REPLACEMENT OF MAIZE IN POULTRY RATIONS WITH WHEAT OFFALS AND BREWERS' DRIED GRAINS

BY

FRANK SARLU NELSON
B.So. (Hons) Agric.
University of Ghana, Legon

1975

A thesis submitted to the Postgraduate School, Ahmadu Bello University, in partial fulfillment of the requirements for the degree of Master of Science

Department of Animal Science
Faculty of Agriculture
AHMADU BELLO UNIVERSITY, ZARIA

MARCH, 1984

UNCLASSIFIED

DECLARATION

I declare that this work is wholly the author's and has not been part of any presentation for any other qualification.

Signed by: _____
Student

Date: MARCH, 1984

THESIS APPROVAL

This thesis by Frank Sarlu Nelson meets the regulations governing the degree, Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

Internal Examiners

Prof. J.M. Olomu
Department of Swine and Poultry Research,
National Animal Production Research Institute, A.B.U.
Shika, Zaria, Nigeria.

Dr. P.C. Njoku
Department of Animal Science
Ahmadu Bello University
Zaria, Nigeria.

External Examiner

Prof. B.L. Fetuga
Department of Animal Science
University of Ibadan
Ibadan, Nigeria.

DEDICATION

To my dear wife, Cynthia, Aunt Millicent and late cousin Mami C. with kind thoughts.

ACKNOWLEDGEMENTS

I am highly indebted to Prof. J.M. Olomu, my major supervisor, from whom I learnt so much within a short time. He critically supervised every stage of the research work and also carefully scrutinized the manuscripts used in the preparation of this thesis. Similarly, to Dr. P.C. Njoku, my academic adviser, for his support, encouragement and supervision, I am most grateful.

I wish to thank the Director, National Animal Production Research Institute, Shika, for placing the Institute's research facilities at my disposal and for providing the necessary funds for my research.

I also wish to express my appreciation to the entire staff of the poultry section of N.A.P.R.I., for their valuable assistance in the preparation of feeds and routine care of the experimental birds. My sincere thanks also go to Mr. S.A. Bello; Mrs. Sekoni and the entire laboratory staff of N.A.P.R.I. for their assistance and co-operation in the analysis of feed ingredients and egg quality measurements.

I would like to express my sincere gratitude to the Commonwealth Scholarship and Fellowship Plan, and for that matter, to the Federal Government for making it possible for me to study in Nigeria.

I also wish to record my special indebtedness to my Head of Department, Prof. N.N. Umunna; Prof. J.O. Akinola, Dr. N.I. Dim, Dr. A.O. Aduku and other senior members of the department for taking special interest in my work and for freely sharing with me the fruits of their many years' experience.

In addition my special gratitude goes to Mr. S.A. Offiong, Mr. & Mrs. S.K.A. Monsah, Mr. & Mrs. C.D. Nottoy, Mr. Kon Bentsi-Enchill and my enthusiastic course mates, especially uncle Sam, A.S. Kwatu and Johnny Ehamon, for time and thought so generously given. In fact a lot of people have contributed in diverse ways to the success of my M.Sc. Programme. To all of them, I express my deepest gratitude and appreciation.

The assistance in statistical analysis of Mr. C. Ehaninful of the Statistical Services of the Institute of Agricultural Research, A.B.U., is also acknowledged. Thanks are also due to Mr. A. Audu for typing the final manuscript.

I would like to express my sincere admiration to my wife, Cynthia, whose patience, tolerance, understanding and steadfast encouragement were an incentive throughout the period of my study. My sincere gratitude is also extended to my parents, Mr. & Mrs. D.A. Nelson, Auntie Millicent, Mr. & Mrs. E.A. Nelson, other members of my family, especially Silas Nelson and friends for their moral and spiritual suppo

Special thanks are also due to my in-laws, Mr. & Mrs. C.K. Seade, for taking good care of my wife during the period of my M.Sc. Programme

Finally, I give praise and thanksgiving to God Almighty, for guarding, guiding and giving me enduring peace throughout the period of my stay in Nigeria.

ABSTRACT

Nine studies were conducted with broiler chickens, chicken pullets and laying chickens to explore the possibility of rearing these birds on rations containing the industrial by products, wheat offals or brewers dried grains (BDG) as partial or complete replacement for maize.

The metabolizable energy (ME) and metabolizable energy corrected to nitrogen equilibrium (ME_n) for wheat offal were 1201.6 and 1117.0 kcal/kg respectively while those for BDG were respectively 1744 and 1664.9 kcal/kg.

For starting broiler chickens, the results indicated that up to 50% of the grains could possibly be replaced with wheat offals without much adverse effects on weight gains, feed consumption and efficiency of feed conversion. The addition of 5% palm oil to the 50% replacement of maize with wheat offals further improved the performance of the birds. The replacement of maize at both 25% and 50% levels with BDG in broiler starter rations significantly depressed weight gains and efficiency of feed conversion. It may therefore not be advisable to incorporate BDG into broiler starter rations at levels beyond 25% replacement of the maize without further experimentation. Generally mortality increased significantly with increase in BDG level in the rations.

For finishing broiler chickens, no significant differences were found in weight gains, feed consumption, efficiency of feed utilization feed cost per kilogram liveweight gain and mortality for the control ration, the ration containing 25% replacement of maize with BDG plus 5% palm oil supplementation and the ration in which 50% maize was

replaced by essentially wheat offals plus 5% palm oil supplementation. The addition of 5% palm oil to the rations generally increased the feed cost per kilogram liveweight gain. Efficiency of feed conversion tended to improve with increase in the level of maize and addition of 5% palm oil to the rations. The highest mortality was obtained on the ration containing 100% replacement of maize with BDG.

The replacement of 50% maize in the ration and complete replacement of maize with wheat offals with or without supplementation with 5% palm oil supported comparable weight gains for starting pullets up to 8 weeks of age as the control ration in which wheat offal was absent. The 50% replacement of maize with BDG with or without 5% palm oil supplementation significantly depressed weight gains and efficiency of feed utilization. However, feed cost to 8 weeks of age was significantly lowered. Pullets fed rations without wheat offals or BDG from day old to 20 weeks of age were significantly heavier than pullets in all other treatments at 20 weeks of age. Similar results were obtained when pullets were fed either wheat offals or BDG from 8 - 20 weeks. Feed consumption generally increased while efficiency of feed conversion was significantly depressed with increasing levels of either wheat offals or BDG from day old to 20 weeks. On the contrary, feed consumption decreased with increase in level of BDG for growing pullets from 8 to 20 weeks of age. Feed costs were significantly lower on the rations containing either wheat offals or BDG. Mortality was highest on the ration containg complete replacement of maize with wheat offals and the replace

of maize with 50% BDG without palm oil supplementation and 75% BDG with 5% palm oil supplementation.

The control birds attained the age to 5% egg production significantly earlier than birds in all other treatments.

The replacement of 50% and 62.5% maize with wheat offals led to egg production which was not significantly different from the all maize ration. However, the inclusion of BDG (37.5% and above) in layer rations significantly depressed egg production, the depression increasing with increase in the level of BDG in the ration. Generally, the replacement of maize with wheat offals caused significant increase in feed consumption. However, feed cost per dozen eggs was reduced by replacement of 50 or 62.5% of the maize with wheat offals. On the contrary, feed consumed per dozen eggs and feed cost per dozen eggs increased with decrease in the level of maize in the rations and increase in the level of BDG in the ration.

Haugh unit value tended to increased with increasing levels of wheat offals while egg shell thickness tended to decrease with increasing levels of BDG in the ration.

TABLE OF CONTENTS

	Page
TITLE	i
DECLARATION	ii
APPROVAL	iii
DEDICATION	iv
ACKNOWLEDGEMENTS	v
ABSTRACT	vii
TABLE OF CONTENTS	x
LIST OF TABLES	xiii
INTRODUCTION	1
LITERATURE REVIEW	4
WHEAT OFFAL	4
Nutritive Profile of Wheat Offal	5
Effects of Wheat offal on chicken performance . . .	6
BREWERS DRIED GRAINS	7
Nutrive profile of BDG	8
Effects of BDG and other brewers by-products on performance of chickens	9
METABOLIZABLE ENERGY EFFECTS ON CHICKEN PERFORMANCE	12
Environmental temperature and M.E. utilization . . .	15
SUPPLEMENTATION OF DIETARY FAT ON METABOLIZABLE ENERGY UTILIZATION IN CHICKEN RATION . . .	19
FIBRE IN THE DIET OF THE CHICKEN	22
Bulkiness	25
EXPERIMENTS	30
SECTION 1, Metabolizable Energy studies . . .	31
Status of the Problem	31
Experimental	31
Results and Discussion	33

Page

SECTION 2, Experiments with broiler chickens . . . 37

Status of the problem 37

Experimental--General 38

A. The effects of replacing maize with wheat offals and BDG in broiler starter ration . . . 39

Trial 1 39

Objective 39

Experimental 41

Results 41

Summary 43

Trial 2 46

Objective 46

Experimental 46

Results 48

Summary 50

B. Extent of replacement of maize grains with wheat offals and BDG in practical rations for broiler finisher . . . 51

Trial 3 51

Objective 51

Experimental 51

Results 51

Summary 55

Trial 4 56

Objective 56

Experimental 56

Results 56

Summary 58

Pag.

SECTION 3, Experiments with pullets . . . 6

The effects of inclusion of wheat offals and BDG on the performance of pullets 6

Objective 6

Experimental 6

Results 65

Summary 70

SECTION 4, Experiments with laying chickens . . . 72

The effects of the inclusion of wheat offals or BDG in layer diets on the performance of laying chickens 72

Objectives 72

Experimental 72

Results 76

Summary 80

GENERAL DISCUSSION 82

REFERENCES 95

APPENDICES 107

LIST OF TABLES

Table		Page
1	Gross energy, classical ME, ME_n and efficiency of energy utilization values	34
2	Metabolizable energy values of wheat offal and BDG	34
3	Proximate chemical composition of the major ingredients used in ration formulation (% Air dry basis)	40
4	Percentage composition of starter rations (Trial 1)	42
5	Effects of different levels of wheat offals and BDG on the performance of broiler chicks (0-5 weeks)	44
6	Percentage composition of starter rations (Trial 2)	47
7	Effedt of different levels of wheat offals and BDG on the performance of broiler chicks (0-5 weeks)	49
8	Percentage composition of broiler finisher rations (Trial 3)	52
9	Effect of different levels of wheat offals and BDG on the performance of broiler chickens (6-9 weeks)	54
10	Percentage composition of broiler finisher rations (Trial 4)	57
11	Effect of different levels of wheat offals and BDG on the performance of broiler chickens (6-9 weeks)	59
12	Percentage composition of rations for chicken pullets (0-8 weeks)	63
13	Percentage composition of growers ration (8-20 weeks)	64
14	Effects of replacing maize with wheat offals and BDG in the rations of chicken pullets (0-20 weeks) ...	66
15	Effects of replacing maize with wheat offals and BDG in the rations of growing pullets (8-20 weeks)	69
16	Percentage composition of experimental rations (wheat offal treatment)	73
17	Effects of replacing maize with wheat offal in rations for laying chickens on laying house performance and egg quality	75

Table		Page
18	Percentage composition of experimental rations (EDG treatment)	77
19	Effects of replacing maize with EDG in rations for laying chickens on laying house performance and egg quality	79

INTRODUCTION

Cereal grains form a major component of poultry feeds. At the same time cereal grains provide food for the sustenance of a major portion of the human population in Africa. As the population continues to increase, cereal grains will assume a more important role in attempts to meet future food requirements. Bolton (1971) surmised that where the amount of food available to the human is limited, it would be wrong to use acceptable human food for feeding animals.

Of late, the market demand for compound feeds for poultry has become high, especially with the realisation of the role of properly balanced rations in profitable animal production programmes. The availability of such feeds in quantities to meet demand, has however, been limited by the availability of cereal grains which form the main energy component of the diets. The situation has been aggravated in recent times, by the increasing demand for these cereal grains (maize, millet and sorghum) as primary food sources for human consumption. Furthermore, most developing countries have to import cereal grains to make up for the usual shortfalls and this involves a lot of foreign exchange. Foreign exchange is becoming rather scarce.

Ghana and Nigeria have great potential for agricultural and livestock production, and the possibility of self sufficiency will be enhanced if local conditions are improved. In an attempt therefore to save cost on the production of a kilogram weight of poultry meat or a dozen of eggs produced, several approaches have been adopted. These include the use of cheaper and more easily

available local ingredients and agro-industrial by-products such as brewers' dried grains (BDG) and wheat offals from our breweries and flour milling industries respectively in poultry rations. An investigation of the usefulness of these products is therefore worthwhile. In their review on agricultural by-products in South East Asia, Devendra and Raghavan (1978) indicated that increased efficiency of the utilization of agro-industrial by-products is both advantageous and justified and is associated with three very important considerations: firstly, inadequate feed supplies to support the livestock populations, secondly, the high cost of feeding animals and thirdly, the need to increase productivity from the animals. These authors concluded that every attempt must therefore be made to maximise the utilisation of these by-products in rations for farm animals.

Considerable interest is being shown in the formulation of high efficiency diets for all classes of poultry based on locally available feed ingredients (Ademosun 1973, Oluyemi and Oyenuga 1974). The use of these local raw materials in cutting down cost and producing cheap feed of acceptable quality will stimulate and sustain the interest of many farmers, since poultry keeping is accepted by many farmers as a way of life. This project was therefore oriented towards solving the problem of grain scarcity and its current prohibitive cost.

The objectives of the project were:

1. to investigate how far wheat offals and brewers dried grains can replace maize in poultry rations.

2. to find out how much the use of these agro-industrial by-products can affect the overall feed cost.
3. to determine the impact these agro-industrial by-products will make on grain replacement.

It is hoped that the results of this study will establish some important information regarding the use of grain by-products, especially wheat offals and brewers dried grains, as major ingredients in poultry feeds.

LITERATURE REVIEW

Due to the current prohibitive prices of cereal grains and the high demand by both human beings and the poultry industry it has become necessary to find suitable and cheap substitutes.

In the past, when the supply of energy sources presented no special problem, several industrial by-products were neglected. But as a result of the current shortage of these energy sources there is now a renewed interest in these materials for feeding animals. According to Devendra and Raghavan (1978) there is an economic advantage for utilizing higher levels of industrial by-products such as rice bran, wheat offal and brewers dried grains in poultry diets. There has however, been little research on performance and nutrient utilization when chickens are fed these agro-industrial by-products. Some of these agro-industrial by-products which could be used as economical sources of energy are described herein.

WHEAT OFFAL

During the processing of wheat, several by-products are obtained. These include wheat middlings, wheat offal, wheat mill run and wheat shorts just to mention a few. Moran and Summers (1970) estimated that these fractions comprise approximately 25% of the whole grain, and considering the large quantities of wheat produced in the world today, these fractions like rice bran, are available in substantial amounts. The method of distinction of these wheat milling by-products according to Kohler et al. (1970) is based on their fibre contents. Thus, the by-product wheat offal contains more than 9.5% crude fibre;

wheat middlings or mill run contains up to a maximum of 9.5% crude fibre, and wheat shorts up to a maximum of 7% crude fibre.

About 50% of the total mill feed production is comprised of wheat offal (Saunders et al., 1974). It is composed of a mixture of the coarse outer covering of the wheat kernel, flour and some fine ground weed seeds and other non wheat material.

Nutritive profile of wheat offal:

Wheat milling by-products are relatively low in ME and high in fibre. The nutritional value of these feedstuffs has been reviewed in detail by many workers (Cave et al. 1965; Moran and Summers 1970; Kohler et al., 1970). Although wheat offal has relatively low ME content, there appears to be potential for increasing its ME content. Cave et al. (1965) reported that pelleting wheat offal increased its ME content by 30% for growing chicks. Saunders et al., (1972) demonstrated that enzymatic treatment of wheat offal caused a significant increase in protein digestibility (both in vitro and in vivo with rats) and suggested that the degradation of indigestible carbohydrate in wheat offal should result in an increase in ME for monogastric animals.

Wheat offal is highly palatable and bulky, and has a laxative effect. Wheat offal averages 16.4% in protein and 4.5% in fat, and does not usually contain more than about 10% fibre. The amino acid balance is superior to that of corn or the whole wheat but inferior to that of most protein supplements. It is extremely high in phosphorus but low in calcium (Morrison, 1959; Osuji, 1982). It is high in niacin, but the niacin present is almost completely unavailable.

It is also fairly high in thiamine, but rather low in riboflavin. It practically has no vitamins A and D (Morrison, 1959). Kent-Jones and Amos (1967) described wheat offal as being essentially the husk of the grain with some adhering endosperm. They stated that wheat offal contains 15.6% protein, 4.5% fat; 61.4% carbohydrate; 12.3% fibre and 6.3% ash. Fetuga (1977) gave the nutrient composition of wheat offal as follows: crude protein 18.2%; crude fibre 15.6% ether extract 4.3%; ash 5.8% and nitrogen free extract as 56.4%. Fetuga (1977) also reported an ME value of 11.09 MJ/kg with range values of 9.71 - 11.89 MJ/kg.

According to Hill and Dansky (1954) because wheat offal is relatively low in available energy and high in fibre content, the chick is able to increase its intake of nutrients to compensate for the low energy, but the chicks ability to increase the amount of bulk ingested is limited physically. However, the chicks capacity to increase the consumption of fibrous feeds is greater for those of high moisture absorbing capacity such as wheat offal (Bell, 1960).

Effects of wheat offals on chicken performance:

Wheat milling by-products namely wheat offal, wheat middlings and wheat shorts have been used as feed ingredients for a long time. Taylor and Lerner (1939) observed that more rapid growth and early sexual maturity were obtained when rations included 15 - 20% wheat offal than when an equivalent amount of whole wheat was used. Fangauf et al. (1956) after evaluating wheat offal and wheat middlings in all mash diets for chicks, concluded that 50% ground grains, with not more than 15% wheat offal or 30% of wheat middlings was sufficient for chick growth.

Wheat offal and middlings as well as the germ meal gave poor feed intake and feed conversion efficiency when used as the sole energy source, though diets were supplemented with vitamins and minerals. Improved values in feed intake and feed conversion efficiency were achieved when ground grains were included (Cave et al., 1965).

Nehring and Uhlemann (1967) related weight gains to the energy content of the diets when evaluating wheat offal with or without fat. Wheat offal alone did not improve gains but 20% offal plus 7% fat gave as good results as the whole ground cereal diets. In another study Ranjhan and Talapatra (1967) cited by Reddy (1975) found that with wheat offal, when used at 95% level as sole feed devoid of grain but containing normal protein, the feed efficiency was significantly lowered as compared to maize containing diets.

Asai and Netko (1971) reported that pullets grew satisfactorily on a diet composed of 60% wheat offal and 30.9% groundnut cake meal when adequately supplemented with minerals and vitamins.

BREWERS DRIED GRAINS (BDG)

This is the main by-products of the brewing industry. It is made up of the dried extracted residue of barley malt alone or in mixture with other cereal grains or grain products resulting from the manufacture of wort or beer and may contain pulverised dried spent hops in an amount not exceeding 3%, evenly distributed (AAFCO, 1976).

Brewers dried grains is considered inedible to the extent that it is not generally usable as food for humans. However, BDG is rich in protein and possesses other nutritive qualities that might make

it an excellent feedstuff for animals.

Nutritive profile of BDG:

The energy content of BDG has been estimated to range between 1800 and 2500 Kcal ME/kg (Harms et al., 1969; Jensen et al., 1976; Gillies, 1978 and Sullivan et al., 1978). Fetuga (1977) reported mean ME value of 11.34 MJ/kg and range values of 10.38 - 12.31 MJ/kg. Ewing (1963) analysed some samples of BDG and found that generally it contains over 20% crude protein, about 6% ether extract, over 15% crude fibre and about 4% ash. Almquist (1972) found that BDG contained 25% crude protein and that is was fairly rich in essential amino acids. The amino acids content is superior to maize or guinea corn used as the major energy source in poultry rations in Nigeria (Ademosun, 1973). Gillies (1978) reported chemical proximate composition of BDG as follows: dry matter 91.9% crude protein 26.4%, crude fibre 15.4%ether 7.1% ash 4.0%. Bafi-Yeboa (1977) stated that BDG is a good source of the B-vitamins. More recent analysis by Deltoro-Lopez et al. (1981) gave the following results, crude protein 28.5%; ether extract 7.5%; crude fibre 11.7%; ash 3.%and NFE 49.2%. Kissell and Prentice (1979) stated that although BDG is spent with respect to starch content, it is actually enriched by a factor of more than two in protein and fibre over the levels of the maize grain. These authors argued that the combination of large continuing supply, relatively low cost, and potential nutritional value makes BDG an attractive feed ingredient for poultry.

