02	5.24
Calcium %	1.12	1.14	1.16	1.18	1.20
Phosphorus %	0.87	0.90	0.93	0.96	1.00
Lysine %	0.96	0.96	0.95	0.94	0.94
Methionine %	0.53	0.52	0.51	0.49	0.48
M.E. Kcal/kg	3013.11	2747.23	2480.21	2208.75	1946.25

[a]Vitamin/mineral Premix composition: Vitamin, Trace mineral Premix with coccidiostat for replacement chicks of 4 to 10 weeks and pullets obtained from Roche (Nig.) Limited. 1kg of the Premix supplied the following: Vitamin A (stabilised), 6670,000I.U., Vitamin D_3 (stabilised), 1,500,000 I.U. vitamin E (stabilised), 3340I.U., Menadione sodium Bisulfite (vitamin K) (stabilised), 1349mg, Vitamin B_2 3000mg, Vitamin B_6, 2000mg, Nicotinic acid 14670mg, Calcium d-pantothenate, 4000mg, Vitamin B_{12}, 8mg, Choline chloride 13340mg, D.O.T. (3, 5 dintro-orthtoluamide), 66700mg, Manganese, 53340mg, Iron,33,340mg, Zinc, 26,670mg, Copper, 1600mg, Iodine, 934mg. Cobalt, 134mg, Selenium, 34mg.

Table 3: Experimental Grower Diets fed from week 9 - 20

	D I E T S				
% Rice offal replacing maize	0%	20%	40%	60%	80%
Ingredients					
Maize	73.40	58.70	44.00	29.40	14.70
Groundnut cake	22.50	23.20	24.00	24.80	25.50
Rice offals	-	14.00	27.90	41.70	55.70
Bone meal	3.00	3.00	3.00	3.00	3.00
Vitamin/Mineral Premix[a]	0.25	0.25	0.25	0.25	0.25
Common salt	0.30	0.30	0.30	0.25	0.25
Lysine	0.30	0.30	0.30	0.30	0.30
Methionine	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis:					
Crude protein %	15.99	15.97	15.99	16.07	15.99
Crude fibre %	4.53	9.57	14.58	19.55	24.59
Ether Extract %	4.13	4.39	4.64	4.89	5.15
Calcium %	1.00	1.12	1.15	1.17	1.20
Phosphorus %	0.84	0.88	0.91	0.95	0.98
Lysine %	0.83	0.82	0.81	0.80	0.80
Methionine %	0.51	0.50	0.48	0.46	0.45
M.E. Kcal/kg	3127.59	2813.52	2500.58	2189.83	1875.75

[a]Vitamin/mineral Premix composition: Vitamin, Trace mineral Premix with coccidiostat for replacement chicks of 4 to 10 weeks and pullets obtained from Roche (Nig.) Limited. 1kg of the Premix supplied the following: Vitamin A (stabilised), 667,000I.U., Vitamin D_3 (stabilised), 1,500,000I.U. vitamin E (stabilised), 3340I.U., Menadione sodium Bisulfite (vitamin K) (stabilised), 1349mg, Vitamin B_2, 3000mg, Vitamin B_6, 2000mg, Nicotinic acid 14670mg, Calcium d-pantothenate, 4000mg, Vitamin B_{12}, 8mg, Choline chloride 13340mg, D.O.T. (3, 5 dintro-orthotoluamide), 6670mg, Manganese, 53340mg, Iron, 33,340mg, Zinc, 26,670mg, Copper, 1600mg, Iodine, 934mg, Cobalt, 134mg, Selenium, 34mg.

Synthetic lysine (L-Lysine HCl) and methionine (DL-Methionine) were used to meet the pullet requirements for these nutrients as recommended by the National Research Council (NRC, 1977). Fifty percent of the birds in each replicate (i.e. 50 birds) were randomly selected and weighed at the beginning of the experiment and every forthnight till the end of the first experiment at 20 weeks of age. Cumulative feed consumption by birds in each replicate was measured at 2-week intervals. Mortality record was kept daily. One-way analysis of variance was used and differences between treatment means were detected by least significant difference test (Steel and Torrie, 1960).

Experiment II: Laying experiment

Objectives:

a) To determine the suitable level of incorporation of rice offal in a layer diet that will be both economical and produce satisfactory performance.

b) To evaluate the carry-over effects of feeding high-fibre grower diets on subsequent laying performance.

Procedure:

770 Warren pullets used in the first experiment were allocated to seven treatments at 24 weeks old. Each treatment had two replicates with 55 pullets in a replicate. In treatments one to four, birds had been fed one to four (ie control, 20%, 40% and 60% rice offal replacing maize) in the pullet growing phase received

similar layer diets in the laying phase. Treatment five consisted of birds that had been fed diet 5 (80%) in the growing phase but reverted to the control diet (0%) in the laying phase. Treatment six was made up of birds which had received diet 4 (ie 60%) in the growing phase but were fed the control diet (0%) in the laying phase. Treatment seven comprised birds that had been fed diet 2 (20%) in the growing stage but received diet 3 (40%) in the laying phase. Diet 5 (ie 80%) of the growing phase was discontinued because the growth rate of birds fed the diet was very poor. The birds were kept on deep litter. The set-up of the experiment was as shown below:

Treatment	Level of rice offal replacing maize in Experiment II	Source of birds and level of rice offal fed in Experiment I
1	0% (control)	all birds previously fed control diet in the growing phase.
2	20%	all birds previously fed 20% diet in the growing phase.
3	40%	all birds previously fed 40% diet in the growing phase.
4	60%	all birds previously fed 60% diet in the growing phase.
5	0%	all birds previously fed 80% diet in the growing phase.
6	0%	birds fed 60% diet in the growing phase mixed.
7	40%	birds fed 20% diet in the growing phase mixed.

The composition of the layer diets are presented in Table 4. Egg production and mortality records were kept on daily basis. Feed intake per replicate was measured every forthnight. At the beginning of the experiment all eggs in each replicate were collected and weighed and this was repeated at the end of the experiment. All birds in each replicate were weighed at the beginning of the laying experiment. Records were kept till all the treatments reached 50% egg production.

Samples of rice offal were analysed for proximate composition, calcium and phosphorus by AOAC (1975) methods, and amino acid analysis was undertaken on rice offal. The amino acid profile was determined using TSM Technicon amino acid analyser (Tables 5 & 6).

Procedure for the determination of metabolizable energy of rice offal using 6-week old pullet chicks and laying hens

a) Using pullet chicks - A total of 120 pullet chicks were randomly allocated to four experimental treatments: 0%, 20%, 40% rice offal replacing maize and negative control. Each treatment had three replicates and three were 10 birds in each replicate. The birds were placed on a common diet for seven days and were subsequently fed their respective experimental diets for another seven days to enable them adapt to the diet and to determine the level of daily intake. They were then starved

for 24 hours. Feeds were weighed out and given to the birds except those on negative control. Faecal collection was started and continued for three consecutive days. The faeces from each replicate were weighed fresh and kept in the oven at the end of each day's collection. Dried feaces were later weighed. The three-day feacal collections of each replicate were bulked, ground and samples taken for energy determination.

b) Using 48-week old laying hens - Twenty four laying hens were randomly allocated to 4 experimental treatments, 0%, 20%, 40% and negative control. The percentages showed the proportion of rice offal in the diet as in the case of the chick diets earlier described. The experimental procedure was similar to the one described above with little modifications. 120g of feed was weighed out and given to each individually-caged bird at the end of the 24 hours starvation. Polythene bags were placed under each bird for feacal collection. Left-over feeds were removed and weighed at exactly 24 hours after given to the birds. Faecal collection was extended 6 hours after feed removal.

Energy contents of all the experimental diets and their respective excreta samples were measured by a Gallenkamp automatic adiabatic bomb calorimeter, calibrated with benzoic acid. Total acid formed during combustion was titrated and heat production corrected accordingly.

