Thesis Title

STUDIES INTO THE NUTRITIVE VALUE AND USE OF ENERGY AND PROTEIN FEEDSTUFFS FOR POULTRY IN GHANA.

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By

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DECLARATION

I do hereby, declare that except for other peoples work which have been qouted and acknowledged, this work is my own original research, and this thesis has not been presented for another degree elsewhere, either in part, or as a whole.

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DEDICATION

This Thesis is dedicated to the memory of my late father C.F. Banini, my mother Madam Afivor Banini and my family Beatrice, Kweku and Fafali

ABSTRACT

This study was conducted to evaluate energy and protein feedstuffs for poultry.

Proximate composition was estimated and metabolizable energy also investigated in experiments I and II respectively. Sorghum and Soybean oil meal were also evaluated as main energy and protein sources replacing maize and fish meal respectively for broilers in experiment III. Experiment III was conducted as a 3x3 factorial in a randomized complete block design with three replicates (blocks). There were three levels of sorghum (ie sorghum (100%); sorghum-maize (46 - 54%); no sorghum (0%)) and three levels of soybean oil meal (ie soybean meal (100%); soybean meal-fish meal (50% - 50%); fish meal no soybean (0%)). Most of the values obtained in experiments I and II conformed to values obtained in literature, with few variations. On basis of energy sources, in experiment III no significant differences ($p < 0.05$) were observed with reference to daily weight gain, feed consumption and feed conversion efficiency. One kg of the maize diet was more expensive than 1 kg of the sorghum diet. It also cost 23.84 cedis more for birds on the maize diet to gain 1 kg live weight than birds on the sorghum diet. Birds on the fish meal diets gained significantly ($p > 0.05$) lower weights than birds on other protein diets. But with regard to feed intake and feed conversion no significant differences were observed among protein treatments. Fish meal diets were more expensive than soybean oil meal diet, and it cost 27.54 cedis more for birds on fish meal diet to gain 1 kg live weight than birds on soybean oil meal diets.

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CHAPTER 1

INTRODUCTION

Protein foods are important commodities for proper nourishment of the population of any country. Thus, the provision of affordable animal products is one of the surest ways of obviating protein malnutrition which is observable in Ghana.

To succeed in doing this means that there should be increased animal production, particularly of poultry and pigs at a lower cost. For these species are also known to be prolific and fast growing.

However, the production of poultry and pigs in most developing countries like Ghana is constrained by a number of factors, among which include the inherently low productivity of the local animals, reduced availability of the major feedstuffs such as maize and fish meal at certain periods of the year and high cost of the feed ingredients as a result of competition between man and animals for the major feed ingredients.

Another constraint contributing to the low productivity and inefficient production of poultry is the use of inaccurate and unreliable proximate and bioavailable energy data for diet formulation. An accurate measurement of energy and nutrient requirements demands adequate knowledge of these values of feedstuffs (Sibbald, 1982).

It is therefore not appropriate to rely heavily on derived nutrient composition data from other areas particularly when most ingredients of plant origin show considerable nutritive variability.

Furthermore the problem of over-dependence on maize and fish meal as the main energy and protein sources can be overcome if good substitutes for them are found. Possible alternatives to maize and fish meal are sorghum and soybean oil meal respectively.

Sorghum is the second highest cereal produced in Ghana (FAO, 1988). It has the potential to be produced on commercial basis, and because its proximate composition is similar to that of maize, it is extensively used as a livestock feed in the United States of America and other large sorghum producing areas (Kramer, 1959).

Soybean oil meal being a by-product and vegetable protein source is relatively cheaper than fish meal. More so, it possesses a better balanced amino acid profile and is particularly high in lysine to supplement cereal diets compared to other vegetable protein sources (Scott et al, 1976).

With regard to the problem of use of unreliable data for feed formulation, there is the need to investigate the nutritional composition of the locally available feed ingredients. Though some results of proximate components of most of the local feed ingredients have been documented (Buamah, 1969; Owusu-Domfeh et al, 1970; Watson, 1971, Food Research Institute, 1975) investigation of ingredients used in poultry feeds in Ghana is limited. There is therefore, the need for a study of local feed ingredients as sources of energy and protein in poultry diets.

The objectives of this study were:

(a) to investigate proximate composition of some poultry feed ingredients,

(b) to determine the metabolizable energy of poultry feed ingredients investigated in 'a'.

(c) to evaluate two of the ingredients investigated in 'a' and 'b'. ie. sorghum and soyabean oil meal as main sources of energy and protein for poultry in Ghana.

CHAPTER 2

LITERATURE REVIEW

2.1 EVALUATION OF FEED INGREDIENTS

Nutritive assessment of feed ingredients is made possible by either chemical analysis for nutrients ie carbohydrate, protein, fat, vitamins and minerals or feeding trial which gives an indication of the availability of these nutrients and hence the performance of the animals.

Chemical analysis of feed ingredients is normally carried out according to the Association of Official Analytical Chemist (A.O.A.C, 1975), methods of analysis. With analysis of ingredients for monogastrics, emphasis is put on their contents of dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE), ash, calcium and phosphorous. By this method the potential usefulness of a feed ingredient is measured and this enables one to classify it as protein, or carbohydrate feedstuff.