Effects of BDG, other brewers by-products on performance of chickens:

Experiments have indicated that BDG can be incorporated into poultry starter and grower mash at levels of up to 10 and 15% respectively without any adverse effects on the performance of the birds (Ademosun, 1974; Jensen, 1981). According to Jensen (1981) growth rate may be stimulated in broilers fed practical diets by the inclusion of as little as 2.5% distillers dried grains with solubles (DDGS). Broiler chicks given a choice between a corn-soybean diet and one containing 10% DDGS consume a greater quantity of the diet with distillers feeds. Several other studies have been conducted to determine the effect of BDG on productive characteristics. Thornton (1962); Kienholz (1964) and Harms et al. (1969) hold the view that it is possible to include 20% BDG in the diet without adversely affecting productive traits. However, Jensen et al. (1976); Eldred et al. (1975) and Damron et al. (1976) did d show that the use of 10% or more BDG caused a decrease in some productive traits. Jensen et al. (1974, 1976) and Damron et al. (1976) however, proved that the negative effects were due to a defficiency of lysine and could be corrected by the addition of this amino acid. Jensen et al. (1974) concluded that if the level of lysine in the diet is not below 0.7%, the included level of BDG would not have negative effects.

Kienholz et al. (1963) reported that a diet containing 40% BDG supported excellent laying performance of caged birds. In a subsequent study, Kienholz et al. (1972) found that birds receiving a diet containing either 20 or 40% BDG produced smaller eggs. When

hens were returned to a control diet containing no BDG, egg size slowly increased.

In an experiment to evaluate BDG and yeast in laying hen diets containing graded levels of sulphur amino acids, Eldred et al. (1975) indicated that the inclusion of up to 10% BDG in the diet is acceptable to the laying hen if the diet formulation is based on the nutrient composition of BDG. Egg production was significantly improved by the addition of BDG to the diets. The BDG treatments significantly reduced body weight when compared to the unsupplemented diets.

In an attempt to gain a better understanding of the effect of BDG on chicken performance, experiments were conducted recently to evaluate BDG in the diets of laying hens. Deltoro Lopez et al. (1981) found that layer diets containing 15 and 30% BDG appeared to be adequate for laying hens, 45% BDG was also acceptable, although the losses of body weight and shell quality suggested that this level should not be used without further research. They also observed a marked decrease in feed intake with birds fed diets containing 60 and 90% BDG. The food intake with 90% BDG was very low. This was accompained with enormous bodyweight losses. They also reported that half of the birds refused to accept the 90% diet and those that accepted it had diarrhoea. Also there was an inhibition of lay during the second week of the experimental period.

Damron et al. (1976) concluded from their experiment that the addition of BDG (up to 10%) to the diet of laying hens resulted in improved interior egg quality. Jensen, Chang and Maurice (1976) similarly reported that the addition of 20% BDG significantly

improved interior egg quality. Jensen et al. (1976) noted that economic evaluation of DDG for layer diets based solely on ME content underestimated its value.

In an article concerning the use of distillers feeds in poultry feeding, Jensen (1981) pointed out that distillers feeds fed to broiler breeder hens appear to contribute a factor which reduces incidence of twisted legs in the offspring and also contain factors which are necessary for normal estrogen metabolism and liver lipid levels in laying hens.

Ferguson et al. (1961) reported that a practical diet containing DDGS, whey, and dehydrated alfalfa meal supported a higher rate of egg production and hatchability than did a complete purified diet. Jensen et al. (1961) found that a mixture of DDGS, dried brewers yeast, and dehydrated alfalfa meal countered the deleterious effects of drugs in the diet of turkey hens. Mauley et al. (1978) in feeding DDGS added to a corn-soy turkey breeder diet reported a higher rate of egg production than did the control diet of corn-soy only. However fertility of eggs were not influenced by the addition of DDGS to the diet. Recent studies at Maryland Experiment Station have indicated that DDGS could be used economically in layer diets. Levels up to 30% were fed in nutritionally-balanced diets. It was found that layers could be fed 10% DDGS as a replacement for 5% corn in a 15.5% crude protein diet. It was pointed out that DDGS is economical for such use when the unit cost of DDGS is less than 1.4 times the unit cost of corn (Waldroup, 1982). Jensen (1981) concluded that distillers feeds can be used effectively in feeds for broilers, broiler breeder hens and laying hens.

METABOLIZABLE ENERGY EFFECTS ON CHICKEN PERFORMANCE

The physiological and physical activities of the bird lead to an energy expenditure. It is therefore convenient to relate this to a dietary requirement in terms of the dietary energy available to the bird. This available dietary energy is conveniently expressed in terms of the metabolizable energy (M.E.) in poultry. This refers specifically to that portion of the dietary energy which is available to the animals for the production of meat and eggs and for the maintenance of body temperature and other vital functions (ARC, 1975). Birds utilize the metabolizable energy for maintenance, growth, fattening and egg production. However, the utilization efficiency of the M.E. above maintenance, for fattening and growth appears to be distinctly influenced by the composition of the diet (De Groote, 1974). Sibbald (1979) indicated that the level of this dietary M.E. determines the minimum levels of inclusion of amino acids and, to a lesser extent, minerals and vitamins in poultry rations. The nutritional usefulness of M.E. in the diet of birds, thus cannot be overemphasized.

It is generally accepted that the chicken tends to adjust its daily consumption of feed so as to maintain an appropriate level of energy within a certain range of intake (Hill, 1956; Wells, 1963 and Morris, 1968; ARC, 1975). However, these authors explained that adjustment is not linear and birds given high energy diets tend to overconsume on energy and deposit additional fat. The primary effect of raising the energy level in poultry ration is to reduce food consumed per kilogram of meat produced (Donaldson et al., 1956 and 1957). The experimental findings of such workers as Sunde (1956); Williamson and Grau (1956) indicated that once a chi-

consumed a sufficient amount of diet to satisfy its energy requirements, increasing the energy level of that diet results in proportionately reduced feed consumption. The studies of Farrell et al. (1973) and Olomu (1976) demonstrated further that food intake of chickens is inversely related to dietary energy concentration. Similar observations on this caloric utilization in relation to chicken performance have been made by other workers. Farrell et al. (1973) reported that there is an optimum energy concentration in the ration beyond which performance of birds does not appear to improve and in some cases does actually deteriorate. However, Donaldson et al. (1956) and Leong et al. (1959) found that feeding diets of higher energy content produced carcasses of higher fat contents. They explained that the chicks appeared to consume energy in excess of normal body requirements, the excess energy being deposited as fat in the carcass.

In recommending the optimum protein and energy levels for broilers in the tropics, Olomu (1976) based this recommendation on three factors namely growth rate, feed conversion efficiency and cost of feed per kilogram liveweight gain. Olomu (1976) concluded that the growth rates of chicks on ration containing 2800 Kcal ME/kg feed were slightly higher than those of chicks on rations containing 3,000 Kcal ME/kg diet. Based on the relative costs of the diets, the ration containing 2,800 Kcal/kg was found to be the cheapest and therefore seemed adequate. Cherry et al. (1977) reported that broilers fed diets containing 3080 Kcal ME/kg of starter diet and 3135 Kcal ME/kg of finisher diets were significantly smaller and required more feed per gain of body weight than broilers fed diets with higher levels of M.E.

The National Research Council (N.R.C., 1971) recommended M.E. level of 3,200 Kcal ME/kg diet while the Agricultural Research Council (A.R.C., 1975) recommends M.E. level of 2,850 Kcal ME/kg for broiler chicks.

It has been postulated that the most efficient nutrition of the chicken is obtained when the diet contains the exact proportion of energy to other nutrients needed to produce the desired growth, egg production or body finish. Scott et al. (1971) indicated that in diets containing adequate amounts of all nutrients, the efficiency of feed utilization depends upon the M.E. content of the diet. Combs (1962) established that as the energy level is raised the protein requirement for best performance also increases. Dietary energy exceeding that needed for normal growth and functioning of the animal is stored as fat since excess M.E. cannot be excreted by the animals body. According to Sugandi et al. (1978), there is a wide-spread opinion that layers which are the result of many generations of selection for high production must have diets of high energy and protein content. Sugandi et al. (1975) observed that egg production was depressed at M.E. of 3050 Kcal/kg while M.E. of 2650 and 2850 Kcal/kg supported adequate egg production in the tropics. Similar results have been reported by Olomu and Offiong (1983) who found that the best M.E. levels for layers in the tropics was about 2400 Kcal/kg diet. Higher energy levels similarly depressed egg production. These results seem to show that M.E. requirements in the tropics are lower than those recommended in the temperate regions of the world.

The value of diet in meeting the needs of an animal, according to Hill (1956) involves two determinants - the concentration of

nutrients that it contains and the amount that the animal consumes. Hill (1956) further stated that the level of voluntary food intake is particularly important in the case of laying birds for which there appears to be a clearly defined homeostatic regulation of intake in terms of energy. Sykes (1972) and Balnave et al. (1978) contended that under ad libitum feeding conditions, the mature laying fowl will consume more energy than is required for body weight maintenance and egg production. According to these workers, this represents an inefficient utilization of energy which would be avoided if intake could be regulated to meet the economic requirements for energy more precisely. However, from a review on restricted feeding during lay, the A.R.C. (1975) indicated that it is possible to restrict the M.E. intake of laying hens by up to 10% ad libitum intake without reducing egg output. Hill (1963) indicated that when chickens are fed well balanced rations which are not limiting in energy concentration, they regulate food intake in accordance with energy needs. Because of this, the gross efficiency of feed conversion is directly related to the energy concentration of the ration. Hill (1963) also stressed that the meat-strain breeding hen tends to become obese when fed a high energy ration.

Environmental temperature and M.E. utilization:

Numerous studies in the literature indicate that the environmental temperature has a marked effect on the utilization of M.E. and hence consequently affects poultry performance. According to Sell et al. (1978) the detrimental effects of heat stress is caused by the physiological response of birds to it. They explained that generally,

the energy requirements of turkeys is inversely proportional to the environmental temperature. Therefore turkeys will eat less as the ambient temperature rises. As the temperature increase up to 27°C, the energy needs will decrease because the birds will then need less energy to keep themselves warm. Boone and Johnston (1978) noted that high temperatures depressed food intake. These workers reported that White Leghorn chickens raised at 35°C consumed 50% less food than those raised at 21.1°C and weighed 20 - 30% less. Similar observations have been made by other workers. Davies et al. (1973) showed that there is a negative linear relationship between energy intake and increase in ambient temperature. Feed intake is adjusted correspondingly so as to maintain energy balance. These workers concluded from their study that the energy available for egg production remained almost constant at 50 Kcal/$kg^{0.75}$/ day equivalent to a rate of egg production of 82% over a temperature range of 7.2°C - 35°C. Leeson et al. (1973) suggested the M.E. requirement be reduced by 9 Kcal per degree centrigrade above thermal neutriality (27°C) that is 4% of maintenance requirement. Dvorak and Bray (1978) reported a significant decrease in feed intake as the temperature was raised from 7.2°C - 23.9°C using chicks. At the lower temperature the chicks attempted to eat enough to meet their energy demands for both growth and body temperature maintenance. Dvorak and Bray (1978) further observed that the increased energy requirements for body temperature maintenance resulted in a greater use of the basal nutrients for heat production. de Andrade et al. (1977) reported correlations between temperature and egg production.

They indicated that egg production is adversely affected by high environmental temperatures. They also observed a decrease in food consumption, rate of egg production, egg weight and egg shell thickness while feed efficiency was improved when temperatures were elevated above the zone of thermoneutrality. Douglas and Harms (1976a and 1976b) explained that the reduction in egg size with increase in ambient temperature is due to the fact that the hen does not consume enough feed to meet her energy requirements in hot weather. They advocated the use of fat in layer rations to stimulate feed intake for increased egg size. Sell et al. (1978) found that the additional ME consumed by hens fed fat containing diets was used for gaining weight and only increased the productivity of eggs where the initial ME consumption was inadequate. Sell et al. (1979) recommended the use of fats where temperatures are often 30°C and above.

Anderson et al. (1957) indicated that during hot weather, egg shell thickness and specific gravity decrease when chickens were fed high energy diets. It has been shown that a temperature of about 32°C tends to reduce feed intake of poultry by about one-third. Mueller (1962) showed that layers kept constantly under high environmental temperatures (32°C) produced less eggs with thinner shells and lower weight than the controls kept at constantly 18°C. Thormann (1966) explained that since heat increases the bird's thirst and reduces feed intake by 20% or more, there is less protein available for egg production.

Smith (1971) working with laying hens reported that there was a reduction in appetite as the temperature rises from 21.1 – 26.7°C

and from 32.2 – 37.8°C. This reduction was estimated to be 0.8% and 4.0% respectively.

In a study with laying hens under two different temperature conditions, that is 21°C and 32.2°C, Reid (1979) observed a decrease in feed intake when the temperature was raised from 25°C to 35°C. Reid (1979) concluded that generally the main effect of the environmental temperature is a reduction in feed intake and consequently a reduction in energy consumption above maintenance which is not sufficient to maintain a high rate of producitivity. Reid (1979) further suggested that the effect of environmental temperature can be reduced by increasing the bird population at lower temperatures, and housing fewer numbers of birds at higher temperatures so as to reduce the total heat load. It has been postulated that when prevailing temperatures rise above the thermoneutral zone, a reduction in feed intake and subsequently energy intake are observed (Dale and Fuller, 1978). This is normally followed by a decline in growth rate. These authors further indicated that in poultry nutrition, energy is the most limiting factor for egg production at higher temperatures. According to them, an energy deficiency during heat stress could be caused by reduced feed intake resulting in turn from the discomfort of dietary heat increment.. They pointed out that a reduction in heat increment of the diet will increase the amount of energy available to the bird, first by increasing the net energy in relation to ME intake. They suggested the addition of dietary fat in reducing the heat increment of the diet due to its associative dynamic effect. The use of fat has the additional

advantage of increasing energy density of the diet. This means less feed could be consumed to meet the energy requirements.

The foregoing remarks suggest that in the tropics, management practices should be geared towards improving feed consumption and reducing heat load to ensure optimum performance of the birds. This could be achieved by harnessing the beneficial effects of fat supplementation (depending on cost) in our poultry feeds and using energy diluents such as wheat offal and BDG in partial replacement of cereal grains to meet this goal.

SUPPLEMENTATION OF DIETARY FAT ON METABOLIZABLE ENERGY UTILIZATION IN CHICKEN RATION.

A number of workers have recognised the beneficial influence of supplemental fats on the physical characteristics of rations (Dam et al. 1959; Treat et al. 1960). These workers concluded that fats could be used successfully to increase caloric density of rations and thereby, improve efficiency of feed utilization. Fuller (1979) documented that the use of fat in feeds increases the energetic efficiency through its increased energy density and its lower heat increment or greater net energy per caloric of metabolisable energy. Fuller's work demonstrated that fats have the greatest sparing effect of all the nutrients on the expense of energy utilization of the total diet. In making a general assessment of available data, Sell (1979) concluded that dietary fat exerts beneficial effects on efficiency of poultry production in four ways (a) by improving physical consistency of feed (b) by increasing the caloric density of the diet (c) by increasing the birds ability to derive useful energy from the diet and (d) by increasing the metabolic efficiency of energy utilization.

Carew and Hill (1964) demonstrated that replacement of dietary carbohydrate with corn oil increases the metabolic efficiency of energy utilization by chicks. Based upon this and other reports in the literature, Carew and Hill (1964) suggested that the beneficial effect of corn oil on efficiency of energy metabolism is mediated through the heat increment component rather than basal component of heat production. Sell and Thompson (1965) reported improvements in feed efficiency of broiler chicks as a result of using 5 or 10% dietary animal tallow. They also observed that the efficiency of conversion of ME to carcass energy was increased by the tallow. In their experiment to find the effects of varying dietary energy levels by supplementation with palm oil in starter diets, Oluyemi and Oyenuga (1974) reported that palm oil supplementation of chick diet improved the rate of growth of the chicks and tended to improve metabolizable energy and nitrogen retention of the diet and livability of the chicks. Similar observations were made by Vermeersch and Vanschoubroek (1968). They indicated that the supplementation of chick diet with palm oil exerts beneficial effects on the efficiency of feed utilization, growth rate of the chicks, the digestibility of the dietary lipid and the livability of the chicks. Palm oil increases the palatability of the diet, the caloric density of the diet and is rich in the B-carotene which is readily converted to Vitamin A (Ogunmodede and Ogunlela, 1970). They further explained that palm oil is rich in linoleic acid, an essential fatty acid. This according to them represents 7% of the total fatty acids in palm oil. Fuller and Rendon

(1977) investigated the energy utilization of 4 and 5 week old broiler chicks through to 7 and 8 weeks, respectively, when fed various fats at 10 and 20% of the diet. Caloric efficiency was found to be better with fat supplementation than without it; however, the heat increment was greater when the 20% fat diets were consumed than observed with birds fed the 10% level.

The available energy content of fats fed in poultry rations depends on a number of factors. According to Sklan (1979) the purity of the fat is important since water unsaponifiables and other impurities contain little or no available energy. Sklan (1979) further explained that the composition and structure of a fat determines its potential ME content. The amount of glycerol in the fat and proportion of glycerides affect lipid digestion and absorption.

The lenghts of the fatty acid chains and their saturation also affect ME values (Renner and Hill, 1961a; Young, 1961). The positions of the fatty acids on the glycerol molecule are also important (Renner and Hill, 1961b). Long chain saturated fatty acids in the '2' positions of the glycerol moeity are better utilised than those in the '1' and '3' positions. This according to Sibbald (1978) explains why lard usually has a higher ME value than tallow even though the fatty acid profiles are similar.

Horani and Sell (1977) showed that the most consistent effects of supplemental fats on ration ME occured when the energy source was used at 4 to 6% of corn based, laying rations. They concluded that, if the entire increase in measured M.E.'s due to added fat

were attributed to fat per se, then the apparent ME of fat would approach or exceed its gross energy value of 9200 or 9300 kcal/kg.

Boll et al. (1978) indicated that the "extra" ME consumed by hens fed fat containing rations was used primarily for gain in body fat, and stimulated true productivity (eggs) only when ME consumption was otherwise inadequate.

Working with turkey poults, Moran (1978) observed that feed efficiency and/or weight gain not only responded to caloric protein ratio and fat content of starting feed but exhibited a highly significant interaction to both. Carcass finish, on the other hand, only changed with the caloric contribution by fat. Moran (1978) argued that early performance more reflected the physical nature of the feed due to its extensive fat and fibre changes than possible effects on bird metabolism.

Evidence from available literature thus indicate that supplementation of poultry ration with fat is beneficial, particularly when the energy concentration of the ration is below optimum. It therefore follows that when a product such as wheat offal and BDG are used in place of grains, and the energy of the ration appears lower than the optimum, supplementation of such a ration with fat may be useful. Palm oil is one of such fat products that have been used in poultry rations.

FIBRE IN THE DIET OF THE CHICKEN

Crude fibre has been defined as that portion of a foodstuff that is insoluble, less digestible and ash-free and which remains after rigorous boiling with dilute alkali and then with dilute acid (Lloyd et al., 1978; Feltwell and Fox, 1978; Cullison, 1979). It

consists primarily of cellulose, hemicellulose and lignin which are known to be almost valueless nutritionally to poultry. According to Mitchell (1964), cellulose is a carbohydrate, a polymer of D-glucose while lignin which has not been obtained in crystalline form consists of phenyl-propanoid building units and is not a carbohydrate.