Table 4: Experimental Layer Diets

	DIETS						
% Rice offal replacing maize	0%	20%	40%	60%	0%	0%	40%
Ingredients							
Maize	62.40	49.60	36.40	23.40	62.40	62.40	36.40
Groundnut cake	27.00	27.30	28.00	28.60	27.00	27.00	28.00
Rice offals	-	12.50	25.00	37.40	-	-	25.00
Lime stone	6.50	6.50	6.50	6.50	6.50	6.50	6.50
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Vitamin/mineral Premix[a]	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine HCl	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-Methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis:							
Crude protein %	17.14	17.00	17.01	16.99	17.14	17.14	17.01
Crude Fibre %	4.80	9.26	13.77	18.22	4.80	4.80	13.77
Ether Extract %	3.99	4.21	4.43	4.66	3.99	3.99	4.43
Calcium %	3.58	3.60	3.62	3.64	3.58	3.58	3.62
Phosphorus %	0.84	0.87	0.90	0.93	0.84	0.84	0.90
Lysine %	0.97	0.86	0.85	0.84	0.97	0.97	0.85
Methionine %	0.51	0.49	0.48	0.46	0.51	0.51	0.48
M.E. Kcal/kg	2851.74	2574.76	2293.55	2015.58	2851.74	2851.74	2293.55

[a]Vitamin/trace mineral Premix composition: Vitamin and Trace Mineral Premix for laying hens obtained from Roche (Nig.) Limited. 1kg of the Premix supplied the following: Vitamin A, 6,670,000I.U., Vitamin D_3, 1,340,000I.U., Vitamin E, 6670 I.U., Menadione sodium bisulfite (vitamin K), 1340mg, vitamin B_2 3000mg, Vitamin B_6, Nicotinic acid, 16,670mg, Calcium d-pantothenate, 5340mg, Vitamin B_{12} 8mg, Vitamin C, 13340mg, Choline chloride 133,400mg, Manganese 6,670mg, Iron, 33,340mg, Zinc 670mg, Copper, 1,600mg, Iodine 934mg, Cobalt 134mg, Selenium 34mg.

The energy values obtained for feed and excreta were used to calculate the M.E. value per gram of diet on a dry matter basis. This was done by subtracting excreta energy from the gross energy intake and then dividing by total dry matter intake.

Computation of the M.E. content of the feedstuff (rice offal) was accomplished by using the following equation:

$$\text{M.E. of the test feedstuff} = \frac{\text{M.E. of diet} \times 100}{\text{Proportion of test feedstuff}} - \begin{array}{l}\text{M.E. of standard feedstuff x proportion of same}\end{array}$$

Gastro-intestinal tract (G.I.T.) Measurement

Ten mature layers previously fed each of the experimental diets (0%, 20%, 40%, 60% and 80% rice offal replacing maize) in the growing period were randomly selected and killed by severing the spinal cord connection from the brain. The birds were opened up and the various gut components measured in terms of weight and length. The objective was to determine the effects of feeding various levels of dietary fibre on the anatomical structure of the gut. Differences between treatments and means were tested by Fisher's least significant difference test (Steel and Torrie, 1960).

RESULTS

a) Chemical analysis of rice offal

The proximate nutrient composition of rice offal and its amino acid profile were as shown in Tables 5 and 6. Rice offal has a high content of crude fibre (37.55%) and ash (20.19%) but is very low in essential amino acids. It is relatively lower in ether extract than rice bran and therefore has a better keeping quality.

b) Gastro-intestinal tract (G.I.T.) measurements

The various components of the gastro-intestinal tract (G.I.T.) did not show any significant differences ($P \leq 0.05$) among dietary treatments (Table 7). The small intestine (including the duodenum) tended to increase with increase in the level of dietary rice offal up to a point and then started decreasing - 170.75, 175.75, 193.60, 183.00 and 176.95cm for 0%, 20%, 40%, 60% and 80% dietary treatments respectively. All other gut components showed similar inconsistent and non-significant ($P > 0.05$) differences.

c) Metabolizable energy of the experimental diets (Using laying hens)

The calculated M.E. values for the various experimental diets are presented in Table 8. No correction for nitrogen retention was effected and values reported are apparent or classical. The M.E. values progressively decreased as rice offal gradually replaced maize in

Table 5: Proximate Nutrient Composition of Rice •ffal

	(%)
Dry matter	97.34
Crude fibre	37.55
Crude protein	6.20
Ether Extract	5.52
Mineral (Ash)	20.19
Nitrogen free extract	30.54
Calcium	0.17
Phosphorus	0.49

Table 6: Amino acid profile of Rice offal

Amino acid	% (Oven-dry basis)
Lys.	0.16
His.	0.12
Arg.	0.26
Asp.	0.34
Thr.	0.17
Ser.	0.18
Glu.	0.53
Pro.	0.22
Gly.	0.21
Ala.	0.26
Cys.	0.06
Val.	0.84
Met.	0.06
Ileu.	0.14
Leu.	0.28
Tyr.	0.10
Phe	0.19

Table 7: Effect of levels of dietary rice offal on portions of the gastro-intestinal tract

	D I E T S					
Levels of rice offal replacing maize	0%	20%	40%	60%	80%	S.E.D.[1]
G.I.T. Portions						
Small intestine + Duodenum (cm)	170.75[a]	175.75[a]	193.60[a]	183.00[a]	176.75[a]	13.11
Ceaca (cm)	36.10[b]	37.65[b]	38.58[b]	36.47[b]	35.50[b]	0.84
Empty gizzard weight (g)	38.195[c]	33. 34[c]	37.10[c]	37.82[c]	32.40[c]	2.49
Pancreas (g)	3.44[d]	3.155[d]	3.92[d]	10.78[d]	3.69[d]	4.11
Liver (g)	34.54[e]	36.61[e]	30.00[e]	31.68[e]	30.80[e]	2.28

a,b,c,d,e Means in the same row with same superscript are not significantly different ($P > 0.05$).

[1] S.E.D. = Standard error of the difference between 2 means.

the control diet. Rice offal has an M.E. value of 1319.63 Kcal/kg as against 3510 Kcal/kg for maize or 1059 Kcal/kg for wheat offals. From the calculated M.E. values the minimum energy levels required for satisfactory performance were 2189.83 and 2293.53 Kcal/kg representing the 60% and 40% rice offal replacement grower and layer diets respectively.

d) Experiment I: Growth experiment

Feed consumption

There was a direct relationship between feed intake and the level of inclusion of rice offal in the diet (Table 9). The cumulative feed intake per bird increased significantly ($P<0.05$) with increase in the rice offal content of the diet. The cumulative feed intake per bird fed the control diet was 5.35 kilogram at 20 weeks of age as against 7.93 kilogram for a bird fed the 80% rice offal replacement diet. Thus, birds fed the 80% rice offal replacement diet consumed 32.61% more feed than those fed the control diet. Feed intake (Table 9) for birds fed the 40% rice offal replacement diet was higher than for those fed the 20% rice offal replacement diet but the difference was not statistically significant ($P>0.05$).

Cost per kilogram of chick and Grower diets

Using the current market prices of the various feed ingredients, the cost of kilogram of the chick diets decreased from ₦0.63 for the control diet to ₦0.39 for the 80% rice offal replacement diet (Table 9). A similar pattern was observed in the case of the grower diets which varied from ₦0.63 from the control diet to ₦0.35 for the 80% rice offal replacement diet.

Table 8: Metabolizable energy values of the expterimental diets.

	% Rice offal replacing maize				
	0%	20%	40%	60%	80%
M.E. CHICK DIETS					
M.E. (Kcal/kg)	3013.11	2747.23	2480.21	2208.75	1946.25
GROWER DIETS					
M.E. (Kcal/kg)	3127.59	2813.52	2500.58	2189.83	1875.75
LAYER DIETS					
M.E. (Kcal/kg)	2851.74	2574.76	2293.55	2015.58	-

NOTE:

Maize 3510 Kcal/kg M.E.

Groundnut cake 2450 Kcal/kg M.E.