In feeding poultry and livestock, it is important to know the fibre content of the various feed since fibers of different origin are often quite different nutritionally. Very fibrous foods are normally too fluffy and carry a low proportion of nutrients per unit volume rather than per unit weight (Feltwell and Fox, 1978) and this is a problem which affects intake. In compiling the digestibility of fibre from different sources, Crampton and Harris (1968) indicated that although fibres from wheat shorts and wheat offal are presumably the same material, digestibility ranges from 53 - 90%. Similarly digestibility for oats, oat chippings, rolled oats and oat hulls ranges from 38 - 80%. These same authors reported the digestibility of the fibre of corn grain as 57% but that of corn bran, corn gluten, corn oil meal and corn distillers grains as ranging between 72 and 90% with an average value of 80%. These figures were obtained from experiments using ruminants. Since species differ in the extent to which they can digest fibre and since the digestibility is not the same even among individuals of a species, the above figures will differ in the case of the monogastric animal. In fact the figures will be considerably lower in the case of the monogastrics since their microfloral population is smaller in

number and composition. Crampton and Harris (1968) further contended that the unprocessed fibre of seeds which in their natural state is an outer protective coating of the seed is relatively resistant to bacterial attack. But in the milling or wet processing of such seeds, some of these coatings may be partially disintegrated or dissolved, thus exposing the cellulose to easy attack by microorganisms of the digestive system. Albanese (1963) stated that although monogastric animals do not have the necessary enzymes for degrading cellulose, nevertheless in some instances a considerable amount of the cellulose may be utilised. Albanese (1963) explained that in cases like this, bacteria present in the intestines have cellulases capable of degrading cellulose. Lloyd et al. (1978) described the digestibility of crude fibre by various species of animals as follows:

Species	Where digested	% Digested
Ruminants	Rumen, colon	50 - 90
Pig	Caecum, colon	3 - 25
Rabbit	Caecum	16 - 18
Guinea pig	Caecum	34 - 40
Human	Small & large intestines	25 - 35
Poultry	Caeca	20 - 30

According to Fetuga (1977), differences in available or utilizable energy contents of different feed materials are due essentially to radical differences in their chemical composition, particularly such fractions as fat, nitrogen free extract and crude fibre. The greatest differences tend to result from differences in the absolute contents as well as chemical components of the fibre

fraction. Fetuga (1977) explained that cellulose, hemicellulose and lignin are usually regarded as being unavailable to monogastric animals.

Bulkiness:

Crude fibre is known to give bulk to feeds. King (1961) statedthat fibre aids digestion because its bulk stimulates peristalsis and secretion and opens up concentrated foods so that digestive juices can come in closer contact with them. Bulk is also considered important from the standpoint that it increases the surface area of the feed particles in the digestive tract. This increase in surface area of feed particles can be accomplished for the tract by feeding high levels of indigestible material such as crude fibre. Deaton et al. (1979) increased the dietary fibre content of a layer diet by substituting a high fibre sunflower meal for soybean meal. They reported significant increases in gizzard weight and intestinal lengths. However, the efficiency of feed conversion was reduced but egg production, egg weight, shell breaking strength and mortality were not affected. The influence of bulk in promoting the elimination of feed residues is essentially based on the laxative properties of the fibre. Feeds high in crude fibre which are high in fatty acid content or has a high water holding capacity are the most laxative (Lloyd et al., 1978).

Apart from these beneficial effects provided by the bulkiness of crude fibre it is also know that food intake by both humans and animals is limited by bulk. When crude fibre is present in high concentrations in the diet, it limits the weight of food eaten by the

bird and thereby imposes a physical limitation upon the intake of digestible nutrients. Rations high in fibre restrict energy intake due to the low energy density of roughages. Also high fibre ration have a relatively high heat increment and therefore contribute to heat stress in a warm climate. This is known to have affected the performance of broiler chicks in the tropics (Stanley and Ishizaki, 1982). High crude fibre contents of diets may lower poultry production. This might be due to the fact that the higher level of crude fibre is associated with a depression in the feeding value. Fibre contributes little, if any, digestible nutrient and also makes other nutrients less available (Ewing, 1963). Food intake is important in profitable poultry production. This is influenced in part by such mechanical considerations as acceptability and bulk or volume of the ration in relation to the nutrients supplied.

According to Ewing (1963) Oklahoma Agricultural Experiment Station workers started experimenting on the fibre requirements of chicken as early as 1930. Their findings indicate that although the general opinion of poultrymen and poultry manufacturers is that the fibre content of the ration should be kept below 7%, the results of their work demonstrated that the amount of fibre in the ration can be increased to 8 or 9% with desirable effects on chick growth, mortality, feed consumption and egg production.

In their study to investigate the effect of different crude fibre levels on the growth and performance of Baladi White chicks up to 20 weeks of age, El-Abbady et al. (1970) found out that male Baladi white chicks could tolerate crude fibre levels up to 12% and female Baladi White chicks up to 4% although the level could be

increased to 7% in females until the age of 8 weeks without any detrimental effect on either mortality or body weight. However, when the male Baladi white chicks were put on a diet of 17% crude fibre. there was a depression in growth rate, feed consumption and mortality rate increased. They therefore concluded that the effect of fibre on the growth of chicks may be quite detrimental depending on the quantity of the fibrous material used in the diet.

The effects of including high levels of fibre in the rations of growing chicken have also been investigated by many workers (Isaachs et al. 1961; Lillie and Denton, 1966). Their work included the dilution of the ration by the addition of high levels of fibre. These workers observed that the use of high levels of fibre during the growing period delayed sexual maturity and reduced body weight at maturity. In another study, Waldroup et al. (1966) fed a 15% fibre and 12% protein diet to broiler breeder pullets during the growing period but observed no significant effects on performance of such stock during the laying period. Work by Kondra, Sell and Guenter (1974) indicated that there is a significant reduction in feed consumed by both meat type strains and egg strain birds when fed high fibre diets but the decrease was greater in the meat strain. Kondra et al. (1974) also observed corresponding decrease in weight gains. They explained that the corresponding weight gain differences between meat strain birds and egg type birds is due to inherent more rapid growth and ultimate body size of the meat strain. On the contrary Waldroup et al. (1976) have shown that feeds of high fibre content encourage feed intake and consequent gain in body weight. Cowlishaw and Eyles (1958) found

that the hen fed high fibre diets compensated for the low ME intake - reduced weight gain.

Dymsza et al. (1957) observed good growth of turkey poults fed mash diets containing 5 - 10% crude fibre. When pelleted diets were used, good growth was obtained on rations containing 5 - 20% crude fibre. Omar et al. (1970) concluded that white Austrian turkey poults can tolerate up to 9% crude fibre in their rations till they are 18 weeks of age without any adverse effect on growth and mortality rate. These authors also indicated that male poults can go on this crude fibre level (9%) up to 24 weeks of age.

Inference from the literature indicate that meat - type strain birds are able to handle high fibre diets better than egg-type strains during the growing period. But during the laying period. layers can be fed more fibre. Crude fibre not only has a low value in itself but is usually accompanied by other materials which also have low feeding values. Ewing (1963) gave an example of this property with rice bran. According to him crude fibre above a certain minimum in rice bran or rice polish, comes from rice hulls which almost totally is indigestible.

Various reports exist in the literature on the efficiency with which low energy diets are utilized by the fowl. Scott (1974) suggested, without any cited experimental evidence though, that in a hot climate, a metabolizable energy level as low as 2400 kcal/kg diet could be consumed in adequate amounts to permit hens to lay at a satisfactory rate. In recent times the practice has been the us

of high fibre feedstuffs as energy diluents in poultry rations. Wheat offal and BDG are examples of such feedstuffs. If these energy saving methods which are still in their experimental stages, prove successful, it will probably facilitate the formation of low energy rations that will give maximum returns for feed cost since feed represent the greatest single cost factor in poultry production.

EXPERIMENTS.

SECTION I

METABOLIZABLE ENERGY STUDIES

Objectives:

The purpose of this study was to determine the ME values of wheat offals and BDG using broiler chickens as the experimental birds.

Status of the problem:

Since the studies were intended to evaluate the suitability of wheat offals and BDG as partial or complete substitutes for maize, it became necessary to determine the metabolizable energy values of wheat offals and BDG. Besides, there are no recent published energy values in Nigeria for these ingredients.

Experimental:

The ME values of both wheat offals and BDG were determined with 5 week-old Shavers Starbro broiler chickens, using the total collection method at one level (20%) of ingredient substitution. The birds used for the studies were divided into groups of 15 birds per group. Three such groups were placed on each treatment and were managed in battery metabolism cages equipped with dropping pans.

To determine the ME of the ingredients, a basal ration devoid of both wheat offals and BDG and corresponding to Ration1 on Table 4 was employed. Ingredient substitution was at the expense of the basal ration. Thus the experimental rations consisted of the basal and the ingredient rations consisting of 80% basal and 20% ingredient. To acclamatize the birds to the battery brooders, they were maintained on the basal ration for five days and then for two days on their respective rations. They were then starved overnight and

fed the following day and excreta voided quantitatively collected for 3 days at 24 hours interval.

Feed and water were provided ad libitum during the collection period. The feed was maintained at low levels in the feed-troughs to minimise spillage. The feed for each group was weighed at the start and end of the collection period. The difference was taken as the feed consumed.

On each day of collection, the excreta was blown free of feathers and other debris before collection. It was then weighed and oven dried at 105°C for 72 hours then re-weighed. The 3 days collection for each replicate were bulked and then finely ground. The dried ground excreta and feed samples were assayed for nitrogen using the AOAC (1975) methods. Gross energy values were determined with the aid of an adiabatic automatic oxygen bomb calorimeter. The apparent metabolizable energy (AME) of the rations were calculated using the following equation.

$$\text{AME/g of feed} = \frac{(F_i \times GE_f) - (E \times GE_o)}{F_i}$$

where F_i = Feed intake (g)
E = Excreta output (g)
GE_f = Gross energy of feed (kcal/g)
GE_o = Gross energy of excreta (kcal/g)

A correction was made for nitrogen retained in the body. Since body nitrogen, when catabolised, is excreted as energy containing products, it is desirable to bring AME data to a basis of nitrogen equilibrium (Sibbald, 1979). Nitrogen corrected apparent metabolizable energy (AME_n) was thus calculated from the equation:

AME_n = Classical ME - 8.22(gN/g feed - gN/g faeces) given by Hill and Anderson (1958).

From the ME of the basal ration and the substituted rations, the ME of the feed ingredients was calculated by simple algebraic equations, an example of which is shown below.

If the ME of the basal ration (x) determined in this study was a kcal/kg and that of the 20% substituted wheat offal ration (y) b kcal/kg, the algebraic equations may be stated as follows:

Taking the ME of the basal ration

$$100x = a \text{ kcal}$$

$$x = \frac{a}{100} \text{ kcal}$$

$$800x + 20y = b \text{ kcal}$$

$$80\left(\frac{a}{100}\right) + 20y = b \text{ kcal}$$

$$\frac{80a}{100} + 20y = b \text{ kcal}$$

$$0.8a + 20y = b \text{ kcal}$$

$$y = \frac{b - 0.8a}{20}$$

$$100y = \left(\frac{b - 0.8a}{20}\right) 100$$

Results and Discussion:

The gross energy (G.E.), classical M.E. and M.E. corrected to nitrogen equilibrium ($M.E._n$) with their corresponding efficiency of utilization values are shown in Table I. The metabolizable energy and metabolizable energy corrected to nitrogen equilibrium values for wheat offal and BDG are given in Table 2.

The classical M.E. and ME_n values for wheat offal were 1201.55 kcal/kg and 1117.05 kcal ME/kg respectively. Those of BDG were 1743.95 kcal ME/kg and 1664.90 kcal ME/kg respectively. These values fell within the ranges reported in the literature for both wheat offal

TABLE I: Gross Energy, Classical ME, ME_n and Efficiency of Energy utilization values

Dietary Treatments	Gross Energy kcal/kg	Classical ME kcal/kg	ME_n kcal/kg.	Efficiency of utilization (%) (classical) [1]	Efficiency of utilization (ME_n) (%) [1]
Basal ration (BR)	3984.35	2899.89	2784.47	72.78	69.89
80% BR + 20% wheat offal	3817.57	2560.22	2450.99	67.06	64.20
80% BR + 20% BDG	3895.39	2668.70	2560.56	68.51	65.73

[1] Efficiency of Energy utilization (%) = $\frac{ME \text{ or } ME_n}{GE} \times 100$

TABLE 2: Metabolizable Energy Values of wheat offal and BDG

Ingredient	Classical ME kcal/kg.	ME_n kcal/kg
Wheat offal	1201.55	1117.05
Brewers dried grains	1743.95	1664.90

and BDG. Brewers' dried grains had the higher ME and ME_n values of the two ingredients. Sibbald (1979) observed that proponents of the nitrogen correction argue that body nitrogen, when catabolised, is excreted as energy containing products and that it is desirable to bring classical M.E. data to a basis of nitrogen equilibrium. Leeson et al. (1977) also found that ME values were influenced by the protein content of the basal diet and that correction for nitrogen retention decreased the differences. However the need for nitrogen correction has been questioned (Baldini, 1961 . cited by Sibbald, 1979, Sibbald and Slinger, 1963). Sibbald and Slinger (1963) indicated that since the correction does little to improve the usefulness of the classical ME values, the additional work involved in measuring nitrogen retention was not justified.

The efficiency of utilization of G.E. as M.E. or $M.E_n$ was slightly higher for BDG based diets than for that of the wheat offal based diets. The values obtained in this study (Table I) were higher than those reported by Fetuga (1977). This may be due to the breed of birds (White Leghorn chicks) used in this study and their ability to handle diets of high fibre contents. Brewers' dried grains and wheat offal are known to have fairly high contents of crude fibre (Table 3). Crude fibre is known to lower the efficiency of utilization of metabolizable energy (Ewing, 1963 and Boonker et al. 1969). In the subsequent studies with broilers, body weight gain and feed efficiency followed the trends of metabolizable energy values of the tested diets. The performance of the birds tended to be better for the rations which contained wheat offals which was lower

in fibre content than for the rations which contained BDG with fairly high crude fibre content. Fetuga (1977) explained that the greatest differences in available or utilizable energy contents of different feed materials tend to result from differences in the absolute contents as well as chemical components of the fibre fraction. Longe and Olomilua (1977) also explained that wheat offal contains about 19% of digestible carbohydrate expressed as glucose as compared to about 8% of that of BDG. Therefore, the wheat offal might have contributed appreciably more to the metabolizable energy of the diet.

SECTION 2

EXPERIMENTS WITH BROILER CHICKENS

Objectives:

To determine the extent to which wheat offals and BDG can replace maize in broiler chicken rations.

To determine economics of replacing maize with wheat offals and BDG.

Status of the problem:

As earlier mentioned, there is stiff competition between human population and the poultry industry for cereal grains. These cereal grains form the main sources of energy in poultry rations. Determining how far cereal grains can be replaced by agro-industrial by-products such as wheat offals and BDG in poultry rations is therefore not only going to be beneficial to the feed miller and poultry farmer, but also to the researcher in search of suitable substitute for cereal grains. The cheapness of these agro-industrial by-products and the ease with which they can be procured (as long as the brewing and milling industries exist) relative to maize, guinea corn or millet, make their assessment as alternatives to cereal grains worthwhile.

The trials carried out in these studies are reported in two parts:

A. The replacement values of wheat offals and BDG for maize in broiler starter rations (0 - 5 weeks).

B. Extent of replacement of maize grains with wheat offals and BDG in practical rations for broiler finishers (6 - 9 weeks).

EXPERIMENTAL - GENERAL

(i) LOCATION: Shika is located 22 kilometers northwest of Zaria along the Zaria - Sokoto road. It lies within the Northern Guinea Savannah Zone of Kaduna State at latitude 11°15'N and longitude 7°32'E and at an altitude of 609.6m (2000 ft) (Keay, 1959). It has a monsoonal climate. Annual rainfall varies from 800mm to 1,300mm (43.86 inches) and the long term average is 1100mm, most of which falls from late April to early October. The station occupies 1,150 hectares of land and is located in the Galmaplains, named after the river Galma, of which the Shika river is a minor tributary.

(ii) Chicks: The birds used in these experiments were Shaver Starbro broiler chicks purchased from a local hatchery at day-old. The chicks were randomly alloted to triplicate treatment pens in batches of forty (40) birds per replicate at the beginning of each trial. Three such replicates were assigned a dietary treatment. The weights of all replicates were equalised on the basis of average chicken weight to within 0.5 gram. In all the broiler experiments, the birds were weighed and food consumption was recorded at weekly intervals. A daily record of mortality was kept.

In all, four trials were conducted; two with starting broiler chickens (0-5 weeks), and two trials with finishing broiler chickens (6-9 weeks).

(iii) Management of brids: The birds were managed in floor pens (3.05 x 1.22m/pen) covered with wood shavings as litter material and in open sided poultry houses. During the first 4 weeks, they were provided with brooders with kerosene lanterns serving as the heat

source and wooden brooder boxes measuring 0.914 x 0.914m (3' x 3'). The sides of the building were covered up with plastic sheets to reduce draught and conserve heat during the first 4 weeks of life of the birds.

(iv) Wheat offals and BDG: The wheat offals used in these studies was obtained from Northern Nigeria Flour Mills, Kano. The BDG came from Guinness (Nig.) Ltd., Benin City.

(v) Feeds: All diets were isonitrogenous, but not isocaloric for each trial. Diets were formulated to meet a standard 23% crude protein for starter rations, and 20% crude protein for broiler finishers in accordance with the recommendations of Olomu (1976, 1978) as well as Olomu and Offiong (1980). Both wheat offals and BDG were added principally at the expense of maize. However, to maintain similar level of protein, the percentage of soyabean meal was adjusted. Because of the higher content of total phosphorus in wheat offal and BDG, the percent total phosphorus increased slightly with increase in level of wheat offal and BDG in the ration. The ingredients were analysed for their proximate chemical composition using the methods of AOAC (1975). The gross chemical composition of the ingredients is given in Table 3.

(vi) Data analysis: The data collected in the trials were subjected to analysis of variance and significance of differences between means assessed by using the Duncan's Multiple Range Test at the 5% level of significance (Steel and Torie, 1960). Details of analyses of variance are presented in appendix 2.

(A) The effects of Replacing Maize with Wheat offals and BDG in Broilers Starter Rations

Trial 1

Objective:

To determine how far wheat offals and BDG can replace maize grains in broiler starter rations.

TABLE 3: Proximate chemical Composition of the major ingredients used in ration formulation (% Airdry basis)

Ingredients	Dry Matter	Crude Protein	Ether Extract	Crude Fibre	Ash	Ca.	P
Maize	92.05	8.57	3.65	2.19	1.67	0.03	0.27
Wheat offal	94.84	17.55	3.82	10.41	5.41	0.17	1.09
Brewers' dried grains	93.02	18.69	6.10	16.95	2.77	0.35	0.48
Soybean meal	94.07	44.27	12.93	6.78	5.12	0.44	0.60
Groundnut cake	93.05	46.18	6.42	5.63	5.42	0.16	0.63
Bone meal	98.40	2.34	0.01	2.14	89.34	34.88	15.97
Periwinkle Shell	98.30	6.54	0.09	2.30	84.50	37.01	0.04

NELSON, 1984

Experimental:

One thousand and eighty (1080) day old Shaver Starbro broiler chicks were alloted to similar groups (replicates) of 40 birds per replicate. Three replicates were alloted to each of nine treatments. The nine experimental rations contained graded levels of wheat offals and BDG. Fifty percent of the total content of the maize was removed at each step of replacement. This was replaced with either wheat offals or BDG in the rations. In addition, the effects of adding palm oil to a partially (50% substitution) or wholly substituted maize rations were studied. The rations were fed from day old to 5 weeks of age.

The birds were managed as described under EXPERIMENTAL - GENERAL above. The parameters measured were weight gain, feed intake, efficiency of feed conversion, feed cost per kilogram gain and mortality.

The composition of the rations is given in Table 4.

Results:

The results obtained in Trial 1 are summarised in Table 5.

The replacement of 50% maize in the ration with wheat offal significantly depressed weight gain (Treatment 1 vs 2). The adition of 5% palm oil to the wheat offal based ration (Treatment 4) corrected this depression. Food intake and food officiency were not significantly changed by the replacement of 50% of the maize by wheat offal. Complete replacement of maize in the ration led to further significant depression in weight gain. Although addition of 5% palm oil to the completely replaced maize ration improved weight gain, the weight gain obtained

TABLE 4

Percentage composition of starter rations (Trial 1).