Rice offal 1319.63 Kcal/kg M.E.

EXPERIMENT I

Table 9: Analysis of feed cost during the Growing Phase (Week 5 - 20)

	D I E T S (% rice offal replacing maize)					
	0	20	40	60	30	S.E.D.[1]
Chick diet consumed (kg/bird)	0.78^{a}	0.90^{b}	0.93^{bc}	0.96^{c}	0.97^{c}	0.02
Cost of a kg of chick diet (₦)	0.63	0.57	0.51	0.45	0.39	-
Cost of chick diet consumed (₦)	0.49^{ab}	0.51^{a}	0.47^{b}	0.43^{c}	0.38^{d}	0.01
Grower diet consumed (kg/bird)	4.57^{c}	5.08^{c}	5.26^{bc}	5.87^{b}	6.96^{a}	0.29
Cost of a kg of grower diet (₦) per bird	0.63	0.56	0.49	0.42	0.35	-
Cost of grower diet consumed (₦) per bird	2.88^{a}	2.84^{ab}	2.58^{b}	2.47^{b}	2.44^{b}	0.13
Total Feed Intake (5-20Wks) kg/bird	5.35^{a}	5.98^{a}	6.20^{ab}	6.83^{c}	7.93^{d}	0.28
Total cost of feed consumed per bird from 5 to 20 Wks (₦)	3.37^{a}	3.35^{ab}	3.05^{b}	2.90^{b}	2.82^{b}	0.12

[1] = Standard error of difference between means for weeks x treatments.

a,b,c,d Means of a particular parameter with same superscript are not significantly different ($P > 0.05$).

Live weight Gain

There was a progressive decrease in body weight gain as the level of dietary rice offal increased. The body weight gain ranged from 1.24kg for birds fed the control diet to 0.84kg for those fed the 80% rice offal replacement diet (figure 1 and Table 10). There was no significant difference ($P > 0.05$) between the cumulative live weight gain of birds fed 0% and 20% rice offal replacement diets at 20 weeks of age. Birds fed the 40%, 60% and 80% rice offal replacement diets showed significant different ($P < 0.05$) from those fed 0% rice offal replacement diet and also from one another.

Feed conversion Ratio (FCR)

The feed conversion ratio became poorer with a decrease in the nutrient density of the diets (Table 10). The FCR of 0% treatment and that of 20% were 4.32 and 4.93 respectively, but the difference was not significant ($P > 0.05$). Similarly the FCR of 20% and 40% treatments did not differ significantly ($P > 0.05$). The feed conversion ratios of 60% and 80% treatments were very poor, 6.81 and 9.50 respectively. They differed significantly ($P < 0.05$) from each other and from those of other treatments.

Mortality

Mortality was not significantly different ($P > 0.05$) between the various treatments up to seven weeks of age (Table 10). At seven weeks of age, there was an outbreak of fowl pox.

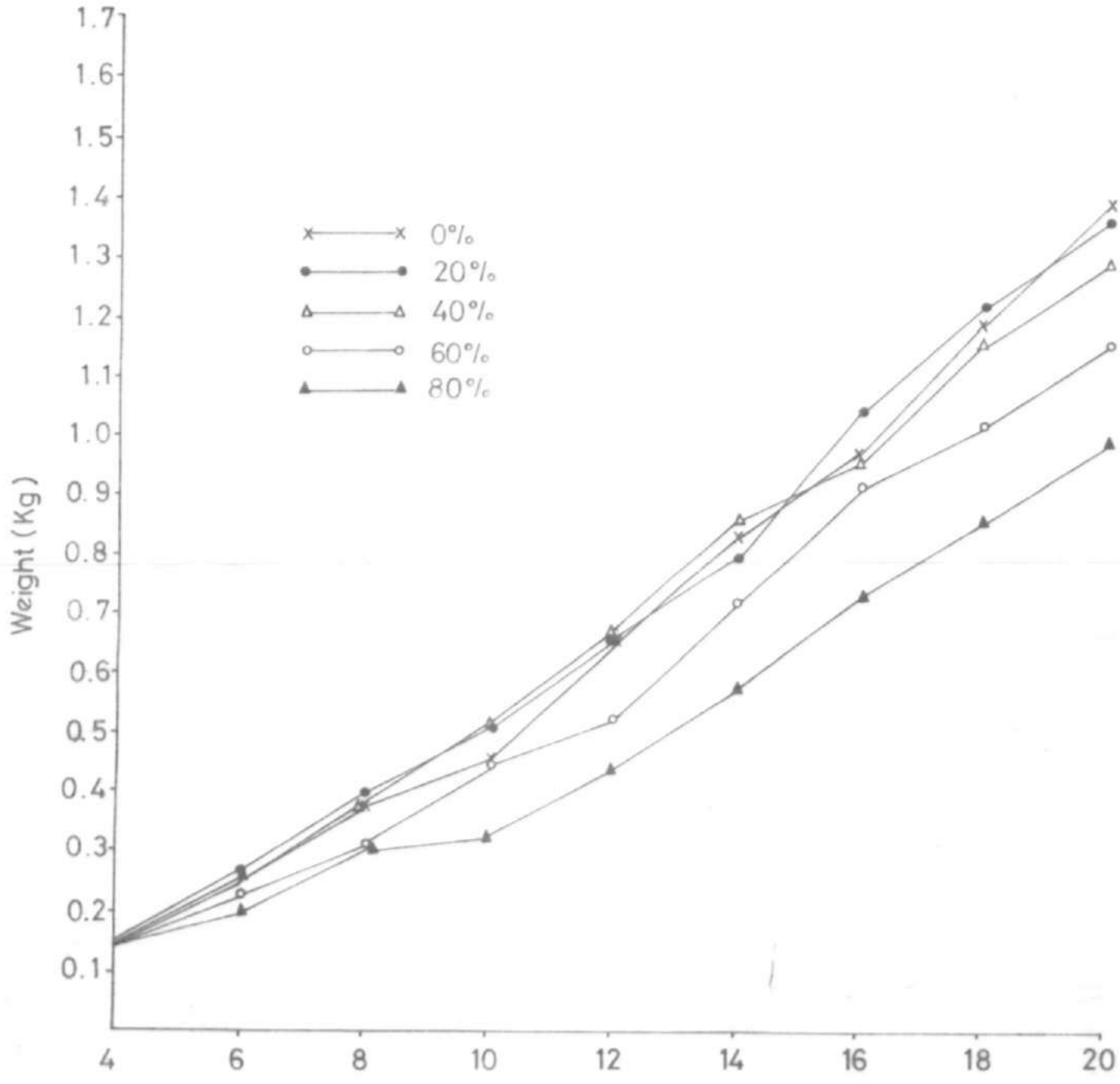


Figure I Graded levels of rice offal on growth of pullets

After this age, mortality records became inconsistent as some diets with less fibre content showed higher mortality figures than diets with higher content. The highest mortality was, however, recorded with birds fed 80% rice offal replacement diet.

Age at onset

The age at which the first egg was laid varied from 151 days for birds fed 20% rice offal replacement diet to 175 days for those fed 80% rice offal replacement diet (Table 10). There was, therefore, a delay of 24 days between the first and the last sets of birds to come to lay. The birds on the control diet came into lay in 154 days, while those on 40% and 60% rice offal replacement diets came into lay when they were 156 and 159 days old respectively.

c) Experiment II: Egg laying experiment

Age at 50% lay

The various ages (in days) at 50% lay are shown in Table 12. Birds that were fed 60% rice offal replacement diet in the rearing phase and continued to be fed this level of rice offal in the laying phase differed but not significantly ($P > 0.05$) in their age at 50% lay from all others.

Hen-day Egg Production

The weekly percentage hen-day egg production were as shown graphically in figure II. The hen-day production for dietary treatments, 0, 20%, 40% (from 20%) and 0% (from 60%) did not differ significantly ($P > 0.05$) at the end of experimental period (Tables 11 and 12). Treatments 60% and 0% (from 80%) differed significantly ($P < 0.05$) from

EXPERIMENT I

Table 10: Effect of graded levels of rice offal on performance traits

Traits	DIETS (% rice offal replacing maize) 0	20	40	60	80	S.E.D.[1]
Body weight at 20 weeks of age (kg)	1.38[a]	1.36[ab]	1.28[b]	1.15[c]	0.98[d]	0.01
Cumulative live weight gain at 20 weeks of age (kg)	1.24[a]	1.22[a]	1.13[b]	1.00[c]	0.84[d]	0.04
Feed consumption (kg/bird)	5.35[a]	5.98[b]	6.20[b]	6.83[c]	7.93[d]	0.13
Mortality (%)*	4[a]	1[a]	0[a]	4[a]	2[a]	2.02
Small intestine (cm)	170.75[a]	175.75[a]	193.60[a]	183.00[a]	176.95[a]	13.11
Ceca (cm)	36.10[a]	37.65[a]	38.58[a]	36.47[a]	35.5[a]	0.84
Days to 1st egg	154[a]	151[a]	156[a]	159[a]	175[b]	0.00
Feed conversion ratio	4.33[a]	4.94[ab]	5.48[b]	6.81[c]	9.50[d]	0.49

[1]Standard error of difference between 2 means

[a,b,c]Means for any particular trait with the same letter are not significantly different ($P > 0.05$).

*Mortality recorded only up to 7 weeks of age due to an outbreak of fowl pox at that age.

the control diet. Birds previously reared on 60% rice offal replacement diet in the growing phase but changed to the control diet in the laying phase performed better than those continuously fed the control diet in both the growing and laying phases. Another striking observation was that birds previously reared on 20% rice offal recplacement diet but changed to 40% rice offal replacement diet performed better than those raised continously on 40% rice offal replacement diet. The difference is not statistically significant ($P > 0.05$).

Feed Intake

The feed intake per bird increased with the rice offal content of the diet (Table 12). The diet became less dense as the level of inclusion of rice offal increased and feed consumption similarly increased. Birds previously fed high-fibre diets (60% and 80%) in their growing phase but reverted to a low-fibre control diet (0%) in the laying phase did not differ ($P > 0.05$) in their feed consumption from those continuously fed the control diets (Table 12). Birds fed the 60% rice offal replacement diet had the greatest feed intake of 110.86g per bird per day.

Egg weight

The egg weights from birds placed on different dietary treatments did not differ significantly ($P > 0.05$). Initial egg weights varied from 36.98 to 51.00g. Final egg weights varied from 49.81 to 52.39g. The eggs became bigger as the birds grew older, regardless of the dietary treatments.

Feed per dozen eggs

The quantity of feed consumed to produce a dozen eggs differed significantly (P/0.05) between the control diet and the 60% rice offal replacement diet (Table 12). Birds fed the control diet required 1.64kg of feed to produce a dozen eggs as against 5.54kg of feed by those on 60% rice offal replacement diet. Birds previously fed 80% rice offal replacement diet and reverted to 0% rice offal replacement diet in the laying phase had the next highest figure of 4.97kg of feed per dozen eggs.

Cost of feed per dozen eggs (₦)

Birds previously fed 80% rice offal replacement diet during the growing phase but changed to the control diet had the greatest cost per dozen eggs (₦2.93). For the remaining diets, the cost per dozen eggs increased progressively with increase in the rice offal content of the diet (Table 12).

Cost per kilogram of layer diets

The cost per kilogram feed decreased with increase in the level of rice offal in the diet. The control diet had the unit cost of ₦0.59 while the 60% rice offal replacement diet cost ₦0.41 per kilogram. The 20% and 40% rice offal replacement diets cost ₦0.54 and ₦0.47 per kilogram respectively (Table 12).

EXPERIMENT II

Table 11: Hen-day egg production (%)

	Weeks					
	1	2	3	4	5	6
% Rice offal replacing maize						
0-(0)	2.47^{a}	6.62^{a}	21.04^{cd}	51.17^{c}	65.08^{c}	72.54^{bc}
20-(20)	1.82	8.44^{a}	25.06^{cd}	49.82^{c}	70.28^{c}	79.59^{c}
40-(40)	1.30^{a}	5.71^{a}	19.87^{bc}	36.36^{b}	61.55^{c}	68.19^{bc}
60-(60)	0	1.82^{a}	7.92^{ab}	16.10^{a}	31.56^{a}	45.4^{a}
0-(80)	0	0	4.55^{a}	21.30^{a}	45.71^{b}	63.76^{b}
0-(60)	2.35^{a}	9.61^{a}	26.23^{cd}	42.72^{bc}	67.96^{c}	78.40^{c}
40-(20)*	2.60^{a}	12.57^{a}	32.60^{d}	45.84^{bc}	59.22^{c}	78.83^{c}

^{a,b,c,d}Means in the same row with the same letter are not different statistically ($P > 0.05$)

S.E.D. between 2 means (for weeks x Trts) = 6.12082

*40-(20) means birds previously fed 20% grower diet but switched to 40% layer diet.

EXPERIMENT II

Table 12: Effect of Graded levels of Rice offal on egg production traits

D I E T S[2]	0	20	40	60	0-(80)	0-(60)	40-(20)	S.E.D.[1]
Traits								
Age to 50% egg lay (days)	186[a]	187[a]	190[a]	201[a]	194[a]	188[a]	189[a]	4.02
Days from 1st egg to 50% lay	32	36	34	42	19	29	38	
6th week Hen-day egg production(%)	72.54[bc]	79.59[c]	68.19[b]	45.40[a]	63.76[b]	76.40[c]	78.83[c]	6.12
Feed intake/bird/ day (g)	90.37[ab]	98.00[abc]	101.60[bc]	110.86[c]	85.80[a]	86.29[a]	105.96[bc]	3.52
Cost of a kg of layer diet (₦)	0.59	0.54	0.47	0.41	0.59	0.59	0.47	
Feed/dozen eggs (kg)	1.64[a]	1.96[a]	2.55[ab]	5.54[c]	4.97[bc]	2.17[a]	2.66[ab]	1.09
Cost of Feed/dozen eggs (₦)	0.97	1.06	1.20	2.27	2.93	1.28	1.25	
Initial egg weight (g)	37.92[a]	36.98[a]	43.75[a]	45.63[a]	51.00[a]	50.15[a]	43.68[a]	8.67
Final egg weight (g)	51.07[b]	51.43[b]	51.18[b]	52.39[b]	51.08[b]	49.81[b]	51.62[b]	2.11

[a,b,c] Means for a given trait with the same letter are not significantly different ($P > 0.05$)

-( ) Sign for dietary treatment of pullets during growing phase.

S.E.D.[1] = Standard error of difference between 2 means.

DIETS[2] = Levels of rice offal replacing maize.