	RATIONS								
Ingredients	1	2	3	4	5	6	7	8	9
Maize	54.40	27.20	-	27.20	-	27.20	-	27.20	-
Soybean meal	41.95	33.25	25.00	36.50	27.75	30.00	17.50	33.65	21.35
Wheat offal	-	35.90	71.35	27.65	63.60	-	-	-	-
Brewers dried grains	-	-	-	-	-	39.15	78.85	30.50	70.00
Palm oil	-	-	-	5.00	5.00	-	-	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated nutrient levels									
Crude protein (%)	23.14	23.11	23.20	23.13	23.09	23.17	23.08	23.10	23.04
M.E. Kcal/kg ration	2844.93	2076.38	1313.10	2461.48	1692.35	2302.19	1756.72	2633.68	2089.21
Calcium (%)	1.20	1.20	1.21	1.20	1.21	1.27	1.35	1.26	1.33
Total phosphorus (%)	0.95	1.25	1.56	1.18	1.48	1.01	1.06	0.98	1.04
Crude fibre (%)	4.10	6.65	9.19	6.01	8.57	9.33	14.62	8.11	13.38
Lysine	1.80	1.69	1.61	1.75	1.64	1.57	1.33	1.64	1.41
Methionine	0.56	0.53	0.51	0.54	0.51	0.55	0.54	0.55	0.54

[1]Premix supplied per kilogram ration: vitamin A, 13,340 I.U.; vitamin D_3, 2680 I.U., vitamin E, 10 I.U. Vitamin K. 2.68mg; vitamin B_2 6.0mg; vitamin B_6, 4.0mg; nicotinic acid, 33.34mg; calcium d - pantothenate, 10.68mg; vitamin B_{12}, 0.02mg; folic acid, 0.668mg; choline chloride, 400mg; chlortetracycline, 26.68mg; 3,5 - dinitro-ortho-toluamide, 166.68mg; manganese, 133.34mg; iron, 66.68mg; zinc, 53.34mg; copper 3.2mg; iodine, 1.868mg, cobalt, 0.268mg; selenium, 0.106mg

was still significantly less than that of the control ration (Treatment 5 vs 1). Feed intake was not significantly depressed while feed efficiency was significantly depressed by the complete replacement of maize in the ration.

The weight gain, feed intake and feed efficiency of birds fed rations with brewers dried grains were significantly less than those of birds on the control ration (Treatments 6 to 9 vs 1). The addition of 5% palm oil to the rations led to slight improvement in performance of the birds. Mortality was significantly influenced by dietary treatments. The highest mortality rate was observed with the ration containing the 100% replacement of maize with BDG. There was no post-mortem examination carried out on the dead chickens. Feed cost per kilogram liveweight gain was least for the diet containing 100% wheat offal replacement of maize (Treatment 3) which was not significantly different from the feed cost per kilogram liveweight gain at 50% replacement with wheat offal and BDG respectively (Treatments 2 & 6). Feed cost per kilogram liveweight gain was significantly increased by 100% replacement of maize with BDG and 100% replacement of maize with BDG plus 5% supplementation with palm oil.

Summary:

A trial was conducted with broiler chicks, 0 - 5 weeks old to assess the effects of replacing 50 or 100% of the maize in chicken broiler rations with wheat offal or brewers dried grains.

Results indicated that:

1. The replacement of 50% maize in the ration with wheat offal significantly depressed weight gain.

TABLE 5

Effects of different levels of wheat offals (W.O) and BDG on the performance of broiler chickens (0–5 weeks)

Ration NO.	Dietary Treatment	Total Weight Gain (g)	Total Feed Intake (g)	EFC[2] (g feed)/(g gain)	Feed Cost/ kg Gain (₦)	Mortality (%)
1	54.4% maize, no BDG & W.O.	731.79[a]	1610.13[a]	2.20[c]	0.67[cd]	1.67[bc]
2	27.2% maize + 35.90% W.O.	600.00[b]	1593.00[a]	2.66[de]	0.62[de]	0.00[c]
3	No maize, 71.35% W.O.	452.54[e]	1522.81[ab]	3.37[c]	0.55[e]	3.33[bc]
4	27.2% maize + 27.65 W.O. + 5% palm oil	703.61[a]	1645.78[a]	2.34[de]	0.71[bc]	1.67[bc]
5	No maize, 63.60% W.O. + 5% palm oil	570.05[bc]	1601.60[a]	2.81[d]	0.65[cd]	5.83[b]
6	27.20% maize + 39.15BDG	504.68[d]	1405.42[b]	2.78[d]	0.62[de]	2.50[bc]
7	No maize, 78.85% BDG	165.83[g]	1047.21[c]	6.35[a]	0.90[a]	19.17[a]
8	27.20% maize + 30.50% BDG + 5% palm oil	544.19[cd]	1408.19[b]	2.59[de]	0.76[b]	1.67[bc]
9	No maize, 70.00% BDG + 5% palm oil	228.35[f]	1027.45[c]	4.51[b]	0.96[a]	4.17[bc]
	SEM[3]	35.99	45. 30	0.25	0.03	1.13

[1]Means within the same column with different superscript are significantly different ($P < 0.05$)

[2]EFC = Efficiency of feed conversion

[3]SEM = Standard error of the mean.

2. Complete replacement of maize in the ration with wheat offal also depressed weight gain.
3. The BDG based diets significantly depressed weight gain, feed intake and efficiency of feed conversion.
4. The addition of 5% palm oil to either the wheat offal or BDG based diets improved the performance of the birds.
5. Complete replacement of maize in the ration with BDG significantly increased feed cost per kilogram liveweight gain.

Trial 2

Objective:

To further assess the replacement of maize grains with wheat offals or brewers dried grains in broiler starter rations. This study became necessary because of the poor performance of broiler chickens fed rations with complete replacement of the maize grain with either wheat offal or BDG in trial 1. Broiler chicknes fed BDG based rations at 50% substitution level of the maize did not also perform well. It was therefore decided to further evaluate wheat offal and BDG not beyond 75% and 50% levels of replacement of maize in broiler starter rations respectively.

Experimental:

One thousand and eighty Shaver Starbro broiler chicks were used in this trial. They were alloted to nine experimental rations in triplicate batches of forty birds each. Experimental diets were formulated to contain similar levels of protein by adjusting the percentage of soybean meal in each ration. The control birds were fed a ration containing 54.5% maize as part of the ration. Wheat offals replaced 50 and 75% of the maize in the wheat offal based rations, while BDG replaced 25 and 50% of the maize in the BDG based rations. In other words, in a ration where 50% of the total maize was removed, which was equivalent to 27.20% maize in the ration, 35.90% wheat offals and 39.15% BDG were added to the rations respectively. The rations containing 50% replacement and 50% plus 5% palm oil respectively were similar to those used in trial 1 (Table 4) and are equivalent to treatments 2, 4, 6 and 8 in Table 6.

Birds were managed as already described under the section on EXPERIMENTAL - GENERAL.

TABLE 6

Percentage composition of starter rations (Trial 2)

	RATIONS								
Ingredients	1	2	3	4	5	6	7	8	9
Maize	54.40	27.20	13.60	27.20	13.60	27.20	40.80	27.20	40.80
Soybean meal	41.95	33.25	28.60	36.50	31.75	30.00	35.85	33.65	39.80
Wheat offal	-	35.90	54.15	27.65	46.00	-	-	-	-
Brewers dried grains	-	-	-	-	-	39.15	19.70	30.50	10.75
Palm oil	-	-	-	5.00	5.00	-	-	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated nutrient analysis									
Crude protein (%)	23.14	23.11	23.01	23.13	23.01	23.17	23.12	23.10	23.12
M.E. Kcal/kg ration	2844.93	2076.38	1688.59	2461.48	2072.53	2302.19	2572.94	2633.68	2905.92
Calcium (%)	1.20	1.20	1.31	1.20	1.21	1.27	1.23	1.26	1.22
Total phosphorus (%)	0.95	1.25	1.41	1.18	1.33	1.01	0.98	0.98	0.96
Crude fibre (%)	4.10	6.65	7.94	6.01	7.30	9.33	6.73	8.11	5.48
Lysine	1.80	1.69	1.63	1.75	1.68	1.57	1.68	1.64	1.76
Methionine	0.56	0.53	0.52	0.54	0.52	0.55	0.55	0.55	0.56

[1] Premix - a commercial vitamin - mineral product with composition as shown in Table 4.

Results:

The effects of dietary treatments on performance of the birds are presented in Table 7.

At 5 weeks of age, broilers given BDG at 75% substitution of maize (Treatment 7) were lowest in body weights while birds receiving the control diet (Treatment 1) were the heaviest. Body weights of broiler chicks fed rations containing 50% wheat offal replacement with or without 5% palm oil (Treatments 2 and 4) supplementation and the control treatment (Treatment 1) were not significantly different. Seventy five percent replacement of maize with wheat offals significantly depressed weight gain while addition of 5% palm oil to this ration significantly improved body weight (Treatments 3 and 5) though the improvement in gain was yet lower to that of control. The inclusion of BDG to the rations depressed body weights, while the addition of palm oil to the BDG rations significantly improved body weights (Treatments 6 and 7 vs 8 and 9) at the 50% maize replacement level and non-significantly at the 25% replacement level.

Feed consumption and efficiency of feed conversion were variable and were influenced by dietary treatments. The addition of 5% palm oil to either the 50% or 75% replacement of maize with wheat offal improved weight gain and feed efficiency (Treatments 2 vs 4 and 3 vs 5). The addition of 5% palm oil to the 25% replacement of maize with BDG did not significantly improve weight gain and efficiency of feed conversion (Treatment 9 vs 7).

There were significant differences in feed cost per kilogram liveweight gain. It was least for the ration containing 50% wheat offal

TABLE 7

Effect of different levels of wheat offals and BDG on the performance of broiler chicks (0 - 5 weeks)

Ration No	Dietary treatment	Total weight gain (g)	Total feed intake (g)	EFC[2] (g feed)/(g Gain)	Feed cost/kg gain (₦)	Mortality (%)
1	54.40% maize, no BDG & WO	573.33^{a}	1402.50^{cd}	2.58^{e}	0.78^{def}	0.00^{b}
2	27.20% maize + 35.90% WO	543.81^{abc}	1654.39^{a}	3.05^{cd}	0.71^{f}	3.33^{b}
3	13.60% maize + 54.15% WO	436.26^{d}	1587.10^{abc}	3.65^{a}	0.72^{f}	4.17^{b}
4	27.20% maize + 27.65% WO + 5% palm oil	564.64^{ab}	1616.44^{ab}	2.86^{de}	0.85^{cd}	2.50^{b}
5	13.60% maize + 46.00% WO + 5% palm oil	517.68^{bc}	1610.06^{ab}	3.14^{bcd}	0.84^{cde}	4.17^{b}
6	27.20% maize + 39.15% BDG	450.99^{d}	1523.38^{bcd}	3.38^{abc}	0.75^{ef}	3.33^{b}
7	40.00% maize + 19.70% BDG	432.46^{d}	1477.58^{cd}	3.43^{ab}	0.90^{bc}	1.67^{b}
8	27.20% maize + 30.50% BDG + 5% palm oil	508.70^{c}	1681.50^{a}	3.32^{bc}	0.97^{b}	11.67^{a}
9	40.00% + 10.75% BDG + 5% palm oil	441.56^{d}	1461.75^{d}	3.31^{bc}	1.10^{a}	0.83^{b}
	SEM[3]	11.61	10.15	0.07	0.02	0.84

[1]Means within each column with same superscript are not significantly different ($P<0.05$)

[2]EFC = Efficiency of feed conversion

[3]SEM = Standard error of the mean.

replacement of maize (Treatment 2) and this was not significantly different from the feed cost per kilogram liveweight gain at 75% wheat offal replacement (Treatment 3); 50% BDG replacement (Treatment 6) and the control ration (Treatment 1). Feed cost per kilogram liveweight gain was significantly increased by 25% BDG replacement of the maize plus 5% palm oil supplementation. Apart from the ration containing 50% BDG replacement with 5% palm oil supplementation which significantly increased mortality (Treatment 8), rate of mortality was generally low and was not significantly affected by dietary treatments.

Summary:

A trial was conducted to further explore the possibility of raising broiler chicks (0 - 5 weeks old) on industrial by-products. Experimental diets contained wheat offal at 50% and 75% replacement of maize and BDG at 25% and 50% replacement of maize respectively only; and then with 5% supplementation with palm oil.

Results indicated that:

1. Up to 50% of the grains in broiler starter rations could be possibly replaced with wheat offals without much adverse effects on weight gain, feed consumption and efficiency of feed conversion.
2. Better performance of the broiler chicks could still be attained if the 50% replacement of wheat offal is supplemented with 5% palm oil.
3. The 50% replacement of maize with wheat offal plus 5% supplementation with palm oil was significantly comparable in feed cost per kilogram gain to the control ration (Treatment 4 vs 1).

4. Although the 50% replacement with BDG plus 5% palm oil supplementation supported quite satisfactory weight gains, consumption, efficiency of feed conversion, feed cost per kilogram gain and mortality were significantly higher than those of the control.

B. Extent of Replacement of Maize with Wheat offals and BDG in Practical Rations for Broiler Finishers.

Trial 3

Objective:

To determine how far maize can be replaced with wheat offal and BDG in rations for finishing broiler chickens.

Experimental

One thousand and eighty (1080) Shaver Starbro broiler chicks were reared on standard broiler starter rations from day old to six weeks of age. They were managed as described earlier under EXPERIMENTAL - GENERAL.

At six weeks old, the birds were randomly alloted in triplicate lots of forty birds each to nine finisher rations containing varying levels of wheat offal and BDG. Fifty percent of the total content of the maize was removed at each step of replacement. In addition, the effects of adding palm oil to a partially (50% substitution) or wholly substituted maize rations were studied. Feed and water were supplied ad libitum. The composition of the rations used are presented in Table 8. The experiment was terminated when the birds were nine weeks old.

Results:

The effects of dietary treatments on performance of the finisher birds are presented in Table 9. Weight gains, feed consumption and

TABLE 8

Percentage composition of broiler finisher rations (Trial 3)

Ingredients	RATIONS 1	2	3	4	5	6	7	8	9
Maize	63.20	31.60	-	31.55	-	31.55	-	31.55	-
Soybean meal	33.25	23.35	13.35	26.50	16.50	19.20	5.05	23.15	9.10
Wheat offal	-	41.50	83.10	33.40	74.95	-	-	-	-
Brewers dried grains	-	-	-	-	-	45.70	91.40	36.75	82.35
Palm oil	-	-	-	5.00	5.00	-	-	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated analysis									
Crude protein (%)	20.07	20.09	20.08	20.08	20.08	20.07	20.07	20.07	20.06
M.E. Kcal/kg ration	2959.79	2069.35	1177.73	2452.06	1561.67	2327.55	1696.58	2660.53	2030.06
Calcium (%)	1.17	1.18	1.19	1.18	1.33	1.26	1.35	1.24	1.33
Total phosphorus (%)	0.91	1.25	1.62	1.19	1.55	0.98	1.05	0.96	1.03
Crude fibre (%)	3.70	6.66	9.62	6.03	8.99	9.80	15.90	8.55	14.64
Lysine	1.49	1.37	1.26	1.42	1.31	1.22	0.95	1.30	1.04
Methionine	0.41	0.38	0.35	0.39	0.36	0.41	0.40	0.41	0.40

[1]Premix - a commercial vitamin - mineral product with composition as shown in Table 4.

mortality were greatly influenced by the treatments. Birds given the control diet (Treatment 1) gained the most while birds receiving the 100% BDG replacement (Treatment 9) gained the least in body weights. Body weight gains and feed consumption of birds fed rations in which 50% of the maize had been replaced by wheat offal or BDG were comparable (Treatments 2 vs 6 and 4 vs 8). In both cases the addition of 5% palm oil significantly improve performance. There were also no significant differences between wheat offal and BDG at the 50% level of maize replacement with or without oil supplementation. (Treatments 2 vs 6, 4 vs 8). These treatments with palm oil supported quite appreciable body weight gains and improved feed efficiency, though not significantly. Generally, weight gains were found to bear a linear relationship with caloric density of the diets. The complete replacement of maize which BDG led to very low weight gain as compared to the control (1.16g vs 1038g) and very poor feed efficiency.

Apart from the ration containing the 100% replacement of maize with BDG (Treatment 7), no two consecutive treatments gave feed conversion efficiencies and feed cost per kilogram gain that were significantly different. There were however, slight numerical increases in the various treatments. The hundred percent replacement of maize with BDG gave the worst results for both the efficiency of feed conversion and the feed cost per kilogram gain. Mortality was significantly influenced by treatments. The ration containing the 100% BDG replacement of maize (Treatment 7) registered the highest mortality.

TABLE 9

Effect of different levels of wheat offals and BDG on the performance of broiler chickens (6 - 9 weeks) (Trial 3)[1]

Ration No	Dietary Treatment	Total Weight gain (g)	Total Feed Intake (g)	EFC[2] (g/Feed)/(g Gain)	Feed Cost/kg Gain (N)	Mortality %
1	63.20% maize, no BDG and WO	1037.76^{a}	2578.68^{de}	2.49^{b}	0.73^{b}	0.83^{c}
2	31.60% maize + 41.50% WO	710.02^{c}	3037.10^{ab}	4.28^{b}	0.93^{b}	0.83^{c}
3	No maize, 83.10% WO	363.05^{e}	2857.24^{bcd}	8.00^{b}	1.08^{b}	9.17^{ab}
4	31.55% maize + 33.40% WO + 5% palm oil	833.53^{b}	3030.28^{ab}	3.65^{b}	1.04^{b}	0.83^{c}
5	No maize, 74.95% WO + 5% palm oil	551.65^{d}	2726.17^{c}	4.94^{b}	1.01^{b}	4.17^{bc}
6	31.55% maize + 45.70 BDG	656.50^{c}	2957.09^{ab}	4.42^{b}	0.90^{b}	0.83^{c}
7	No maize, 91.40% BDG	1.16^{g}	2472.61^{ef}	127.85^{a}	13.05^{a}	11.67^{a}
8	31.55% maize + 36.75 BDG + 5% palm oil	851.52^{b}	3070.20^{a}	3.62^{b}	0.99^{b}	2.50^{c}
9	No maize, 82.35 BDG + 5% palm oil	167.31^{f}	2363.59^{f}	14.60^{b}	2.64^{b}	5.83^{abc}
	SEM[3]	63.15	51.61	15.05	1.54	0.94

[1] Means within each column with same superscript are not significantly different ($P < 0.05$)

[2] EFC = Efficiency of feed conversion

[3] SEM = Standard error of the mean.

Summary:

A trial was conducted with 1000 six week old broiler chickens to investigate the effects of substituting maize with wheat offals or BDG and the effects of supplementation of the substituted rations with palm oil. The experimental findings indicated that:

1. Weight gains tended to increase with increasing level of maize in the rations. The addition of 5% palm oil to the rations in which maize was replaced by either wheat offal or BDG at the 50% level significantly further improved performance.
2. Feed cost per kilogram weight gain was highest for the ration containing 100% replacement of maize with BDG.
3. Apart from the ration containing the 100% replacement of maize with BDG (Treatment 7) which gave very bad performance with high mortality rate, there were no significant differences among the mean values of efficiency of feed conversion and feed costs per kilogram liveweight gain of the various treatments.

Trial 4

Objective:

To further assess the replacement of maize with wheat offals and BDG in broiler finisher rations.

Experimental:

One thousand and eighty broiler chicks which have been reared on standard broiler starter rations from day old to six weeks of age were used in trial 4. They were randomly alloted to nine experimental finisher rations in triplicate batches of forty birds each. The experimental diets contained varying levels of wheat offal and BDG. Wheat offal replaced maize at 50 and 75% levels, while BDG replaced maize at 25 and 50% levels in the rations. In addition the effects of adding palm oil to partially substituted (25%, 50 and 75% substitution) maize rations were studied. The composition of the experimental rations are shown in Table 10. Feed and water were supplied ad libitum. The experiment was terminated when the birds were nine weeks old.

Results:

The results obtained in Trial 4 are summarised in Table 11.