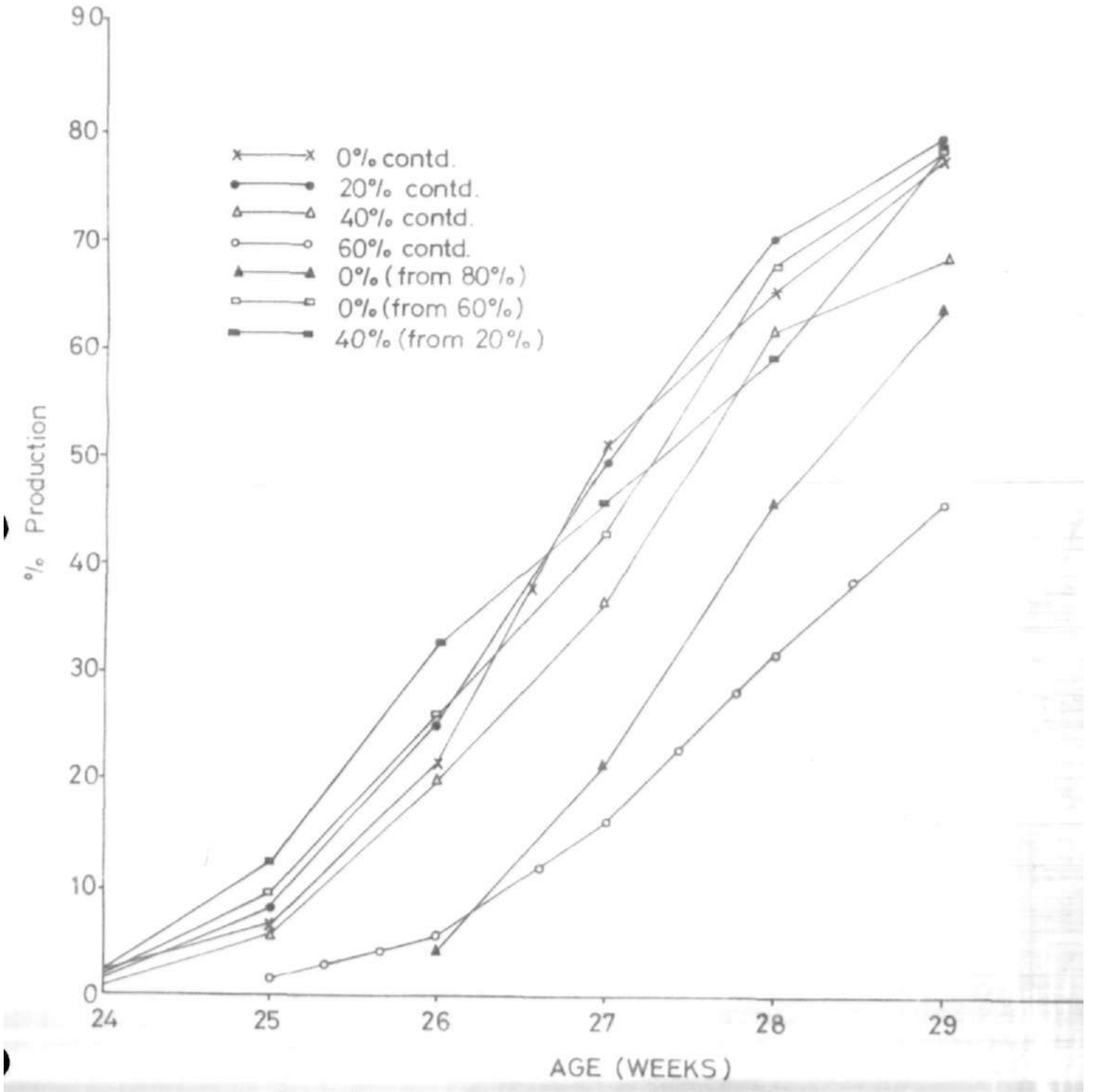


Figure II Hen-day egg production curves

Note: The curves were plotted beyond the targeted 50% production just to show the laying pattern after that level of production.

DISCUSSION

Gastro-intestinal measurements

The differences in the length and weight of the various gut components did not show any significant ($P > 0.05$) dietary effect. Deaton *et al.* (1979) observed a significant increase in gizzard weight and gut length with increase in the level of dietary fibre. There were 4-7% and 3-13% increases in the length of ceaca and small intestine respectively.

Experiment I: Growth experiment

Feed consumption per bird

The feed intake per bird increased as the diet became dense due to the inclusion of rice offal. This was in agreement with the observation by several workers. Dvorak and Bray (1978) added cellulose to a basal diet at levels of 10, 20% and 30% in one trial and 15%, 30% and 45% in a second trial and noted a linear increase ($P < 0.05$) in feed intake as the level of the cellulose in the diet increased. Savoury and Gentle (1976) noticed increased feed intake with increased dietary fibre in Japanese quail (*Conturnix conturnix*). Nelson (1972) reported an increase in the total feed intake with increase in dietary fibre in growing and laying diets. Baumgardt (1969) pointed out that at low energy concentrations, physical capacity and distention of the digestive organs restrict both feed and nutrient intake. Baumgardt (1969) further stated that at such low energy

levels, the energy "needs" of the bird are not satisfied even though a transient "satisfaction" due to a distended digestive tract occurs. As soon as the digesta passes down the gut, hunger returns.

Live weight gain

The progressive decrease in the body weight gain as the level of dietary rice offal increased agrees with the observation of several earlier workers. Hurwitz et al. (1983) noticed that birds fed low-energy, high-fibre diets could not maintain their calorie intake by a compensatory increase in feed intake because the capacity of feed intake was exceeded. This insufficient feed consumption would result in a progressive decrease in weight gain as the dietary energy decreases. Lee et al. (1971), Pym and Dillon (1974) and Watson (1975) all showed that restricting feed intake of broiler females decreased body size in proportion to the degree of restriction. Kondra et al. (1974) fed a high-fibre diet (19.6% CF) to meat-and egg-type chickens during the last six weeks of their growing period and found a reduction in body weight gain per bird. Reid et al. (1961) noted that limitation of the dietary intake of pullets from 9 weeks of age to maturity delayed sexual maturity and reduced growth rate. Direct restriction of intake and the addition of bentonite and wood flour were used to obtain this effect. Deaton et al. (1977) did not find any

effect on body weight when caged laying hens were fed diets containing graded levels of ground pine shavings. In the present study, birds fed the control and 20% rice offal replacement diets did not show any difference ($P > 0.05$) in their cumulative liveweight gain. Birds fed the 80% rice offal replacement diet showed stunted growth and consumed more feed than those fed the control diet and other diets with less rice offal content. Issacks et al. (1960), Waldroup and Harms (1962), Yates and Schaible (1963) and Waldroup et al. (1966) used diets containing more than 35% oat hulls resulting in very low energy levels in the rearing diets for broiler breeder pullets and noticed marked adverse effects on growth rate and maturity.

Feed Conversion Ratio

The feed conversion ratio (FCR) became poorer as the dietary rice offal increased. This differed from what Kondra et al. (1974) observed. They found that there was no effect on feed efficiency with the addition of fibre to the diet. In the present study, the birds consumed more feed and put on less body weight as the level of rice offal in the diet increased. This resulted in poorer feed efficiency with increase in dietary rice offal. This observation was in agreement with the findings of Dvorak and Bray (1978). They noticed that growth rates of chicks decreased linearly as the level of cellulose in a basal diet increased. Lower efficiencies of converting

feed to body gain with progressively increasing additions of rice offal indicate that there was a reduction in the utilization in the basal portion of the diet. The lower utilization might have been due in part to an increased rate of passage of the feed through digestive tract. This would reduce the time of ingesta exposure to enzymatic degradation and the time of nutrient contact with the absorptive membranes. The rice offal might have sufficiently distended the digestive tract, thereby limiting the mixing of ingesta with digestive secretions. The proportion of the total ingesta making contact with the absorptive surfaces might have also been due to this distention. Digestion and absorption would be adervsely affected under these conditions. Furthermore, greater abrasive action of the added fibrous rice offal might have contributed to higher maintenance costs for gut epithelial replacement,

Mortality

The dietary treatments had no significant ($P>0.05$) effect on mortality. This was in agreement with the findings of Deaton et al. (1979) and Kondra et al. (1974) when they fed high-fibre diets to birds.

Cost per kilogram of the chick and grower diets

The cost of a kilogram of the chick and the grower diets decreased gradually with increase in the level of dietary rice offal (Table 9). The total feed cost

of rearing a bird from 5 to 20 weeks was progressively cheaper with increase in the rice offal content of the diet. Since the age at point of lay for the birds fed the control (0%), 20%, 40% and 60% rice offal replacement diets did not differ much (Table 10), there was a lot of saving in feed cost as the level of rice offal in the diet increased. The 24-day delay of sexual maturity of birds fed the 80% diet outweighed its advantage of having the cheapest unit cost as shown in Table 9.