Analysis of variance of data of this trial (appendix 2) showed that dietary treatments had significant effects on weight gain, efficiency of feed utilisation and feed cost per kilogram liveweight gain. Birds fed the ration in which BDG replaced 25% of the maize with 5% palm oil supplementation were the heaviest while birds receiving the 75% wheat offal replacement were the lowest in body weights (Treatment 9 vs 3). Body weights and feed consumption of birds fed rations in which 50% and 25% of the maize had been replaced by wheat

TABLE 10

Percentage composition of broiler finisher rations (Trial 4)

	R A T I O N S								
Ingredients	1	2	3	4	5	6	7	8	9
Maize	63.20	31.60	15.80	31.55	15.80	31.55	47.40	31.55	47.40
Soybean meal	33.25	23.35	18.35	26.50	21.55	19.20	26.30	23.15	30.30
Wheat offal	-	41.50	62.30	33.40	54.10	-	-	-	-
Brewers dried grains	-	-	-	-	-	45.70	22.75	36.75	13.75
Palm oil	-	-	-	5.00	5.00	-	-	5.00	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated nutrient levels									
Crude protein (%)	20.07	20.09	20.09	20.08	20.09	20.07	20.08	20.07	20.09
M.E. Kcal/kg ration	2959.79	2069.35	1623.54	2452.06	2008.06	2327.55	2644.49	2660.53	2977.72
Calcium (%)	1.17	1.18	1.18	1.18	1.19	1.26	1.22	1.24	1.20
Total phosphorus (%)	0.91	1.27	1.44	1.19	1.37	0.98	0.95	0.96	0.93
Crude fibre (%)	3.70	6.66	8.14	6.03	7.50	9.80	6.74	8.55	5.49
Lysine	1.49	1.37	1.32	1.42	1.37	1.22	1.36	1.30	1.44
Methionine	0.41	0.38	0.37	0.39	0.37	0.41	0.41	0.41	0.41

[1]Premix - a commercial vitamin-mineral product with composition as shown in Table 4.

offal and BDG respectively plus 5% palm oil were comparable to the control ration (Treatments 4, 9 vs 1). Generally, weight gain and efficiency of feed conversion tended to improve with 5% palm oil supplementation.

Apart from rations 6 and 7, no two consecutive dietary treatments had any significant influence on feed intake. There were, however, slight numerical increases of the feed intake between the various groups. Feed intake was generally higher for the wheat offal based rations. Also, there was an observed increase in feed wastage with the group of birds fed rations in which maize was partially replaced with 50% BDG. There were significant differences in feed cost per kilogram weight gain. However, the differences between the rations which supported the best growth (Treatments 9, 1 and 4; 7 and 2 respectively) were not appreciable. Mortality was very low and was not significantly affected by dietary treatments.

Summary:

A trial was conducted with 1080 six weeks old broiler chickens to further assess the replacement value of different wheat offal and BDG levels on the performance of finishing broiler chickens. The results obtained indicated that:

1. The ration containing the 25% replacement of maize with BDG plus 5% palm oil supplementation (Treatment 9) supported the best weight gains, feed consumption, efficiency of feed utilization and was comparable in cost per kilogram gain to the control ration (Treatment 1).

TABLE 11

Effect of different levels of wheat offals and BDG on the performance of broiler chickens (6 - 9 weeks)

Ration No	Dietary Treatment	Total Weight Gain (g)	Total Feed intake (g)	EFC[2] (g/Feed)/(g gain)	Feed Cost/kg Gain (₦)	Mortality(%)
1	63.20% maize, no BDG & WB	1099.17[a]	3388.33[a]	3.09[e]	0.91[bc]	0.00
2	31.60% maize + 41.50% WO	920.83[bc]	3339.17[ab]	3.63[c]	0.76[d]	0.00
3	15.80% maize + 62.30% WO	756.67[d]	3362.50[ab]	4.47[a]	0.79[d]	0.00
4	31.55% maize + 33.40% WO + 5% palm oil	1037.50[ab]	3260.33[ab]	3.15[de]	0.89[bc]	0.00
5	15.80% maize + 54.10% WO + 5% palm oil	900.00[c]	3213.33[ab]	3.58[c]	0.86[bcd]	0.00
6	31.55% maize + 45.70% BDG	765.00[d]	3156.67[b]	4.15[ab]	0.84[cd]	0.00
7	47.40% maize + 22.75% BDG	968.33[bc]	3382.50[a]	3.50[cd]	0.87[bcd]	0.00
8	31.55% maize + 36.75% BDG + 5% palm oil	850.00[cd]	3197.50[ab]	3.77[bc]	1.03[a]	0.00
9	47.40% maize + 13.75% BDG + 5% palm oil	1115.83[a]	3307.21[ab]	2.97[e]	0.95[ab]	1.67
	SEM[3]	26.69	23.80	0.10	0.17	0.19

[1] Means within each column with same superscript or no superscript are not significantly different ($P<0.05$)

[2] EFC = Efficiency of feed conversion

[3] SEM = Standard error of the mean.

2. There were no significant differences in weight gains, feed consumption, efficiency of feed conversion, feed cost per kilogram gain and mortality for the control ration, the ration containing the 25% replacement of maize with BDG plus 5% palm oil supplementation and the ration in which 50% maize was replaced by essentially wheat offal plus 5% palm oil (Treatments 1, 9 and 4).
3. Feed consumption was generally higher for the rations containing the wheat offal than the BDG containing rations.
4. Rations containing palm oil supplementation supported better weight gains and efficiency of feed utilization than their corresponding rations without any palm oil supplementation.
5. Feed cost per kilogram gain tended to increase with palm oil supplementation.

SECTION 3

EXPERIMENTS WITH PULLETS

The effects of inclusion of wheat offals and brewers dried grains on the performance of pullets.

Objective:

To investigate the use of wheat offals and brewers dried grains as a partial or complete replacement for maize in pullet rations.

Experimental:

Shaver Starcross pullets purchased from a commercial hatchery at day old were raised on deep litter in open sided poultry house with floor space allowance of 0.093sq metre/bird. Heat for brooding was supplied by kerosene heated lanterns. Two experiments were carried out. In the first experiment, the pullets were placed on the experimental treatments from day old while in the second experiment, the birds were placed on the treatments at 8 weeks of age. Experimental rations fed contained varying amounts of wheat offal and BDG in such a way that as the level of these ingredients increased, the level of maize was progressively decreased by 50% until the 3rd ration when maize was completely replaced and wheat offal constituted 80.50% of the chick mash. Only 50% of the maize was replaced in the BDG treatments. Complete replacement of the maize by essentially BDG resulted in very high mortalities. This treatment was thus discontinued. In the grower rations, total maize replacement occured in ration 2 in which wheat offals constituted 97.40%. However, BDG replaced maize up to 75% and constituted 40.99% of the rations. One hundred percent replacement was not attempted because of the high mortalities associated with very high levels of BDG during the period 0 - 8 weeks.

Experiment 1

One thousand and eighty (1080) chicks were initially used in the first experiment (0-20 weeks). The chicks were randomly assigned to nine treatments of three replicates per treatment and forty birds per replicate. The composition of the rations during the starting stage (0 - 8 weeks) is shown in Table 12. Five percent palm oil was included in some of the treatments to determine whether the utilisatio of wheat offal or BDG could be improved in the presence of an additional energy source, palm oil. The treatments in which 100% of the maize was replaced by essentially BDG were discontinued because of the high mortalities recorded on these treatments.

During the growing period (8 - 20 weeks), birds on treatment 1 (chick stage) were fed ration 1(Table 13); while birds on treatments 2 and 3 (Table 12) were changed to ration 2 (Table 13), and birds on treatments 4 and 5 were changed to ration 3. Birds on treatments 6 and 7 were respectively fed rations 4 and 5 (Table 13) during the growing stage. After 27 weeks of age, when the birds were laying at 5%, all birds were fed a typical layers feed for the rest of their lives.

Experiment 2

In the second experiment (8 - 20 weeks) a total of 840 growing pullets were used. Chicks were assigned randomly in triplicate lots of 40 birds per lot to each of the 7 dietary treatments (Table 13). After 27 weeks of age, the birds were changed to a typical layers mash.

In both experiments, chicks and growing pullets were selected for uniformity of body weight. Food and water were provided ad libitum. All diets were isonitrogenous but not isocaloric. Diets were formulated to contain 21% crude protein during the starting stage (0 - 8 weeks)

TABLE 12

Percentage composition of rations for chicken pullets (0 - 8 weeks)

	RATIONS						
Ingredients	1	2	3	4	5	6	7
Maize	61.00	30.50	-	30.50	-	30.50	30.50
Soybean meal	35.55	25.80	16.05	29.05	19.30	22.05	26.05
Wheat offal	-	40.25	80.50	32.00	72.25	-	-
Brewers dried grains	-	-	-	-	-	44.00	35.00
Palm oil	-	-	-	5.00	5.00	-	5.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated nutrient levels							
Crude protein (%)	20.89	20.86	20.83	20.88	20.85	20.90	20.91
M.E. Kcal/kg ration	2933.86	2072.14	1210.42	2457.25	1595.52	2324.79	2658.02
Calcium (%)	1.27	1.19	1.19	1.19	1.20	1.26	1.25
Total phosphorus (%)	0.85	1.27	1.61	1.19	1.53	0.99	0.97
Crude fibre (%)	3.81	6.67	9.53	6.03	8.89	9.69	8.43
Lysine	1.57	1.45	1.34	1.51	0.92	1.32	1.40
Methionine	0.33	0.30	0.27	0.30	0.27	0.32	0.32

[1]Premix supplied per kilogram ration: vit. A, 13340 I.U., vit D_3 3,000 I.U., vit E, 6.68 I.U.; vit. K, 2.68mg; vit. B_2 6.0mg; vit. B_6 4.0mg, nicotinic acid, 29.34mg; calcium d-pantothenate, 8.0mg; vit. B_{12} 0.016mg; choline chloride, 266.8mg; 3,5-dinitro-ortho-toluamide, 133.4mg; manganese, 106.68mg; iron, 66.68mg; zinc, 53.34mg copper, 3.2mg; iodine, 1.868mg; cobalt, 0.268mg; cadmium, 0.068mg

TABLE 13

Percentage composition of growers ration (8 - 20 weeks)

	RATIONS						
Ingredients	1	2	3	4	5	6	7
Maize	74.00	-	-	37.00	37.00	18.50	18.50
Soybean meal	23.40	-	3.20	6.90	11.00	-	2.70
Wheat offal	-	97.40	89.20	-	-	-	-
Brewers dried grains	-	-	-	53.50	44.40	78.90	71.20
Palm oil	-	-	5.00	-	5.00	-	5.00
Bone meal	2.15	2.15	2.15	2.15	2.15	2.15	2.15
Common salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Calculated nutrient analysis							
Crude protein (%)	16.66	16.66	16.66	16.65	16.68	16.97	16.66
M.E. Kcal/kg ration	3119.22	1031.47	1415.99	2397.73	2713.50	2016.69	2343.46
Calcium (%)	0.90	0.86	0.86	0.94	0.93	1.00	0.98
Total phosphorus (%)	0.86	1.55	1.48	0.80	0.78	0.84	0.82
Crude fibre (%)	3.25	10.19	9.55	10.39	9.13	13.82	12.70
Lysine	1.14	0.87	0.92	0.83	0.91	0.71	0.75
Methionine	0.27	0.19	0.20	0.26	0.26	0.26	0.25

[1]Premix - a commercial vitamin - mineral product with composition as shown in Table 12.

and 17% during the finishing stage (8–20 weeks). All the ration had almost similar amounts of calcium. Because of the higher content of the total phosphorous in wheat offal and BDG, the percent total phosphorous (P) increased slightly with increase in the level of wheat offal or BDG in the ration. No artificial light was provided after 8 weeks of age.

During the experimental period which lasted up to 20 weeks, the birds were observed daily and record of mortality was kept Records of weight gain, feed consumption, feed efficiency, mortality and feed cost per kilogram liveweight gain were determined at four week intervals.

The effects of the various growing stage treatments on the age at 5% egg production were also determined.

Data collected during the experimental period were subjected to analysis of variance and the significance of differences assessed by applying Duncan's Multiple Range Test (Steel and Torrie, 1960), at 0.05 level of probability. Details of analysis of variance are given in Appendices 3 and 4.

Results:

The results of the first experiment are presented in Table 14. Starting pullets fed rations containing wheat offal replacing 50% of the maize (Treatments 2 & 4) and complete replacement of the maize with wheat offal plus 5% palm oil (Treatment 5) supported comparable weight gains with those of the control ration (Treatment 1) up to 8 weeks of age. Starting pullets fed rations in which 50% of the maize was replaced with BDG with or without palm oil supplementation

TABLE 14

Effects of replacing maize with wheat offals and BDG in the rations of chicken pullets (0–20 weeks)

	TREATMENTS							
	1	2	3	4	5	6	7	SE
Body weight at 8 weeks, g	449^{a}	469^{a}	417^{b}	445^{a}	457^{a}	365^{c}	381^{c}	8.59
Feed intake (0–8 weeks), kg	1.50^{bc}	1.69^{a}	1.69^{a}	1.57^{abc}	1.62^{ab}	1.56^{abc}	1.43^{c}	0.03
Feed/gain, at 8 weeks	3.62^{d}	3.90^{cd}	4.41^{ab}	3.83^{cd}	3.83^{cd}	4.72^{a}	4.12^{bc}	0.09
Feed cost to 8 weeks, ₦	0.43^{a}	0.36^{b}	0.23^{d}	0.44^{a}	0.33^{c}	0.31^{c}	0.39^{b}	0.02
Body weight at 20 weeks, g	1318^{a}	927^{d}	904^{d}	1031^{c}	1027^{c}	1037^{c}	1171^{b}	31.0
Feed intake (0-20 weeks), kg	7.03^{d}	8.52^{ab}	8.91^{a}	7.70^{cd}	7.96^{bc}	7.58^{cd}	7.49^{cd}	0.15
Feed/gain at 20 weeks	5.48^{d}	9.54^{a}	10.24^{a}	7.74^{bc}	8.02^{b}	7.57^{bc}	6.59^{cd}	0.36
Feed cost (0-20 weeks) ₦	2.03^{a}	1.06^{d}	0.97^{d}	1.49^{c}	1.41^{c}	1.40^{c}	1.92^{b}	0.08
Mortality (0-20 weeks) %	1.67^{c}	5.83^{abc}	10.00^{a}	0.83^{c}	3.33^{bc}	7.50^{ab}	3.33^{bc}	0.87
Age to 5% production (days)	151^{d}	184^{a}	186^{a}	167^{a}	185^{a}	170^{b}	161^{c}	3.06

Row values with same superscript are not significantly different ($P < 0.05$).

(Treatments 6 & 7) were significantly lighter than those in the other treatments. Feed intake was significantly increased in the wheat offal containing rations. The addition of 5% palm oil to the partially or wholly replaced maize rations reduced feed intake and improved efficiency of feed utilization. Feed cost decreased significantly with decrease in maize content of the rations. The addition of palm oil to the by-product rations tended to increase feed cost at 8 weeks but this increase did not result in feed cost above that obtained on the control rations.

At 20 weeks of age, the pullets on the control ration (Treatment 1) were significantly heavier than pullets in all other treatments. The addition of 5% palm oil to the partially or completely replaced maize ration with either wheat offal or BDG improved weight, but the body weights obtained were still significantly less than that of the control ration (Treatments 4, 5 & 7 vs 1). Feed intake at 20 weeks was significantly increased by the complete replacement of maize with wheat offal. The addition of 5% palm oil in addition to wheat offal tended to reduce feed intake. Feed efficiency was also significantly improved by the addition of 5% palm oil to the various rations. However, the feed efficiencies at 20 weeks on all but one (Treatment 7) of the rations containing wheat offal and BDG were still significantly less than that of the control ration (Treatment 1). Feed costs at 20 weeks were significantly less in the rations in which maize had been partially or wholly replaced by wheat offal or BDG (Treatments 2 to 7) as compared to the control (Treatment 1). The pullets fed rations from which maize was absent and wheat offal present (Treatment 3) recorded the highest mortality.

The average age to 5% egg production was significantly influenced by dietary treatments. The control birds attained this age earliest, at 151 days while the group of birds fed the ration in which maize was completely replaced with wheat offal but supplemented with 5% palm oil were the latest to attain this age at 167 days. However, there were no significant differences in the age at which the birds on the wheat offal based diets (with or without palm oil supplementation) attained this age.

The results obtained in the second experiment in which growing pullets were placed on the experimental treatments from 8 weeks of age are presented in Table 15. Pullets given the control diet (Treatment 1) were the heaviest while birds receiving the 75% BDG replacement of maize in the ration (without palm oil) were the lowest in body weights. The addition of 5% palm oil to rations in which maize had been partially or completely replaced by either wheat offal or BDG significantly improved body weight although this was not better than the control treatment. There were slight variations in feed consumption. Apart from the ration containing BDG at 75% level of replacement of maize (Treatment 6), no two consecutive treatments differed significantly. The birds were also observed to select the grains first in the rations where maize was partially replaced with 50 and 75% BDG respectively. Little of the remaining diet was then eaten and the rest refused. Feed efficiency was significantly depressed when rations containing the wheat offals and BDG were fed to the pullets. Feed cost was significantly highest for the control rations and for the ration containing wheat offal at 50% replacement of maize with 5% palm oil supplementation.

TABLE 15

Effects of replacing maize with wheat offals and BXK in the rations of growing pullets (8-20 weeks)

	TREATMENTS							
	1	2	3	4	5	6	7	SE
Body weight at 20 weeks, g	1314^{a}	915^{d}	1062^{c}	1100^{bc}	1192^{e}	769^{a}	952^{d}	40
Feed intake (8-20 weeks), kg	5.65^{b}	5.82^{ab}	5.94^{ab}	6.08^{ab}	6.41^{a}	5.52^{b}	5.95^{ab}	0.08
Feed/gain at 20 weeks	5.66^{c}	10.91^{b}	8.70^{cd}	8.40^{d}	7.86^{d}	14.13^{a}	10.36^{bc}	0.58
Feed cost (8-20 weeks), ₦	1.64^{a}	0.60^{d}	1.02^{c}	1.10^{bc}	1.62^{a}	0.72^{d}	1.18^{b}	0.08
Feed cost/kg gain at 20 weeks,₦	1.70^{bcd}	1.12^{e}	1.48^{d}	1.53^{cd}	1.99^{ab}	1.84^{abc}	2.06^{a}	0.07
Mortality %	1.67^{b}	1.67^{b}	0^{b}	0.33^{b}	2.50^{b}	2.50^{b}	7.50^{a}	0.70
Age to 5% production (days)	156^{e}	181^{b}	181^{b}	172^{c}	166^{d}	192^{a}	189^{a}	2.75

Values in rows with the same superscript are not significantly different (P<0.05).

The inclusion of palm oil in addition to wheat offal and BDG tended to increase feed cost. Apart from the ration containing 75% replacement of maize with BDG with 5% palm oil supplementation (Treatment 7), dietary treatments did not have any significant differences on mortality.

The average age to 5% production was significantly influenced by dietary treatments. Pullets on the control diet were the earliest in producing eggs while pullets fed rations in which BDG replaced 75% of the maize were the latest in attaining 5% production. They were delayed by 36 days.

Summary:

Two studies were conducted in which Shaver Starcross starting pullets (from day old) and growing pullets (from 8 weeks to 20 weeks) were fed rations containing varying levels of wheat offals and BDG which replaced maize in the ration.

The results obtained indicated that:

1. The replacement of 50% maize in the ration and complete replacement of maize with wheat offal in the presence or absence of 5% palm oil supported comparable weight gains for starting pullets as the control ration in which wheat offal or BDG was absent.
2. At 20 weeks of age, pullets fed rations without wheat offal or BDG were significantly heavier than pullets in all other treatments.
3. Feed consumption generally increased while feed efficiency was significantly depressed with increasing levels of either wheat offal or BDG and decreasing levels of maize in the rations.

4. Feed costs were significantly cheaper on the rations containing either wheat offals or BDG.

5. The average age to 5% production was significantly influenced by dietary treatments. In both experiments, the control birds attained the age to 5% production significantly earlier than all other treatments.

SECTION 4

EXPERIMENTS WITH LAYING CHICKENS

The effects of the inclusion of wheat offals or BDG in layer diets on the performance of laying chickens.