Age at onset of egg laying

Numerous studies have been shown that restricting feed intake of pullets, either directly or by nutrient dilution, during the rearing period will decrease body size and delay sexual maturity in proportion to the degree of restriction (Lee et al., 1971; Pym and Ditton, 1974; Watson, 1975). Similar observations were noticed in the present study. Brody et al. (1980) noticed an absence of sexual maturity in birds severely restricted from feed throughout and a uniform appearance of sexual maturity in severely restricted birds but changed to ad lib. feeding. Lister et al. (1966) made similar observations. Such observations could be interpreted to indicate a minimum body size requirement for the onset of sexual maturity in poultry. Lee et al. (1971) observed that the greater the degree of feed restriction in poultry (and hence the lower the body weight at the end of the

the restriction period), the longer the delay in egg production when feed restriction ceases. Similar observations have been reported for cattle (Chrichton et al., 1959), pigs (Dickerson et al., 1964), rats (Kennedy and Mitra, 1963), and humans (Frisch and Revelle, 1970).

Brody et al. (1980) also reported a time lag between the onset of sexual maturity, as indicated by accelerated development of the ovary, oviduct, comb and the onset of lay as indicated by first egg. They suggested that the onset of sexual maturity in poultry may be merely a matter of appropriate body size, but that the onset of lay might have an absolute age requirement as well. This separation in time between onset of sexual maturity and onset of lay in poultry is analogous to the period of adolescent sterility observed in human females following the onset of menstruation (Frisch and McArthur, 1974). No attempts were made in the present study to separate the time of sexual maturity as regards accelerated development of the reproductive organs from the time of onset of lay as regards the production of first egg. The savings in feeding up to 60% rice offal in chick and grower diets from 5 to 20 weeks seem to over-ride the delay in sexual maturity (Table 9).

EXPERIMENT II: Laying Experiment

Age at 50% lay

The ages of 50% lay varied but not significantly ($P > 0.05$) from 186 to 201 days for birds fed the control

and 60% rice offal replacement diets respectively (Table 12). This difference was attributed to the poor quality of the high-fibre diet which did not support laying satisfactorily. The ages at 50% lay for birds fed the remaining experimental diets did not also differ significantly ($P > 0.05$) and ranged from 187 to 194 days. The poor rate of egg production exhibited by birds fed on diets with high fibre content agreed with the work of Kondra (1974) who noticed a reduction in the rate of lay and feed efficiency when the birds were fed high-fibre diets both in the rearing and laying periods. When the birds fed the high-fibre diet (60%) were changed to a low-fibre diet, there was a period of compensatory growth during which time they attained normal body size. The period between age at first egg and 50% lay was shorter for birds changed from high to low-fibre diets than for birds continuously fed low-fibre diets. This may have been due to compensatory growth by birds previously fed high-fibre diets.

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Hen-day Egg Production

Birds fed 60% rice offal replacement diet continuously and those previously reared on high-fibre diets attained 50% egg production later than those on low-fibre diets. The feed intake per bird was higher for birds on high-fibre diets and this was attributed to low nutrient density. Hen-day egg production(Table 11)

for birds on 40% rice offal replacement was not significantly different from those on 0% rice offal replacement. The crude fibre level in this diet (ie 40% rice offal replacement) was 13.77%. Although the diet had lower nutrient density due to dilution with fibrous feedstuff (rice offal), the birds may be extracting more nutrients possibly due to the non-significant anatomical modifications of gut components (Table 10) and microbial activity. The differences in the length and weight of the various portions of the gut were inconsistent and did not show any significant ($P > 0.05$) dietary effect in this study. These observations differed from those of Deaton et al. (1979) who found that increased dietary fibre resulted in a significant increase in gizzard weight and gut length.

Bedbury and Duke (1983) examined the ceacal contents from turkeys fed either a high-fibre (HF) or a low-fibre (LF) diet and found that direct microscopic counts of microbes were significantly higher in HF-fed than in LF-fed birds. The avian ceaca have been assumed to perform a number of functions which include: microbial degradation of indigestible substances such as cellulose (Gasaway, 1976; Inman, 1973), microbial synthesis of vitamins (Coates et al., 1968), cholesterol digestion and absorption (Tortuero et al., 1975), enhanced immune response in growing chicks via a greater density of lymphoid tissue

(McBee, 1977). Microbially mediated non-protein nitrogen (Barnes and Impey, 1974), and ceacal flora have been implicated as a factor in the protection of fowl from Salmonella infections (Schneitz et al., 1981).

Microbial degradation of fibre is of particular interest and conditions in the lumen of the ceacum favour cellulolysis. A high and constant temperature accelerates fermentation, the pH within the ceaca of turkeys is 5.5 to 7.0 (Sudo and Duke, 1980), which is optimal for bacterial cellulose activity (Gascoigne and Gascoigne, 1960), and peristalsis and anti-peristalsis provide thorough mixing of the ceacal contents (Duke et al., 1980).

Knowledge of the degradation of cellulose by ceacal microflora may stimulate the exploitation of that function in digestion of poor quality diets, high in fibre. That would reduce competition between humans and livestock (poultry) for cereal grains.

Feed Intake and Cost per kilogram of feed

The daily feed intake of bird increased with a decrease in the nutrient density of the diet due to increase rice offal inclusion. This observation was similar to many other reported work. Lillie and Denton (1966) and Ascroft (1961) observed increased feed consumption but little effect on live weight gain and maturity when they used 25% and 30% oat hulls in the grower

diet. Wheat bran and wheat shorts made up 80% of grower diets fed to broiler breeder pullets in experiments reported by Summer et al. (1967). These diets were much lower in energy than the control diet, and consequently the birds greatly increased their feed consumptions.

The cost per kilogram diet decreased with increase in the level of rice offal in the diet.

Feed per dozen eggs

It is striking to note that while there was no difference ($P > 0.05$) in feed intake per day by birds continuously fed the control diet (0%) and those previously fed a high-fibre diet (80%) in the rearing period but changed to the control diet in the laying phase; there was a significant difference ($P \leq 0.05$) in their feed consumption per dozen eggs (Table 12). The difference in feed consumption per dozen eggs by these two groups of birds eating the same diet could be explained on the high-fibre diet in their growing phase. Similarly birds continuously fed a high-fibre diet (60%) in the growing and laying phases had a significantly ($P \leq 0.05$) higher feed intake per dozen eggs when compared to those previously fed 60% rice offal replacement diet but reverted to 0% rice offal replacement diet. The values were 5.54kg and 2.17kg of feed per dozen eggs respectively. The 60% rice offal replacement diet did not give satisfactory egg output. It is also worth noting that birds previously

fed 60% rice offal replacement but later changed to the control diet had higher feed per dozen eggs than those birds continuously fed the control diet. The values were 2.17kg and 1.64kg of feed respectively. This difference was not, however, significant ($P > 0.05$). Compensatory growth could be regarded as a contributory factor to the higher feed intake per dozen eggs among these birds. The cost of feed per dozen eggs similarly varied making it more costly to feed the high-fibre diets. This observation was in line with the finding of some workers as reviewed by Lee *et al.* (1971). The researchers used high levels of oat hulls (30-40% of the diet) as diluent to delay sexual maturity. At this high level of inclusion, the total feed cost was found to be greater than that of normal diet. They concluded that the *ad lib.* feeding of low energy grower diets was uneconomical unless the diluent could be obtained for less than 10% of the cost per unit weight of grower diet.

Egg weight

The differences in egg weight were not statistically significant ($P \geq 0.05$). The eggs, however, increased in size with the age of the bird and this was regardless of the dietary treatments. Reports of larger initial egg size from birds kept under restricted feeding (Walter and Aitken, 1961) are thus attributable to the later

age at which these birds start to lay. It follows that biological response was not implied, except late onset of lay when restricted birds are found to have a larger egg size of all eggs laid (Quinsenberry, 1966) as quoted by Lee et al. (1971). These observations agreed also with the findings of Olomu and Offiong (1983), Singh and Talapatra (1974) and Mowbray and Sykes (1971) who found that dietary energy levels have no effect on egg weights.

SUMMARY

Two experiments were conducted with egg-type pullets from 4 weeks old to 20 weeks of age in the first experiments and with the same birds from point-of-lay to 50% hen-day egg production.