Objectives:

To determine the value of and optimum level of substitution of wheat offal for maize in the rations of laying chickens.

To determine the effects of partial substitution of maize with BDG in layer rations.

Experimental:

Two experiments were conducted. The first experiment was to assess the value of wheat offal and the second to assess that of BDG.

In the first experiment, seven hundred and twenty (720) Shaver Starcross pullets of 28 weeks of age and laying at 5% production were selected and randomly divided into similar groups of 24 birds each. Five such groups were placed on each of six experimental rations shown on Table 16. Birds were housed in battery cages, two to a cell measuring 36cm^2 in an open sided building. Ration 1 contained no wheat offal. In the other five rations, varying levels of wheat offal replaced maize. As the level of wheat offal increased, the level of maize was progressively decreased until in ration 6 when maize was completely absent and wheat offal constituted 80.2% of the ration. All the rations were iso-nitrogenous but not iso-caloric, the dietary energy level decreasing as the level of wheat offal increased in the ration. The rations had similar amounts of calcium. The crude fibre content of the ration also increased with increase in the level of wheat offals in the diet. The highest level of dietary

TABLE 16

Percentage composition of experimental rations (wheat offal treatment)

	RATIONS					
Ingredients	1	2	3	4	5	6
Maize	67.60	33.80	25.35	16.90	8.45	-
Groundnut cake	22.30	12.00	9.40	6.85	4.25	1.70
Wheat offal	-	44.10	55.15	66.15	77.20	88.20
Bone meal	2.25	2.25	2.25	2.25	2.25	2.25
Periwinkle shell	7.00	7.00	7.00	7.00	7.00	7.00
Lysine	0.20	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Common salt	0.25	0.25	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20
Calculated nutrient levels						
Crude protein %	15.85	15.85	15,84	15.84	15.84	15.85
M.E. Kcal/kg ration	2880.31	1926.52	1687.77	1449.63	1210.88	972.73
Ca (%)	3.63	3.65	3.66	3.67	3.67	3,68
Crude fibre (%)	2.95	6.22	7.03	7.85	8.67	9.49
Lysine	0.66	0.94	0.96	0.98	1.87	2.02
Methionine	0.40	0.39	0.39	0.39	0.39	0.38

[1]Premix supplied per kilogram ration: vit. A, 13,340 I.U., vit. D_3, 2680 I.U. vit. E, 13,34 I.U., vit. K, 2.68mg; vit. B_2 6.0mg; B_6, 4.0mg; nicotinic acid, 33.34mg; calcium d-pantothenate, 10.68mg; vit. B_{12}, 0.016mg, vit. C., 26.68mg; choline chloride, 266.8mg; manganese, 133.34mg; iron 66.68mg; zinc 53.34mg; copper, 3.2mg; iodine, 1.868mg; cobalt, 0.266mg; selenium, 0.068mg.

crude fibre was however 9.5%. The initial weights of the birds were obtained at the start of the experiment. Feed and water were provided ad libitum. No artificial light beyond the natural day light was provided.

During the experimental period of 224 days (eight-28 day periods) records were kept on daily mortality and egg production; egg weight (average of eggs laid by each group on one day of each week); Haugh unit value (HUV), Yolk Index and shell thickness, (average of eggs laid by each group on one day of every 4 weeks). Feed consumption was determined at four week intervals. The final weights of the birds were determined at the end of the experiment.

In another experiment (experiment 2), 480 Shaver Starcross pullets also laying at 5% production were selected and randomly divided into similar groups of 24 birds each. Five such groups were placed on each of four experimental rations shown on Table 17. In this experiment, maize was replaced at varying levels with BDG. Ration 1 contained no BDG and ration 4 had the highest level of replacement where 62.5% of the maize was replaced and BDG constituted 60.3% of the ration. Feed and water were provided ad libitum. No artificial light was provided. The birds were weighed at the beginning and end of the experiment. The same parameters measured in the previous layer experiment were also measured here.

Data collected from the two experiments (1 and 2) during the experimental period were subjected to analysis of variance and the significance of differences assessed by applying Duncan's

TABLE 17

Percentage composition of experimental rations (BDG treatment)

Ingredients	RATIONS 1	2	3	4
Maize	67.60	42.25	33.80	25.35
Groundnut cake	22.30	11.55	7.90	4.25
Brewers dried grains	-	36.10	48.20	60.30
Bone meal	2.25	2.25	2.25	2.25
Periwinkle shell	7.00	7.00	7.00	7.00
Lysine	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20
Common salt	0.25	0.25	0.25	0.25
Premix[1]	0.20	0.20	0.20	0.20
Calculated nutrient levels				
Crude protein (%)	15.85	15.87	15.87	15.85
M.E. Kcal/kg ration	2880.31	2371.47	2201.49	2031.53
Ca (%)	3.63	3.71	3.74	3.77
P (%)	0.70	0.75	0.78	0.80
Crude fibre (%)	2.95	7.90	9.56	11.22
Lysine	0.86	0.86	0.86	0.86
Methionine	0.40	0.42	0.43	0.43

[1] Premix -- a commercial vitamin-mineral product with composition as shown in Table 16.

Multiple Range Test (Steel and Torries, 1960) at 5% level of probability. Details of analysis of variance are given in Appendices 5 and 6.

Results:

The results obtained in the first experiment with layers are summarised in Table 18. The analysis of variance results showed a significant influence of the dietary treatments on egg production. The replacement of 50% and 62.5% maize with wheat offal (treatments 2 & 3) led to non-significant improvement in egg production. Complete replacement of maize with wheat offal significantly depressed egg production. In all, the increase in level of wheat offal from 75% - 100% replacement of maize in the rations lowered egg production significantly. Hen housed production (HHP) also followed a similar pattern with treatment 2 having the best HHP and treatment 6 the worst.

There were significant variations in the feed consumed by the various treatments. Birds in treatment 1 had the lowest feed intake while birds fed rations containing 75 - 100% replacement of maize with wheat offal (treatments 4, 5 and 6) had the highest food intake. In general, the replacement of maize with wheat offal caused a significant increase in feed intake. The efficiency of feed utilization (feed/doz. eggs) improved with increase in the level of maize in the rations. The best feed efficiency was obtained on the control ration and the worst on the ration from which maize was completely absent. Apart from the ration containing 100% replacement of maize with wheat offal, there were no significant differences between the other treatments in terms of feed cost per dozen eggs produced.

TABLE 18

The effects of replacing maize with wheat offal in rations for laying chickens on laying house performance and egg quality[1].

	Treatments and levels of replacement of maize in rations 1 0	2 50%	3 62.5%	4 75%	5 87.5%	6 100%	SE
Hen-day production[2] (%)	55.58^{ab}	61.45^{a}	57.83^{a}	50.07^{bc}	45.65^{c}	34.22^{d}	1.83
Hen-housed production[3] (%)	52.78^{b}	59.59^{a}	56.27^{ab}	48.39^{c}	44.95^{c}	34.11^{d}	1.73
Daily feed consumption (g/bird)	121.52^{d}	142.28^{c}	150.72^{b}	154.71^{ab}	159.02^{a}	157.09^{a}	2.46
Feed/dozen eggs (kg)	2.67^{d}	2.89^{cd}	3.51^{cd}	4.26^{bc}	5.06^{b}	8.13^{a}	0.38
Feed cost/dozen eggs (N)	0.82^{b}	0.65^{b}	0.72^{b}	0.76^{b}	0.82^{b}	1.14^{a}	0.04
Mortality (%)	8.33^{ab}	5.00^{abc}	3.33^{bc}	10.00^{a}	2.50^{bc}	0.83^{c}	0.97
Average initial body weight (kg)	1.59	1.59	1.60	1.60	1.60	1.61	0.02
Average final body weight (kg)	1.96^{a}	1.87^{ab}	1.81^{b}	1.71^{c}	1.57^{d}	1.61^{cd}	0.03
Income/bird (N)[4]	21.26^{a}	22.62^{a}	21.07^{a}	18.81^{b}	16.44^{c}	12.66^{d}	0.61
Egg Haugh unit value	82.05^{b}	82.98^{b}	83.47^{b}	85.26^{ab}	85.68^{ab}	89.28^{a}	0.75
Average egg weight (g)	61.52	63.88	63.53	63.34	63.95	61.86	0.38
Egg Yolk Index	0.43	0.44	0.44	0.44	0.44	0.45	0.004
Egg shell thickness (mm)	0.435	0.418	0.418	0.435	0.438	0.443	0.004

[1]Means within each row with different superscript are significantly different ($P<0.05$)

[2]Hen-day production = $\frac{\text{no of eggs/day} \times 100}{\text{no of birds alive}}$

[3]Hen-housed production = $\frac{\text{no of eggs/day} \times 100}{\text{no of birds housed}}$

[4]Income/bird = value of eggs + carcass value. Eggs = N1.60/doz., carcass = N2.30/kg liveweight.

However, feed cost per dozen eggs was numerically lowered when 50 - 75% of the maize in the ration was replaced by wheat offals. Income per bird improved significantly with increase in the level of maize in ration. However, there were no significant differences between treatments 1, 2 and 3.

Mortality was significantly affected by dietary treatments. Mortality was lowest in the all wheat offal ration. The final body weights were affected by dietary treatments. Generally, heavier body weights were produced with increasing levels of maize in the rations.

Dietary treatments had no significant effects on egg weight, yolk index and shell thickness. However, there were significant differences between treatments for Haugh unit values. Generally, there was the tendency of the Haugh unit values to increase with increasing levels of wheat offal and decreasing levels of maize.

The experimental results obtained in the second experiment are summarised in Table 19.

There was a wide variation between the various groups in the number of eggs laid. Dietary treatments exerted significant effects on egg production. The average hen day production (HDP) for the group fed the control diet was significantly higher than those of the groups fed the BDG based diets. Egg production decreased significantly with increase in the level of BDG in the rations.

Significant differences were observed between treatments for feed consumption. Birds on the control ration consumed the least amount of feed while the most was consumed by the group fed the ration containing 37.5% BDG replacement of maize. The birds fed the rations

TABLE 19

The effects of replacing maize with BDG in rations for laying chickens on laying house performance and egg quality.[1]

	Treatments and levels of replacement of maize in rations				
	1 0	2 37.5%	3 50%	4 62.5%	SE
Hen-day production[2] (%)	58.67^{a}	50.02^{b}	35.63^{c}	22.59^{d}	3.31
Hen-housed production[3] (%)	55.88^{a}	45.84^{b}	34.85^{c}	22.30^{d}	3.07
Daily feed consumption g/bird	128.05^{b}	141.24^{a}	137.67^{a}	130.42^{b}	1.61
Feed/dozen eggs (kg)	2.38^{c}	4.30^{bc}	6.03^{b}	8.76^{a}	0.60
Feed cost/dozen eggs (N)	0.89^{b}	1.01^{b}	1.27^{ab}	1.64^{a}	0.09
Mortality (%)	8.33	10.00	4.17	2.50	4.39
Average initial body weight (kg)	1.49	1.50	1.50	1.50	0.04
Average final body weight (kg)	1.96^{a}	1.80^{b}	1.56^{c}	1.51^{c}	0.05
Income/bird[4] (N)	22.16^{a}	17.77^{b}	13.81^{c}	9.29^{d}	1.16
Egg Haugh unit value	81.79	82.59	83.90	85.46	0.96
Average egg weight (g)	62.47^{ab}	64.33^{a}	62.77^{ab}	61.28^{b}	0.41
Egg Yolk Index	0.42	0.43	0.43	0.43	0.01
Egg shell thickness (mm)	0.438^{a}	0.425^{a}	0.410^{ab}	0.390^{b}	0.01

[1]Means within each row with same superscript or no superscript are not significantly different ($P < 0.05$)

[2]Hen-day production, [3]Hen-housed production, [4]Income/bird ..... as shown at Table 18.

in which maize was partially replaced with 50 and 62.5% BDG respectively, were observed to selected the grains first in the rations. Little of the remaining diet was then eaten and the rest refused. The addition of BDG to the rations significantly depressed efficiency of feed utilization (feed/dozen eggs) when compared to the control ration. Feed cost per dozen eggs increased also with increase in the level of BDG in the ration. However no two consecutive treatments were significantly different.

There were no significant differences between treatment means for mortality. The final body weights were significantly affected by dietary treatments. The average final body weight of the group fed the control ration was significantly higher than that of groups fed rations containing BDG. The income for birds improved significantly with increase in the level of maize in the ration.

Dietary treatments did not have any significant effects on the Haugh unit values and the yolk indices. The significant differences in egg weight did not follow any pattern. Egg shell thickness tended to decrease with increasing level of BDG in the ration. Egg shell thickness was thus lowest for birds on treatment 4 and highest for birds on the control ration.

In both experiments one (wheat offal based diets) and two (BDG based diets) the birds produced droppings which tended to be drier than the droppings of the control group.

Summary

Studies were conducted to determine the effect of feeding rations containing varying levels of wheat offal and BDG on the performance of laying Shaver Starcross pullets (28 weeks to 60 weeks,

Results of the two experiments indicated that:

1. The replacement of 50% and 62.5% maize with wheat offal led to egg production not significantly different from the all maize ration.
2. The incorporation of BDG in laying rations significantly depressed egg production, the depression increasing with increase in the level of BDG in the ration.
3. In general, the replacement of maize with wheat offal caused a significant increase in feed consumption.
4. Feed cost per dozen eggs was reduced by replacement of 50 to 75% of the maize by wheat offal.
5. Dietary treatments had no significant effects on egg weight, yolk index and shell thickness while Haugh unit value tended to increase with the presence of wheat offal and BDG in the rations.
6. Feed consumed per dozen eggs and feed cost per dozen eggs increased with increase in the level of BDG in the ration.
7. The presence or absence of BDG in the ration did not have any significant effects on the egg Haugh unit value and yolk index. Egg shell thickness however tended to decrease with increasing level of BDG in the ration.
8. Birds on rations containing wheat offals and BDG produced droppings which tended to be drier than the droppings of the control group.

GENERAL DISCUSSION

The experimental findings with broiler chickens indicated that the complete replacement of maize with wheat offals and especially BDG in the rations resulted in lowered performance of the birds The depression in performance may be due to the low caloric and high fibre values of these diets which may not be too conducive to optimum performance of broiler chickens, and which might have led to impairment of utilization of the birds of essential nutrients (Boenker et al., 1969). By increasing the percentage of these low energy feedstuffs in the rations, the fibre contents of the entire rations are increased and their energy densities lowered. Ewing (1951) explained that fibre has a low value in itself, decreases apparent dry matter, contributes little, if any digestible nutrients and also makes other nutrients less available. Also, it is usually accompanied by other materials which also have low feeding values.

Feed consumption and feed conversion were variable and were influenced by the dietary treatments. Generally, feed consumption of broilers fed rations containing wheat offal or BDG was higher than the control. This result is in agreement with the results of Ademosun (1973) and Din et al., (1979) who fed BDG and plant by products to pullets respectively. The higher feed consumption may probably be due to the lower caloric values of the feeds that stimulated feed consumption in an attempt by the birds to consume more energy.

Broiler chickens on rations in which all the maize was completely replaced with wheat offal principally performed better in terms of

weight gains and feed consumption than those on rations in which all the maize was replaced by BDG. The birds on the wheat offal based rations were probably able to increase their intake of nutrients to compensate to a certain extent for the low energy content of the ration. But their ability to increase the amount of bulk ingested was limited physically in agreement with earlier report of Hill and Dansky (1954). Also, wheat offal is comparatively less fibrous and contains about 19% of digestible carbohydrate expressed as glucose as compared to about 8% of that of BDG (Longe and Olonilua, 1977). The wheat offal might have contributed appreciably more to the metabolizable energy of the diet. On the other hand, the excessive crude fibre content of BDG in the ration resulted in excessive bulk and in a low energy content, thus limiting its level of acceptance by the birds. Bell (1960) explained that the birds capacity to consume fibrous feeds is greater when the material has a higher moisture absorbing capacity such as wheat offal.

In the broiler, grower and layer experiments where maize was partially replaced with 50% BDG, the birds were observed to select the grains first. Then little of the remaining diet was eaten and the rest refused. Deltoro-Lopez et al. (1981b) also pointed this out in their experimental findings which indicated that poultry rations containing more than 60% BDG cause a tremendous decrease in feed intake and in some cases (90% BDG) half the birds refused to accept the diet. Kare and Scott (1962) showed that chicks would select some practical feedstuffs in preference to others (e.g. corn was prefered to barley or rye) when these feedstuffs were offered in a free choice situation, and

that feeding performance did not correlate with the known nutritional value of the feedstuff. Feeding preferences much as these may be functions of the taste (i.e. chemoreception in the mouth) or more likely of the palatability of individual feedstuffs (Alonier and Combe, 1981). The findings in this study may suggest that probably maize grains were prefered to high levels (50% and above) of BDG by the birds in their ration.

The present results also indicate that 25% replacement of maize with BDG may be used in broiler rations without much adverse effects on the performance of the birds. However, optimum performance was recorded with birds on rations containing 5% palm oil plus BDG replacing approximately 25% of the maize. The level of BDG in this case was 13.75%. Based on their experimental findings, Ademosun (1974) recommended that levels up to 10% BDG can be used in poultry starter rations. Jensen (1981) recommended levels up to 15%. However, the experimental findings of such workers as Thorton (1962); Kienholz (1964); and Harms et al. (1969) indicated that it it possible to include 20% BDG in the diet without adversely affecting productive traits. But this is contrary to the findings of Jensen et al. (1976, 1978); Eldred et al. (1975) and Damron et al. (1976) who reported that the use of 10% or more BDG caused a decrease in productive traits. Ademosun (1973) also reported that levels of 45% BDG caused a marked decrease in body weight gains. These workers did not make any deliberate attempt to use BDG as replacement for maize.

In the case of the birds fed rations containing wheat offals, the experimental findings indicated that optimum performance could be ge

with rations containing 50% replacement of maize with wheat offal with 5% palm oil supplementation. In such rations wheat offal formed 27.65% of the starter rations and 33.40% of the rations respectively. However, the results also suggest that maize could possibly be replaced with wheat offal at 50% of replacement without much adverse effects on performance of the birds.

Birds fed diets containing 50% replacement of maize with BDG or wheat offals with or without palm oil supplementation were slightly lighter at 9 weeks of age than those fed the control diet. However, the addition of 5% palm oil to the rations improved the performance of the birds. Generally the palm oil supplementation resulted in increased weight gains, feed intake and improved efficiency of feed utilization. Similar results have been reported by Vermeerson and Vanschoubrock (1968) who indicated that the supplementation of chick diet with palm oil in common with many other oils improves the growth rate of chicks. This has been verified by Oluyemi and Oyenuga (1974) who have shown that palm oil supplementation of chick diets improve the rate of growth and also tended to improve metabolizable energy and nitrogen retention of the diet and livability of the chicks. Many other workers (Dam et al. 1959; Treat et al., 1960; Fuller, 1979 and Sell, 1979) are of the view that fat supplementation not only improves the caloric density of the diet but also improves the efficiency of feed utilization. This was reflected in the present study where birds fed rations containing palm oil exhibited better efficiency of feed conversion than birds fed on corresponding rations without any palm oil supplementation. Where the energy density is maintained by the addition of fat to the diet, the

retarding effect on growth of the increased fibre content may be largely nullified (Richardson, et al., 1953, cited by Hallsworth and Coates, 1962).

Mortality was high in both the brooding and the finishing stages of the experiments among birds fed the rations with the high fibre contents, especially the 100% BDG replacement of maize. An argument can be advanced that the high fibre contents of the diet might have imposed a lot of stress on the birds. At the same time the low energy contents of these same rations might have stimulated high intakes which might have led to distortion of the digestive tract, especially the small intestines and hence impaired absorption of essential nutrients. This is known to have happened to birds fed high fibre diets (Hallsworth and Coates, 1962).

An economic evaluation of the results based on prices of feedstuffs prevailing during the experimental period showed that the low energy rations which contained 50%, 75% and 100% replacement of maize with wheat offals gave savings in feed cost per kilogram of liveweight gain during the brooding stages of 6, 5 and 12 kobo per bird respectively relative to the control. The replacement of 50% of the maize in the ration with BDG also gave savings of 4 kobo per bird. During the finishing stages, the replacement of 50% of the maize in the ration with wheat offals and BDG gave savings of 13 and 17 kobo per bird respectively. However the rations containing 100% replacement of maize with either BDG or wheat offals rather inflated the cost for producing a kilogram liveweight gain. This was probably due to their low efficiency of feed utilization and hence low rate of gain. The most substantial savings were made on rations containing

either 50% replacement of maize with BDG or wheat offals.

The BDG and wheat offals based diets (25% and 50% replacement respectively) which supported good growth were comparable in costs of feed required to support a kilogram liveweight gain to the control diet since no significant differences were found between these treatments.

The results with the starting pullets (0-20 weeks) show that weight at 8 weeks for birds fed rations containing 50% replacement or complete replacement of maize with wheat offal with 5% palm oil supplementation were comparable in performance to the control ration. Comparable findings have been reported elsewhere. Nehring and Uhlemann (1967) indicated that wheat offal alone did not improve wieght gain but 20% wheat offal plus 7% fat gave as good results as the whole ground cereal diets for growers. Asai and Netko (1971) also reported that pullets grew satisfactorily on a diet composed of 60% wheat offal and 30.9% groundnut cake meal when adequately supplemented with minerals and vitamins. The restuls of the complete replacement of maize with wheat offal in this study are also similar to the findings of Ranjhan and Talapatra (1967) who found that when wheat offal is used at 95% level as sole feed devoid of grain but containing normal protein, the feed efficiency is lowered as compared to maize containing diets. The poor performance of starting pullets fed BDG based diets could be attributed to the low energy and fairly high fibre contents of the diets. Ewing (1951) and Boenker et al., (1969) explained that fibre has a low value in itself, and when present in high concentrations imposes a physical limination on the intake of digestible nutrients as

well as the depressing of nutrient digestibility are possible reasons. The resultant inadequate energy intake therefore probably impairs the efficient utilization of other nutrients. Earlier, Ademosun (1973) had suggested that BDG should not be incorporated into pullet rations at levels beyond 30% without further experimentation. Ademosun (1973) further explained that the high crude fibre content of BDG is probably the most important single factor limiting the extent to which BDG can be used in the diets of monogastric animals.

The observation that growing pullets which were placed on experimental treatments at 8 weeks of age performed better than those placed on experimental rations at day old may be explainable on the basis that the older birds were able to tolerate the high fibre diet better than the younger ones.

The performance trends in pullets of improving weight gains, decreasing feed consumption and improving feed efficiency with decreasing fibre contents of the rations and increasing energy levels up to a certain point observed is in agreement with the findings of Kondra et al., (1974) and Wells (1980). The increased feed consumption observed with the rations containing the industrial by-products may be due to the low energy contents of these rations. It is known that chickens tend to adjust their daily feed intake so as to maintain an appropriate energy level within a certain range of dietary intake, with the result that the weight of feed consumed generally decreases when balanced diets are offered (Hill and Dansky, 1954, ARC, 1975). The observation that feed consumption reduced as the dietary energy increased agrees also with the findings of Farrell et al., (1973); Oloma (1976) as well as Oloma and Offiong (1980) who showed that feed

intake of chickens was inversely related to dietary energy concentratio The experimental findings of Summers et al., (1967) also demonstrated that birds (broiler breeder hens) increase their food consumption greatly when low energy grower diets containing up to 80% of wheat offal and wheat shorts were fed. Lillie and Denton (1966) using 25% of oat hulls in the grower ration also observed increase food consumption but little effect on liveweight gain and maturity.

Feed costs were significantly cheaper on the rations containing either wheat offals or BDG. However, when palm oil was included, feeds costs increased significantly but the diets were still cheaper than the control diets. Feed costs per kilogram gain on the BDG rations were also much higher probably due mainly to the lower weight gain on the rations and also the higher feed wastage observed on these rations. However, the use of industrial by-products in pullet rations based on costs would depend on some factors. For example, Wells (1980) reported that the savings in rearing feed cost when growing pullets are fed diets restricted qualitatively are rather small, being limited to those resulting from the lower costs per unit weight of the diets of reduced quality as compared with the control diets. Similarly Lee et al., (1971) explained that unless these by-products can be obtained for less than 10% of the cost per unit weight of a grower diet, they effectively make the feeding of low energy diets an uneconomical proposition.

There were significant differences between dietary treatments in terms of mortality, probably suggesting that qualitative feed rationing imposed some stress on the birds. The high rate of mortality recorded from the group of starting pullets fed rations containing 10%

BDG replacement of maize with or without palm oil supplementation probably suggests that broiler starters, which were not as affected, can tolerate high levels of BDG better than starting pullets. This study also suggests that it may not be advisable to replace more than 50% of the maize in pullet ration with BDG and all the maize with wheat offals without further experimentation. The level of replacement, especially with BDG should also take cognisance of the age of the birds.

The age to 5% egg production may bear a significant relationship with the liveweight of growing pullets at 20 weeks of age as depicted by the results. The heavier the pullet, the more likely it is for her to attain sexual maturity early.

In the experiments with laying chickens, the replacement of 50% and 62.5% maize with wheat offal resulted in slight but insignificant improved performances than the control ration. However, the replacement of 75% and above of maize with wheat offal and the inclusion of BDG in layers rations at all levels of replacement tested (37.5; 50 and 62.5%) did not improve production parameters and actually depressed productive performance. On the contrary, Kienholz et al., (1963) reported that a diet containing 40% BDG supported excellent laying performance of caged birds. Recent work by Deltoro-Lopez et al., (1981b) had indicated that layer diets containing 15 and 30% BDG appear to be adequate for laying hens and although 45% BDG was acceptable it should not be used without further research due to poor experimental findings. The results of the present study would suggest further research into the use of BDG in layer rations at lower (40% and below) levels of replacement of maize in layer rations. The

rations containing high percentage (75% and above) of wheat offal replacement of maize and more than 30% replacement of the maize with BDG resulted in significantly higher feed consumption, low egg production, low body weight gains, poor feed conversion and consequently reflected low margin per bird income. Since these rations were low in energy contents, the birds ate to satisfy their energy requirements. The observation that feed consumption increased as the dietary energy decreased agree with the finding of Olomu (1976); Olomu and Offiong (1983); and Farrell et al. (1973) who showed that food intake of chickens was inversely related to dietary energy concentration within limits. Generally, a higher feed consumption was observed with the wheat offal based diets than with the BDG based diets. This observation can be attributed to the nutritive value and acceptability of the wheat offal based diets. It also seems quite likely that the degree of feed wastage would increase with decreasing density of the diet (Jackson, 1972) as such consumption data obtained with BDG based diets (which is more dense than wheat offal) was not as high as that of the wheat offal based rations.

There were significant effects of dietary treatments on feed efficiency. The feed efficiency at the highest energy level and the lowest fibre level was significantly better than that at the lowest energy, highest fibre level. The 62.5% replacement of maize with BDG and the complete replacement of maize with wheat offal had the poorest feed conversion efficiencies. In the case of the BDG based diets, excessive wastage of feed was observed. Similar observations were made by Deltoro-Lopez et al. (1981b) who fed high levels (above 60%) of

BDG to laying chickens. According to Ewing (1963) excessive levels of fibre in poultry rations reduce food efficiency, growth, and egg production. He further explained that because of the small size of the caecum of the birds, there is very little opportunity for bacterial digestion to take place. The birds thus select the grains in the ration and throw to waste the bulk of the BDG in the ration, as was observed in the present studies.

Generally, there was an improvement in the rate of lay, the efficiency of food conversion, final body weight and economic margin per bird with increasing level of maize in the rations. This trend of improving biological efficiency of conversion of food to eggs, meat and hence high income per bird with increasing energy levels and decreasing fibre contents of the rations is in agreement with the findings of Kondra et al. (1974). There was no evidence that dietary treatments had any consistent effect on mortality. However livability of birds fed rations containing complete replacement of maize with wheat offal and 62.5% replacement of maize with BDG seem to be improved. It was also noticed that there was a problem of wet droppings with the control rations. The droppings of the groups fed with the rations containing the industrial by-products (wheat offal and BDG) were observed to be drier.

Egg internal quality as depicted by Haugh unit value improved with increasing levels of wheat offal and BDG. Jensen et al. (1976) observed that economic evaluation of BDG for layer diets solely based on metabolizable energy content underestimates their value. The present result shows that the industrial by-product may be useful

in terms of egg quality. In addition, the response of the birds fed the rations in which 50% to 62.5% of the maize was replaced with wheat offal indicated that laying birds could be fed low energy diets without any adverse effects on production parameters. Sykes (1972) and Balnave et al. (1978) observed that laying hens generally consume amounts of feed energy that exceeded their requirements for body weight maintenance and egg production. These authors explain that the excess energy which is converted to fat, represent an inefficient utilization of energy which would be avoided if intake could be regulated to meet the economic requirements of energy more precisely. Ration dilution therefore seems to be the answer to this over-consumption of energy by laying birds fed ad libitum. Furthermore, Smith et al. (1963) postulated that energy intake by laying birds is considerably influenced by temperature; during hot weather it may decreased by 10% and during cold weather increased by 10%. The need to feed high energy layer ration seems more important in the temperate countries with the characteristics low temperature spells at certain times of the year than in the tropics where all the year round high ambient temperatures render the high energy diets of doubtful importance. Therefore, low energy diets can be recommended for laying hens in the tropics. The results of this study suggest that low energy feedstuffs like wheat offal can replace up to 62.5% of maize which is equivalent to 42.25% of maize in the ration for layers without any adervse effects on production parameters while at the same time reducing the cost of the layer feed. If the feedmiller does not reduce his prices of poultry feed after manufacturing feed based on the use of these industrial by-products, then his profit margin would

be higher. However to make such findings have considerable influence on poultry production, the feed miller must reduce his prices in accordance with his cost of production. The poultry producer must also pass the benefit of the reduced poultry feed prices to the consumer.

REFERENCES

REFERENCES

Ademosun, A.A., 1973. Evaluation of brewers' dried grains in the diets of growing chickens. Brit. Poult. Sci. 14:463-468.

Ademosun, A.A., 1974. The use of brewers' dried grains in poultry and pig rations in Nigeria. Proceedings of the the conference on animal feeds of tropical and subtropical origin. London. pp. 331.

Agricultural Research Council, 1975. The Nutrient Requirements of Farm Livestock No 1. Poultry 2nd. Ed. Agricultural Research Council, London.

Albanese, A.A., 1963. Newer Methods of Nutritonal Biochemistry. Academic Press, New York and London.

Alenier, J.C. and G.F. Combs, Jnr., 1981. Effects on feed palatability of ingredients believed to contain unidentified growth factors for poultry. Poultry Sci. 60:215-224.

Almquist, H.J., 1972. Protein and Amino Acids in Animal Nutrition. S.B. Pernick and Co., New York.

Anderson, G.J., C.F. Peterson, A.C. Wiese and C.E. Lampman, 1957. The effect of high level vitamin supplementation of high and low energy rations on egg production and egg shell quality. Poultry Sci. 36:1369-1376.

Asai, R.G. and S.P. Netke, 1971. Wheat offal-groundnut cake ration for poultry. Indian J. Animal Health 71:235-238.

Association of Official Analytical Chemists (AOAC), 1975. Official Methods of Analysis of the A.O.A.C., 11th ed. Washington D.C.

Association of American Feed Control Official (AAFCO), 1976. Feedstuffs 46(36): 111.

Bafi-Yeboa, M., 1977. Brewers' grains as a supplement to weaned heifers. World Rev. of Anim. Prod. 13:71-74.

Balnave, D., D.J. Farrell and R.B. Cumming, 1978. The minimum metabolizable energy requirements of laying hens. World's Poultry Sci. J. 34:149-154.

Bell, J.M., 1960. A comparison of fibrous feedstuffs in non-ruminant rations: effects on growth responses, digestibility, rates of passage and volume of ingesta. Can. J. Anim. Sci. 40:71-82.

Boenker, D.E., L.F. Tribble and W.H. Pfander, 1969. Energy and Nitrogen evaluation of swine diets containing added fat and corn cobs. J. Anim. Sci. 28:615-619.

Bolton, W., 1971. Aspects of Poultry Nutrition in Development of Food Resources and Improvement of Animal Feedings Methods in the CENTO region countries. CENTO conference proceedings pp 107-109.

Boone, M.A. and W.E. Johnston, 1978. Effect of three life time ambient temperature on growth feed and water consumption and various blood components in male and female leghorn chickens. Poultry Sci., 57:798-803.

Carew L.B. Jnr. and F.W. Hill, 1964. Effects of corn oil on metabolic efficiency of energy utilization by chicks. J. Nutr. 83:293-299.

Cave, N.A.C., J.D. Summers, S.J. Slinger and G.C. Ashton, 1965. The nutritional value of wheat milling by-products for the growing chick. 1. Availability of energy. Cereal chem. 42:523-582.

Cherry, J.A., W.L. Beane and W.D. Weaver, Jnr., 1977. The influence of dietary energy on the performance of broilers reared under different lighting regimes. Poultry Sci. 57:998-1001.

Combs, G.F., 1962. The interrelationships of dietary energy and protein in poultry rations. In "Nutrition of Pigs and Poultry". Edited by Morgan J.T. and D. Lewis. Butterworths Scientific Publications, London.

Coulishaw S.J. and D.E. Eyles, 1953. The use of dried clover in the diet of laying hens. Poultry Sci. 37:960-965.

Crampton, E.W. and L.E. Harris, 1969. Applied Animal Nutrition 2nd Edition. W.R. Freeman and Company, San Franscisco pp 237-239.

Cullison, A.E., 1979. Feeds and Feeding. 2nd Edition, Reston Publishing Company, Inc. Reston, Virginia pp 449 and 568.

Dale N.M. and H.L. Fuller, 1978. Effect of ambient temperature and dietary fat on feed preference of broilers. Poultry Sci., 57: 1635-1640.

Dam, R, R.M. Leach, T.S. Nelson, L.C. Norris and F.W. Hill, 1959. Studies on the effect of quantity and type of fat on chick growth. J. Nutr. 68: 615-632.

Damron, B.L., A.R. Eldred and R.H. Harms, 1976. An improvement in interior egg quality by the feeding of brewers dried grains. Poultry Sci. 55:1365-1366.

Davies, R.H., D.E.M. Hassan and A.H. Sykes, 1973. Energy utilization in the laying hen in relation to ambient temperature. J. Agric. Sci. Camb. 81:173-177.

de Andrade, A.N., J.C. Regler, W.R. Featherstone and C.W. Allisten, 1977. Interrelationship between diet and elevated temperature (cyclic and constant) on egg production and shell quality. Poultry Sci. 56:1178-1188.

De Groote, G., 1974. Utilization of metabolizable energy. In Energy Requirements of Poultry: Edited by Morris, T.R. and B.M. Freeman. Poultry Science Symposium, No. 9. 113-134.

Deaton, J.W., J.L. McNaughton and D. Burdick, 1979. High fibre sunflower meal as a replacement for soya bean meal in layer diets. Br. Poultry Sci. 20:159-162.

Deltoro-Lopez, J. and J.L.M. Pascual, 1981a. Influence of the drying process on the composition of brewers dried grains. Anim. Feed Sci. Tech. 6:163-168.

Deltoro-Lopez, J., J.F. Carmona and J.L.M. Pascual, 1981b. Evaluation of brewers dried grains in the diets of laying hens. Anim. Feed Sci. Tech. 6:169-178.

Devendra, C. and C.V. Raghavan, 1978. Agricultural by-products in South-East Asia: Availability utilization and potential value. World Rev. Anim. Prod. 14:11-25.

Din, N.G., M.L. Sunde and H.R. Bird, 1979. Effects of feeding plant by-product diets on growth and egg production. Poultry Sci. 58:1274-1283.

Donaldson, W.E., C.F. Combs and G.L. Romoser, 1956. Studies in energy levels in poultry rations. 1. The effect of calorie-protein ratio of the ration on growth, nutrient utilization and body composition of chicks. Poultry Sci. 35:1100-1105.

Donaldson, W.E., C.F. Combs, G.L. Romoser and W.C. Supple, 1957. Studies on energy levels in poultry rations. 2. Tolerance of growing chicks to dietary fat. Poultry Sci. 36:807-815.

Douglas, C.R. and R.H. Harms, 1976a. The influence of protein level of the grower diet upon subsequent size. Poultry Sci., 55:1593.

Douglas, C.R. and R.H. Harms, 1976b. Influence of added dietary fat and methionine upon egg weight of commercial egg type hens. Poultry Sci., 55:2030-2031.

Dvorak, R.A. and D.J. Bray, 1978. Influence of cellulose and ambient temperature on feed intake and growth of chicks. Poultry Sci. 57:1351-1354.

Dymsza, H., R.V. Boucher and M.C. McCarthy, 1957. The influence of fiber content and physical form of the diet on the energy requirements of turkeys. 2. Studies with growing turkeys 10 to 16 weeks of age. Poultry Sci., 36:914-923.

El-Abbady, M.R., M.I. El-Kotoury, E.M. Omar and M.A. Ibrahim, 1970. The effect of different crude fiber levels on the growth and performance of growing Baladi White chickens. United Arab Republic J. Anim. Prod. 10:199-208.

Eldred, A.R., B.L. Damron and R.H. Harms, 1975. Evaluation of dried brewers grains and yeast in laying hen diets containing various sulfur amino acid levels. Poultry Sci. 54:856-860.

Ewing, W.R., 1951. Poultry Nutrition. 4th Edition. W. Ray Ewing Company Publisher, California.

Ewing, W.R., 1963. Poultry Nutrition. 5th Edition. The Ray Ewing Company Publisher, California.

Fangauf, W., K.W. Klein and G.V. Barlowen, 1956. Wheat offal and wheat feed in all mash rations for chicks. (Archivs fur geflugelkunde. 20:24-34). (Cited from Nutr. Abs. and Rev. 26:3939).

Farrell D.J., R.D. Cumming and J.B. Hardaker, 1973. The effects of dietary energy concentration on growth rate and conversion of energy to weight gain in broiler chickens. Br. Poult. Sci. 14:329-340.

Feltwell, R. and S. Fox, 1978. Practical Poultry Feeding Faber and Faber Ltd, Great Britain.

Ferguson, T.M., C.H. Whiteside, C.R. Creger, M.L. Jones, R.L. Jones, R.L. Atkinson and J.R. Couch, 1961. B-vitamin deficiency in the mature turkey hen. Poultry Sci. 40:1151-1159.

Fetuga, B.L., 1977. The metabolizable energy value of some cereals and cereal-by-products for chickens. West African J. Biol. and Appl. Chem. 20:3-15.

Fuller, B.L. and M. Rendon, 1977. Energetic efficiency of different dietary fats for growth of young chicks. Poultry Sci. 56:549-557.

Fuller, H.L. 1979. The extra caloric value of fat reduced heat increment. "In selected Topics Concerning Feeding and Management of Poultry in Hot Weather. Florida Cooperative Extension Service Gainswille. 43-51.

Gillies, M.T., 1978. Animal Feeds from waste Materials. Noyes Data Corporation, Park Ridge, New Jersey, USA.

Hallsworth, E.G. and J.I. Coates, 1962. The growth of the alimentary tract of the fowl and the goose. J. Agric. Sci. 58:153-162.

Harms, R.H., R.S. Moreno and B.L. Damron, 1969. Evaluation of distillers dried grains with solubles in diets of laying hens. Poultry Sci. 48:1652-1655.

Hill, F.W. and L.M. Dansky, 1954. The effect of dietary energy level on growth and feed consumption. Poultry Sci. 33:112-119.

Hill, F.W., 1956. Studies of the energy requirements of chicken. Evidence for a linear relationship between dietary productive energy level efficiency of egg production. Poultry Sci. 35:59-63.

Hill, F.W. and D.L. Anderson, 1958. Comparison of metabolizable energy and productive energy determinations with growing chicks. J. Nutr. 64:587-603.

Hill, F.W., 1963. The energy values of feeding materials for poultry. In "World Conference o' Animal Production". Roma.

Horani, F.G. and J.L. Sell, 1977. Effect of feed grade animal fat on laying hen performance and on metabolizable energy of rations. Poultry Sci. 56:1972-1980.