The studies were undertaken primarily to examine the feeding value of rice offal as a feed ingredient for growing pullets and layers and to determine a suitable level of incorporation in chick, grower and layer diets that would be both economical and give satisfactory performance. Five and four experimental diets were formulated in the growth and laying experiments respectively, with rice offal replacing maize in the control diet by approximately 0, 20, 40, 60 and 80%. The last diet was discontinued in the laying phase because of its poor performance in the growing phase.

In the growing phase, there was a reduction in body weight gain as the level of rice offal in the diet increased, but body weight between birds fed the control and 20% diets did not differ significantly ($P > 0.05$). Feed consumption increased with increase in the rice offal content of the diet. Birds fed the 20% and 40% diets did not differ significantly ($P > 0.05$) in their feed intake. There was a 24-day inrerval between the first and last groups of birds to reach the age of onset of lay. Feed conversion

ratio increased with the level of rice offal. The control and 20% rice offal replacement diets did not differ significantly ($P > 0.05$) in terms of feed conversion ratio. Similarly birds fed diets 20% and 40% did not have a significant difference in their feed to gain ratio but those on 60% and 80% rice offal replacement diets had very poor feed efficiency.

Despite the higher feed intake by birds fed diets with low nutrient density (diets with high rice offal levels), the total cost of feed consumed per bird up to 20 weeks of age decreased with increase in the dietary rice offal content. This resulted in a lot of saving in terms of feed cost with those diets that had high rice offal content.

In the laying phase, hen-day production on 40% rice offal replacement diet was not significantly ($P > 0.05$) different from those on the control diet (0%). The period for birds to reach 50% lay became longer with increase in the rice offal content of the diet. The interval between first egg and 50% hen-day production was shorter for birds fed the high-fibre diets at growing period but changed to low-fibre laying diets. Feed intake per bird was - greatest for birds fed the diet with highest rice offal inclusion (60% rice offal replacement diet). Feed per dozen eggs increased with increase in rice offal content of the diet and also for birds previously

reared on the 80% diet but changed to the control diet in the laying phase. There were no significant ($P > 0.05$) differences in mortality and egg weight among the various treatments.

Recommendations

Satisfactory growth rates were obtained up to the diet with 40% rice offal replacing maize. Birds could also be reared on the 60% rice offal replacement diet and then change to a diet of lower rice offal content in the laying phase. Such birds will, however, have reduced body weight at point-of-lay and will come to lay at a much later age. Since the unit feed cost during the growing phase decreased with increase in dietary rice offal, the 40% diet (replacement of maize by rice offal) proved to be the optimum diet, with relatively low cost and good performance in birds.

Though the unit cost of the layer diets decreased with increase in the level of dietary rice offal, the cost of feed per dozen eggs increased with the rice offal content of the diet. However, optimum egg production was achieved in diet with 40% rice offal replacing maize.

Since the laying experiment was designed to stop at the time when birds in the various treatments attained 50% hen-day production, the observations made in this study are not conclusive and need further investigation.

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Appendix 1: Ingredient Prices used

Ingredients	Prices
Maize	₦600.00 per tonne
Groundnut cake	₦500.00 per tonne
Rice offals	₦100.00 per tonne
Common salt	₦12,00 per 25 kg
Bone meal	₦120.00 per tonne
Vitamin/Mineral Premix for:	
a) Chick Diet =	₦525.00 per 50 kg
b) Grower Diet =	₦398.00 per 50 kg
c) Layer Diet =	₦380.00 per 50 kg
L-Lysine HCl	₦260.00 per 25 kg
DL-Methionine	₦195.00 per 25 kg
Lime stone	₦10.00 per 50 kg

Appendix 2: Costing of Chick Diets

Ingredients	D I E T S 0% Quant. (kg)	0% Cost (₦)	20% Quant. (kg)	20% Cost (₦)	40% Quant. (kg)	40% Cost (₦)	60% Quant. (Kg)	60% Cost (₦)	80% Quant. (kg)	80% Cost (₦)
Maize	62.60	37.56	50.10	30.06	37.60	22.56	25.00	15.00	12.50	7.50
Groundnut cake	33.30	16.56	34.00	17.00	34.60	17.30	35.00	17.50	36.00	18.00
Rice offals	-		11.80	1.18	23.70	2.37	35.90	3.59	47.40	4.74
Bone meal	3.00	0.36	3.00	8.57	3.00	8.57	3.00	8.57	3.00	8.57
Vitamin/Mineral Premix	0.25	2.63	0.25		0.25		0.25		0.25	
Common salt	0.25	0.12	0.25		0.25		0.25		0.25	
L-Lysine HCl	0.30	3.12	0.30		0.30		0.30		0.30	
DL-Methionine	0.30	2.34	0.30		0.30		0.30		0.30	
Total 100kg =		₦62.78		₦56.81		₦50.80		₦44.66		₦38.81
∴ 1kg of diet =		₦0.63		₦0.57		₦0.51		₦0.45		₦0.39

Appendix 3: Costing of Grower Diets

Ingredients	0%		20%		40%		60%		80%	
	Quant. (kg)	Cost (₦)	Quant (kg)	Cost (₦)	Quant (kg)	Cost (₦)	Quant (kg)	Cost (₦)	Quant (kg)	Cost (₦)
Maize	73.40	44.04	58.70	35.22	44.00	26.40	29.40	17.64	14.70	8.82
Groundnut cake	22.50	11.25	23.20	11.60	24.00	12.00	24.80	12.40	25.50	12.75
Rice offals	-		14.00	1.40	27.90	2.79	41.70	4.17	55.70	5.57
Bone meal	3.00	0.36	3.00)		3.00)		3.00)		3.00)	
Vitamin/Mineral Premix	0.25	1.99	0.25)		0.25)		0.25)		0.25)	
Common salt	0.25	0.22	0.25)	7.93	0.25)	7.93	0.25)	7.93	0.25)	7.93
L-Lysine HCl	0.30	3.12	0.30)		0.30)		0.30)		0.30)	
DL-Methionine	0.30	2.34	0.30)		0.30)		0.30)		0.30)	
Total	100kg =		₦63.22		₦56.15		₦49.12		₦42.14		₦35.07
	1kg of diet =		₦0.63		₦0.56		₦0.49		₦0.42		₦0.35

Appendix 4: Costing of Layer Diets

Ingredients	DIETS 0% Quant. (kg)	0% Cost (₦)	20% Quant (kg)	20% Cost (₦)	40% Quant (kg)	40% Cost (₦)	60% Quant (kg)	60% Cost (₦)
Maize	62.40	37.44	49.60	29.76	36.40	21.84	23.40	14.04
Groundnut cake	27.00	13.50	27.30	13.65	28.00	14.00	28.60	14.30
Rice offals	-	-	12.50	1.25	25.00	2.50	37.40	3.74
Lime stone	6.50	1.30	)		)		)	
Bone meal	3.00	0.36	)		)		)	
Vitamin/Mineral Premix	0.25	1.90	)	9.14	)	9.14	)	9.14
Common salt	0.25	0.12	)		)		)	
L-Lysine HCl	0.30	3.12	)		)		)	
DL-Methionine	0.30	2.34	)		)		)	
Total =	100kg =		₦59.08	₦53.80		₦47.48		₦41.22
	1kg of diet =		₦0.59	₦0.54		₦0.47		₦0.41

Appendix 5: Average live weight with age (Gram) (Cumulative)

Age (Weeks)	DIETS 0% (i)	0% (ii)	20% (i)	20% (ii)	40% (i)	40% (ii)	60% (i)	60% (ii)	80% (i)	80% (ii)
4	152	142	142	146	150	146	146	142	140	144
6	252	250	268	260	250	238	222	232	186	214
8	370	372	390	392	384	392	300	336	310	292
10	466	453	478	534	520	503	450	442	319	334
12	653	630	617	696	628	706	529	518	429	451
14	830	821	773	812	818	898	692	738	587	568
16	976	958	1015	1060	879	1020	940	868	776	682
18	1173	1195	1172	1253	1102	1185	1011	995	877	808
20	1392	1372	1296	1422	1206	1354	1136	1158	950	1008