Isaachs, R.E., B.L. Reid, R.E. Davies, J.H. Quisenberry and J.R. Couch, 1960. Restricted feeding of broiler type replacement stock. Poultry Sci. 39:339-346.

Jackson N., 1972. Effect of restricting the energy intake of the laying hen, directly and by dilution of the diet, on egg production and the efficiency of energy utilization. J. Sci. Fd. Agric. 23: 413-428.

Jensen, L.S., H.C. Saxona and J. McGinnis, 1961. Nutritional investigatio with turkey hens. iii. Concentration by dietary unidetified factor supplements of deleterious effects of drugs on egg producti in turkeys. Poultry Sci. 40:1524-1525.

Jensen, L.S., C.H. Chang and L. Falen, 1974. Response to lysine supplementation to laying hens fed practical diets. Poultry Sci. 53:1387-1391.

Jenson, L.S., C.M. Chang and D.V. Maurice, 1976. Improvement in interior egg quality and reduction in liver fat in hens fed brewers dried grains. Poultry Sci. 55:1841-1847.

Jenson, L.S., C.M. Chang and S.P. Wilson, 1978. Interior egg quality: improvement by distillers feeds and trace elements. Poultry Sci. 57:648-654.

Jenson, L.S., 1981. Distillers feeds in poultry feeding. Poultry Digest, September issue : 482.

Kare, M.R. and M.L. Scott, 1962. Nutritional value and feed acceptability. Poultry Sci. 41:276-278.

Keay, R.W.J., 1959. An outline of Nigerian Vegetation. 3rd edition. Federal Government Printer, Lagos.

Kent-Jones, D.W. and A.J. Amos, 1967. Modern Cereal Chemistry. Food Trade Press Ltd., London.

Kienholz, E.W., P.A. Thornton and R.E. Moreng, 1963. The use of dried brewers grains in some poultry rations. Poultry Sci. 42:1280-12.

Kienholz, E.W., 1964. Brewers grains as a protein supplement in chicken starter, grower, layer and breeder diets. Feedstuffs May: 34-35, 56-57 and 61-62.

Kienholz, E.W., C.A. Darras and D.D. Caveny, 1972. Small egg size from dried brewers grains. Poultry Sci. 51:1625-1827.

King, J.O.L., 1961. Veterinary Dietetics. A Manual of Nutrition in Relation to Disease in Animals. The Williams and Wilkins Company, Baltimore.

Kissell, L.T. and N. Prentice, 1979. Protein and fiber enrichment of cookie flour with brewer's spent grains. Cereal Chem. 56:261-266.

Kohler, G.O., R.M. Saunders, D.D. Kuzmicky and R.E. Enochian, 1970. Biological availability of nutrients and computer evaluation of millfeeds. Feedstuffs. 42(3):41-43.

Kondra, P.A., J.L. Sell and W. Guenter, 1974. Response of meat-and egg-type chickens to a high fiber diet. Can. J. of Anim. Sci. 54:651-658.

291513

Lee, P.J.W., A.L. Gulliver and T.R. Morris, 1971. Restricted feeding of broiler breeder pullets during the rearing period and its effects on productivity and breeding. Br. Poult. Sci. 12:499-510.

Leeson, S., D. Lewis and D.W. Shrimpton, 1973. Multiple linear regression equations for the prediction of food intake in the laying fowl. Br. Poult. Sci. 14:595-607.

Leeson, S., K.N. Boorman, D. Lewis and D.M. Shrimpton, 1977. Metabolizable energy studies with turkeys Nitrogen correction factor in ME determination. Br. Poult. Sci. 18:373-379.

Leong, K.C., M.L. Sunde, B.R. Bird and C.A. Elvehjem, 1959. Interrelationships among dietary energy, protein and amino acids for chickens. Poultr Sci. 38:1267-1285.

Lillie, R.S. and C.A. Denton, 1966. Effect of nutrient restriction on white leg horns in the grower and subsequent layer periods. Poultry Sci. 45:810-818.

Lloyd, L.L., B.E. McDonald and E.W. Crampton, 1978. Fundamentals of Nutrition. 2nd Edition. W.H. Freeman and Company, San Francisco

Longe, O. and J. Olonilua, 1977. Characterization of the carbohydrate fractions of some fibrous feeds. Nig. J. Anim. Prod. 4:125-131.

March, B., 1980. Layers could still do well on feed based on by-products Poultry Digest June issue. pp 304.

Mauley, J.M., R.A. Voitle and R.R. Harms, 1978. The influence of distillers dried grains with solubles in the diet of turkey breeder hens. Poultry Sci. 57:726-728.

Mitchell, H.H., 1964. Comparative Nutrition of Man and Domestic Animals. Academic Press, New York and London.

Moran, E.T. Jnr., 1978. Influence of starting ration energy-protein ratio and fat content on finish grade of early and late marketed broiler tom turkeys. Canadian J. Anim. Sci. 58:605-614.

Moran, E.T. and J.D. Summers, 1970. Nutritional value of wheat mill feeds. Feedstuffs 42(17) : 26-28.

Morris, T.R., 1968. The effect of dietary level on the voluntary calorie intake of laying birds. Br. Poultry Sci. 9:285-295.

Morrison, F.B., 1959. Feeds and Feeding - A handbook for the students and stockman 22nd Edition. The Morrison Publishing Company, Clinton, Iowa.

Mueller, W.J., 1962. The effect of constant and fluctuating environmental temperature on the performance of laying pullets. Poultry Sci. 40:1562-1571.

Nehring, K. and N. Uhlemann, 1967. Supplementation of milling by-products with animal fat (Archiv furgeflugelkunde. 16:207-212) (Cited from Nutr. Abs. and Rev. 38:6126).

National Research Council, 1971. Nutrient Requirements of Domestic Animals. 1. Nutrient requirements of Poultry. 6th Edition. National Academy of Sciences, Washington, D.C.

Offiong, S.A., J.M. Olomu and I.J. Fulani, 1979. The effects of stocking density on the performance of broiler chickens. Nig. J. Anim. Prod. 6:21-25.

Ogunodedo, B.K. and B. Ogunlola, 1974. Utilization of palm oil, groundnut and melon seed oils by pullets. Br. Poultry Sci. 12:187-196.

Olomu, J.M., 1976. Determination of optimum protein and energy levels for broiler chicks in the tropics. Nigerian J. Anim. Prod. 3:177-183.

Olomu, J.M., 1978. Protein and energy nutrition of poultry in Nigeria. "In Breeds and Nutrition of Poultry in Nigeria. Worlds Poultry Sci. Assoc., Nigeria Branch.

Olomu, J.M and S.A. Offiong, 1979. Determination of protein and energy levels for laying chickens. Annual Report of Research in Animal Production. National Animal Production Research Institute. Ahmadu Bello University, Shika-Zaria. pp 59-62.

Olomu, J.M. and S.A. Offiong, 1980. The effects of different protein and energy levels and time of change from starter to finisher ration on the performance of broiler chickens in the tropics. Poultry Sci. 59:828-835.

Olomu, J.M. and S.A. Offiong, 1983. The performance of brown egg-type layers fed different protein and energy levels in the tropics. Poultry Sci. 62:345-352.

Oluyemi, J.A. and V.A. Oyenuga, 1974. The effects on chicks of varying by supplementation with palm oil, the dietary energy levels in starter diets. West African J. Biol. Appl. Chem. 17:12-17.

Omar, E.H., M.R. El-Abbady, M.I. El-Kotoury and M.A. Ibrahim, 1970. The effects of feeding different crude fiber levels on the growth and performance of White Austrian turkey poults. United Arab Republic J. Anim. Prod. 10;223-232.

Osuji, P.O., 1982. Agro-industrial by-products and animal feeding in the Caribbean Region. World Rev. Anim. Prod. 18:43-56.

Ranjhan, S.K., 1980. Animal Nutrition in Tropics. Vikas Publishing House, PVT Ltd., New Delhi.

Reddy, C.V., 1975. Utilization of by-products in poultry feeding in India. World. Rev. Anim. Prod. 11:67-72.

Reid, B.L., 1979. Feeding and management practices for improving performance in hot weather. In Proceedings of the Florida Nutrition Conference, St. Petersburg Beach, Florida.

Renner, R. and F.W. Hill, 1961a. Utilization of fatty acids by the chicken. J. Nutr. 74:259-264.

Renner, R. and F.W. Hill, 1961b. Factors affecting the absorbability of saturated fatty acids in the chick. J. Nutr. 74:251-258.

Saunders, R.M., and G.O. Kohler, 1972. In vitro determination of protein digestibility in wheat mill feeds for monogastric animals. Cereal Chem. 49:98-103.

Saunders, R.M., M.G. Walker, Jnr. and G.O. Kohler, 1974. Food uses of wheat and its products. In "Wheat Production and Utilization". AVI Publishing Co. Inc. Westport, Connecticut.

Scott, M.L., M.C. Neshein and R.J. Young, 1971. Nutrition of the chicken. M.L. Scott and Associates, Ithaca, New York.

Scott, M.L., 1974. Poultry feeding and management in the tropics. In Animal Production in the Tropics. J.K. Loosli, V.A. Oyenuga and G.M. Babatunde editors ed. Heinemann Educational Books Nigeria Ltd., Ibadan.

Sell, J.L. and O.J. Thompson, 1965. The effect of ration pelleting and fat level on the efficiency of nutrient utilization by the chicken. Br. Poultry Sci. 6:345-354.

Sell J.L., W.J. Owings and R.J. Hasiak, 1978. Influence of dietary metabolizable energy and ME: nutrient ratio on growing turkeys. Poultry Sci. 57:1161-1162.

Sell, J.L., 1979. Use of supplemented fat to improve productive efficiency of poultry. In "Selected Topics Concerning Feeding and Management of Poultry in hot weather. Florida Cooperative Extension Services, Gainsville.

Sell, J.L., G. Tenesaca and G.L. Bales, 1979. Influence of dietary fat on energy utilization by laying hens. Poultry Sci. 58:900-905.

Sibbald I.R. and S.J. Slinger, 1963. A biological assay for the ME in poultry feed ingredients together with findings which demonstrate some of the problems associated with evaluation of fats. Poultry Sci. 42:313-325.

Sibbald I.R., 1978. The metabolizable energy value of mixtures of tallow with either soybean oil or lard. Poultry Sci. 57:473-477.

Sibbald I.R., 1979. Metabolizable energy evaluation of poultry diets. In "Recent advances in Animal Nutrition. Edited by Haresign and D. Lewis Butterworths. pp 35-49.

Sklan D., 1979. Digestion and absorption of lipids in chicks fed triglyceride or free fatty acids; synthesis of monoglycerides in the intestine. Poultry Sci. 58:885-889.

Smith A.J., 1971. The productivity of laying pullets at high environmental temperatures. Feedstuffs 43(17) : 26.

Smith, G.M., C.C. Payne and D. Lewis, 1963. Energy, protein balance in layer ration. Notthingham School of Agriculture Report, Nottingham.

Stanley, R.W., and S.M. Ishizaki, 1982. Local by-products as feeds for dairy cattle. 1. High-energy, high fiber supplements. Research Report 223, Hawaii Agricultural Experimental Station. College of Tropical Agriculture, University of Hawaii.

Steel, R.C.A. and J.R. Torrie, 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company Inc., New York, Toronto and London.

Sugandi, D., H.R. Bird and D. Atmadilaga, 1975. The effect of different energy and protein levels on the performance of laying hens in floor pens and cages in the tropics. Poultry Sci. 54:1107-1114

Sugandi, D., H.R. Bird, J. Wahju and R. Anggorodi, 1978. Poultry feed formulas based on ingredients indigenous to the tropics. Poultry Sci. 57:740-746.

Sullivan, T.W., J.R. Kuhl and D.P. Holder, 1978. Evaluation of brewers dried grains and yeast in turkey diets. Poultry Sci. 57:1329-1

Summers J.D., W.F. Pepper, S.J. Slinger and J.D. McConachie, 1967. Feeding meat type pullets and breeders. Poultry Sci. 46:1158-1164.

Sundo, M.L., 1956. A relationships between protein level and energy level in chick ration. Poultry Sci. 35:350-354.

Sykes, A.H., 1972. Energy cost of egg production. In "Egg Formation and production. Edited by Freeman B.M. and P.E. Lake. Poultry Science Symposium No 8 :187-196.

Taylor, L.W. and I.M. Lerner, 1939. Effect of varying levels of wheat offal on age at sexual maturity (Poultry Sci. 18:323-326) (Cited by Nutr. Abs. Rev. 1940:3851). Vo. 9:3851.

Thormann, W.W., 1966. Some special problems in poultry production in developing countries. World Rev. Anim. Prod. 4:87-95.

Thornton, P.A., 1962. An improvement in growth and egg production in chickens fed brewers dried grains. Feedstuff: April issue pp 50, 62.

Treat, C.M., B.L. Reid, R.E. Davis and J.R. Couch, 1960. Effect of animal fat and mixtures of animal and vegetable fats containing varying amounts of free fatty acids on performance of caged layer Poultry Sci. 39:1550-1555.

Vermeersch, G. & F.Vanschoubroek, 1968. The quantification of the effect of increasing levels of various fats on body weight gain, efficiency of feed conversion and feed intake of growing chicks. Br. Poultry Sci. 9:13-20.

Waldroup, P.W., B.L. Damron and R.H. Harms, 1966. The effect of low protein and high fiber grower diets on the performance of broiler pullets. Poultry Sci. 45:393-402.

Waldroup, P.W., W.D. Brunsell and Z.B. Johnson, 1976. Attempts to control body weight gains of growing broiler breeder females with high fiber diets. Poultry Sci. 55:1118-1120.

Waldroup, P.W., 1982. Distillers dried grains plus solubles. Poultry Digest. December issue. pp 602.

Wells, R.G., 1963. The relationship between dietary energy level, food consumption and growth in broiler chicks. Br. Poult. Sci. 4:161-168.

Wells, R.G., 1980. Pullet feeding systems during rearing in relation to subsequent laying performance. In Recent Advances in Animal Nutrition. Edited by W. Haresign. Butterworths. London - Boston.

Williamson, H.A. and C.R. Grau, 1958. Food intake and utilization of lysine deficient protein by the chick in relation to the digestive energy concentrations of the diet. J. Nutr. 59:243-250.

Young, R.J., 1961. The energy value of fats and fatty acids for chicks. 1. Metabolizable energy. Poultry Sci. 40:1225-1233.

A P P E N D I C E S

APPENDIX I

Amino acid profile of yellow maize, wheat offal and brewers' dried grains used in ration formulation (% air dry basis)

Amino Acid	Yellow Maize	Wheat Offal	BDG
Alanine	0.72	0.78	0.95
Arginine	0.49	1.21	0.95
Aspartic acid	0.58	1.25	1.32
Cystine	0.51	0.95	0.98
Glutamic acid	1.60	3.27	3.37
Glycine	0.37	0.91	0.82
Histidine	0.39	0.74	0.58
Isoleucine	0.31	0.55	0.77
Leucine	1.19	1.14	1.60
Lysine	0.31	0.89	0.83
Methionine	0.15	0.20	0.29
Phenylalanine	0.55	0.80	1.16
Proline	0.87	1.16	1.74
Serine	0.44	0.74	0.79
Threonine	0.32	0.58	0.70
Tryptophan	0.47	0.57	0.68
Valine	0.41	0.80	1.01

APPENDIX 2

Analysis of variance for weight gain, feed consumption, feed efficiency, feed cost/kg wt. gain and mortality for Trails 1, 2, 3 and 4.

Source of variation[1]	DF[1]	Mean squares				
		Weight gain	Feed Consumption	EFC	Feed cost/kg wt. gain	Mortality
Trial 1						
T	8	112417.99	169982.78	5.303	0.0550	100.00
E	18	561.08	4471.30	0.0087	0.0019	5.093
Trial 2						
T	8	9825.79	20378.17	0.3144	0.0491	34.259
E	18	893.58	3785.15	0.0320	0.0022	12.037
Trial 3						
T	8	346232.41	212092.82	5010.10	48.032	49.199
E	18	1647.52	9613.02	6604.67	70.625	12.269
Trial 4						
T	8	52733.22	22077.54	0.7275	0.0186	0.9259
E	18	4349.07	12428.13	0.0493	0.0029	0.9259

[1] T = Treatment; E = Error; DF = degrees of freedom.

APPENDIX 3

Analysis of variance - Experiments with chicken pullets (0 20 weeks)

Source of variation	DF[1]	Mean squares				
		Body wt[2]	Feed cons[2]	EFC[2]	Feed cost[2]	Body wt
T	6	4736.18	0.0279	0.4463	0.0164	61698.41
E	14	183.19	0.0080	0.0344	0.0003	1913.38
		Feed cons	EFC	Feed cost	Mortality	Age to 5% prod. days
T	6	0.9478	8.1077	0.4713	32.540	629.540
E	14	0.1525	0.4900	0.0030	9.631	11.238

[1] T = Treatment, E = Error, DF = Degrees of Freedom

[2] Production parameters measured at 8 weeks of age.

APPENDIX 4

Analysis of variance - Experiments with growing pullets (8 - 20 weeks)

Source of variation	DF[1]	Mean squares						
		Body wt	Feed cons	EFC	Feed Cost	Feed Cost/ kg gain	Mortality	Age to 5% prod. days
T	6	107069.56	0.2534	20.941	0.4839	0.3168	17.654	503.270
E	14	2819.10	0.0994	1.045	0.0040	0.4294	7.143	10.191

[1] T = Treatment, E = Error, DF = Degrees of Freedom

APPENDIX 5

Analysis of variance - Laying chicken experiment (wheat offal treatments)

Source of variation	DF[1]	Mean squares						
		HDP	HHP	Feed cons	Feed/doz. eggs.	Feed cost/ doz. eggs	Initial body wt.	Final body wt.
T	5	437.626	421.603	987.016	20.396	0.1458	0.0011	0.1163
E	24	19.707	20.067	13.992	1.058	0.0236	0.0083	0.0057
		Mortality	Margin/ bird	Haugh Unit	Egg wt	Yolk Index	Shell thickness	
T	5	62.497	69.092	26.941	3.536	0.0002	0.0005	
E	24	20.833	1.840	9.968	3.497	0.0005	0.0002	

[1] T = Treatment, E = Error, DF = Degrees of freedom

APPENDIX 6

Analysis of variance - Laying chicken experiment (BLV Treatment)

Source of variation	DF[1]	Mean squares						
		FDF	HHP	Feed cons	Feed/doz. eggs	Feed cost/ doz eggs	Initial body wt	Final body wt.
T	3	1265.94	1064.54	139.444	32.030	0.5600	0.0011	0.2298
E	16	22.86	24.59	25.821	2.423	0.1063	0.0425	0.0069
		Mortality	Margin/ bird	Haugh unit	Egg wt.	Yolk index	Shell thickness	
T	3	61.310	158.957	10.355	6.300	0.0002	0.0017	
E	16	13.846	2.304	15.660	1.794	0.0005	0.0003	

[1] T = Treatment, E = Error, DF = Degrees of Freedom.

APPENDIX 8

Monthly egg production of layer fed rations containing BDC replacing maize (4 week - intervals)

Level of replacement	T_1 0		T_2 37.5%	
Age of birds (weeks)	No of eggs	HDP	No of eggs	HDP
32	8.9	46.2	7.7	37.8
36	15.2	55.0	8.6	43.0
40	17.6	62.8	16.6	59.2
44	16.7	59.4	19.4	69.7
48	15.7	56.0	12.7	47.5
52	18.1	65.1	12.8	45.6
56	18.0	64.3	12.0	44.6
60	19.7	64.1	9.6	53.0
Total	129.9		99.4	
Average	16.2	58.7	12.4	50.1

Level of replacement	T_3 50%		T_4 62.5%	
Age of birds (weeks)	No of eggs	HDP	No of eggs	HDP
32	5.4	26.2	3.8	18.5
36	6.8	26.5	4.1	16.7
40	13.4	48.1	8.6	31.2
44	13.7	49.0	7.4	26.4
48	4.6	22.5	5.7	20.7
52	11.2	40.5	5.5	19.9
56	11.3	40.3	5.7	20.8
60	9.0	32.3	5.2	23.3
Total	75.4		46.0	
Average	9.4	35.6	5.8	22.6

[1] No of eggs/bird/month (HDP)