Appendix 6: Growth Experiment : Cumulative live weight gain (g) per Bird

Age (Weeks)	D I E T S 0% (i)	0% (ii)	20% (i)	20% (ii)	40% (i)	40% (ii)	60% (i)	60% (ii)	80% (i)	80% (ii)
6	100	108	126	114	100	92	76	90	46	70
8	218	230	248	246	234	246	154	194	170	148
10	314	311	336	388	370	357	304	300	179	190
12	501	488	475	550	478	560	383	376	289	307
14	678	679	631	666	668	752	546	596	447	424
16	824	816	873	914	729	874	794	726	636	538
18	1021	1053	1030	1107	952	1039	865	853	737	664
20	1240	1230	1154	1276	1056	1208	990	1016	810	864

Appendix 7: Growth Experiment : Cumulative Feed Consumption per Bird (Gram)

Age (weeks)	0% (i)	0% (ii)	20% (i)	20% (ii)	40% (i)	40% (ii)	60% (i)	60% (ii)	80% (i)	80% (ii)
6	297.98	288.89	366.00	355.00	362.00	371.00	341.00	358.76	352.00	349.40
8	763.54	768.89	922.22	883.84	942.00	925.00	959.57	970.21	957.58	990.72
10	1282.77	1294.57	1464.65	1435.05	1466.00	1439.00	1642.70	1667.78	1789.41	1732.22
12	1883.33	1881.57	2235.94	2214.29	2320.31	2263.54	2579.52	2692.98	3254.35	3315.71
14	2762.79	2783.71	3126.06	3072.22	3213.16	3179.79	3570.73	3810;00	4447.05	4530.00
16	3336.05	3418.18	4016.67	3981.89	4053.89	4070.21	4548.78	4843.04	5551.39	5547.14
18	4313.95	4373.86	4888.71	4875.22	4685.47	5117.78	5487.80	5924.36	6846.42	6868.57
21	5325.58	5368.18	5990.76	5966.35	5818.11	6475.59	6586.59	7079.49	8134.62	7672.86

Appendix 8: Growth Experiment : Feed Conversion Ratio

Age (weeks)	DIETS 0% (i)	0% (ii)	20% (i)	20% (ii)	40% (i)	40% (ii)	60% (i)	60% (ii)	80% (i)	80% (ii)
4	2.98	2.67	2.90	3.11	3.62	4.03	4.49	3.99	7.65	4.99
6	2.98	2.67	2.90	3.11	3.62	4.03	4.49	4.99	7.65	4.99
8	3.50	3.43	3.72	3.59	4.03	3.76	6.23	5.00	5.63	6.69
10	3.86	4.16	4.36	3.70	3.96	4.03	5.40	5.56	10.00	9.12
14	4.07	4.10	4.95	4.61	4.81	4.23	6.54	6.39	9.95	10.21
16	4.05	4.19	4.60	4.36	5.56	4.66	5.73	6.67	8.73	9.94
18	4.23	4.15	4.75	4.40	5.16	4.93	6.34	6.95	9.29	9.59
20	4.29	4.36	5.19	4.68	5.60	5.36	6.65	6.97	10.12	8.88

Appendix 9: Egg Production Parameters

	DIETS													
	0%		20%		40%		60%		0%(80%)		0%(60%)		40%(20%)	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
Parameters														
Feed/dozen eggs (kg)	1.53	1.75	1.83	2.10	2.42	2.68	7.15	3.92	6.04	3.89	2.69	1.65	2.97	2.35
Cost/kg of diet (₦)	0.59	0.59	0.54	0.54	0.47	0.47	0.41	0.41	0.59	0.59	0.59	0.59	0.47	0.47
Feed intake/ bird/day(g)	88.01	92.73	96.02	100.00	100.61	102.60	105.89	115.85	95.15	85.45	88.92	82.67	104.89	107.04

Appendix 10: Gastro-Intestinal Measurements

	D I E T S									
	0%		20%		40%		60%		80%	
	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)	(i)	(ii)
G.I.T. Components										
Entire G.I.T. (cm)	232.50	227.20	225.00	230.60	245.20	229.80	220.30	230.10	217.00	223.70
Ceaca (cm)	35.10	37.10	37.40	37.90	38.26	38.90	35.70	37.70	35.30	
Small intestine + Duodenum (cm)	156.70	184.80	168.50	183.00	203.80	183.40	174.80	191.20	174.00	179.90
Empty gizzard (g)	40.88	35.51	33.20	33.48	35.99	38.21	36.83	38.81	34.88	29.92
Pancreas (g)	3.23	3.65	2.95	3.36	3.88	3.96	4.29	17.28	3.81	3.57
Liver (g)	32.19	36.89	35.76	37.46	33.04	30.96	33.84	39.53	29.77	31.84

Appendix 11: Cumulative live weight gain
Anova Summary Table

Source of variation	df	ss	ms	F
Periods[1]	7	8.82266E+06	1.26038E+06	779.733
Treatments	4	568197	142049	87.879
Weeks x Trts.	28	173742	6205.43	3.839*
Residual	40	64657	1616.43	
Total	79	9.62925E+06		

Appendix 12: Cumulative Feed Intake/Bird (From 5th to 20th week) Anova Summary Table

Source of variation	df	ss	ms	f
Periods[1]	7	3.3033E+08	4.719E+07	2410.34
Treatments	4	1.64426E+07	4.11066E+06	209.961
Weeks x Trts.	28	7.98442E+06	285158	14.565*
Residual	40	783127	19578.2	
Total	79	3.5554E+08		

Appendix 13: Feed conversion Ratio
Anova Summary Table

Source of variation	df	df	ss	ms	f
Periods[1]	7		45.214	6.214	26.279
Treatments	4		276.223	69.056	280.948
Weeks x Trts.	28		23.538	0.841	3.42*
Residual	40		9.832	0.246	
Total	79				

*Significant at 5% level of significance

[1]Forthnightly recording.

Appendix 18: Length of small intestine (+ Duodenum)
Anova Summary Table

Source of variation	df	ss	ms	f
Between treatments	4	613.812	153.453	0.892 N.S.
Within treatments	5	859.906	171.981	
Total	9	1473.72		

Appendix 19: Empty gizzard weight (g)
Anova Summary Table

Source of variation	df	ss	ms	f
Between treatments	4	58.225	14.556	2.334 N.S.
Within treatments	5	31.182	6.236	
Total	9	89.408		

Appendix 20: Length of entire gut (cm)
Anova Summary Table

Source of variation	df	ss	ms	f
Between treatments	4	319.906	79.976	1.828 N.S.
Within treatments	5	218.75	43.75	
Total	9	538.656		

N.S. = Not significant at 5% level of significance.

Appendix 14: Daily feed intake/bird (Layer Diets)
Anova Summary Table

Source of variation	df	ss	ms	f
Between Treatment	6	1157.69	192.947	15.544*
Within treatments	7	86.89	12.412	
Total	13	1244.58		

Appendix 15: Hen-day egg production
Anova Summary Table

Source of variation	df	ss	ms	f
Weeks	5	53509.9	10702	285.657
Treatments	6	5518.34	919.723	24.549
Weeks x Trts.	30	2362.74	78.758	2.102*
Residual	42	1573.51	37.464	
Total	83	62964.5		

Appendix 16: Feed per dozen eggs
Anova Summary Table

of variation	df	ss	ms	f
treatments	6	28.363	4.727	3.96*
treatments	7	8.355	1.193	
	13	36.718		

17: Ceacal length (cm)
Anova Summary Table

variation	df	ss	ms	f
treatments	4	12.323	3.08	4.284N.S.
treatments	5	3.595	0.919	
al	9	15.918		

N.S. = Not significant at 5% level of significance
* Significant at 5% level of significance.