Though the chemical analysis scheme gives an index of nutritional value of a feedstuff, it is not precise and is associated with inaccuracies in the measurement of the various fractions (Crampton and Harris, 1969; Macdonald et al, 1987). Therefore, estimates of the ability of an animal to digest, absorb and metabolise the nutrients of the feed are still required.

2.2 METABOLIZABLE ENERGY (ME) OF FEED INGREDIENTS

i. BIOLOGICAL DETERMINATION OF ME. OF FEED INGREDIENTS

Usable energy of a feed for farm animals is conveniently expressed as digestible energy (DE), metabolizable energy (ME) or net energy (NE). But for poultry, energy content of a diet is more appropriately expressed in terms of ME than either DE or NE, because ME has the following advantages over DE and NE,

a. ME determination is associated with low variations and hence high precision of estimation could be achieved.

b. No surgical operation is carried out on the birds which requires expertise as is done in DE, determination.

c. ME determination is faster than NE

d. Less expensive equipment is required than in NE determination (Hill and Anderson, 1958; Sibbald et al, 1960; Foster, 1968; Miller, 1974).

Various biological procedures including both direct and indirect methods have been used in determining the ME of a feedstuff.

The indirect methods provide a way to estimate energy when laboratory facilities such as a bomb calorimeter is unavailable. In a review Sibbald (1982) enumerated the various indirect assays by grouping them under the following headings:

- Biological (Yoshida and Morimoto, 1966,1970)
- Physical (Lockhart et al, 1961; Sibbald and Slinger, 1963a)
- Chemical (Carpenter and Clegg, 1956; Bolton, 1962; Titus, 1958).

However, these methods have found little use in predicting an acceptable ME values of an ingredient.

The direct methods which are the conventional methods, involve two main procedures, viz total collection or the use of an indicator. These methods relate quantitatively the excreta output to the feed consumed (Vohra 1972).

The total collection procedure involves taking records of total feed intake and quantitative collection of excreta. However, several researchers such as Manoukas et al (1964), Shannon and Brown (1969) have reported of difficulties in the drying of faeces without any loss of nitrogen and energy. Compounding this problem is the fact that spilled feed, feathers and scales tend to contaminate the excreta giving a wrong estimate of gross energy of the faeces.

To overcome the energy losses during drying of faeces, Fenner and Archibald (1959) recommended the use of primer in determining the energy of fresh faeces. The two most commonly used primers are cellulose and polythylene. As regards the type of primer to use, Fleischer et al (1981) found polyethylene film (Pef) to be better than cellulose.

To reduce nitrogen losses it is recommended that few drops of concentrated sulphuric acid be added to the faeces to acidify it before drying (Fleischer et al, 1981). Terpstra and Janssen (1975) also recommended the use of mature birds in the determination to reduce the down feather and scale contamination of faeces.

With the indicator method, a physiologically inert indicator material is fed together with the diet. Then the concentration of the indicator is measured in both the feed and faeces. This helps to avoid problems of fluctuating moisture levels in the feed and faeces. It also eliminates the need for measurement of feed intake and total collection of faeces thus reducing the amount of faeces which has to be stored and prepared for analysis. Though Sibbald et al (1960) considered it to be more precise because they found the standard errors associated with the method to be lower, Halloran (1972) found the procedure to be associated with considerable intra-and-inter-laboratory variations.

In order to lessen the load of work, Farrel, (1978) adopted a modified total collection method by training adult cockerels to consume voluntarily their daily feed requirements within one hour, to determine ME of several feed ingredients. Feed intakes were measured and faeces voided during the subsequent 24 hours is collected for analysis. This method makes the analytical load to be minimal and the test material required small. This method is also faster and less expensive and the precision achieved is as high as with other conventional methods. Farrel (1978) for instanceobtained a standard deviation ranging from 0.00-0.06kcal/g only.

Even though many birds could not be trained to eat their feed requirements in one hour, and those that are trained immediately reduce their intakes when novel feeds are offered (Schang and Hamilton, 1982), nevertheless this technique has been used in the present ME determination because of the associated advantages of this method which far outweigh the problems.

ii. FACTORS THAT INFLUENCE ME. DETERMINATION

Several reports indicate that ME values vary with the type of assay birds used. For example, Slinger et al (1964) found differences between chicken and turkey, whilst Sugden (1974) observed differences between chickens and ducks and observed these differences were not more than 11%. Several other authors also have reported of very small (about 1 - 2% of the mean) differences in ME values between chickens of different breeds and strains (Sibbald and Slinger, 1963b; Foster, 1968; and Proudman et al, 1972). Evidence that ambient temperature affects ME values is neither consistent nor conclusive (Peterson et al, 1969; Olson, 1970, 1971; Davis et al, 1972). However, it is known that sex does not have an influence on determination of ME (Mueller et al, 1956; Sibbald and Slinger, 1963d; and Begin, 1967).

ME values of feedstuffs show small but significant increases as assay birds mature, with the change being greatest for fibrous and low energy materials (Sibbald et al, 1960b; Lockhart et al, 1963; Zelenka, 1968; 1973a,b). For practical situations the change is assumed to be negligible (Bayley et al, 1968a; Farrel, 1978). Adult roosters are advocated for use in ME determinations (Sibbald and Price, 1975). This is because as birds mature they approach nitrogen equilibrium and therefore there is no need to correct for variable nitrogen retention between birds, hence reduction in analytical load. Adult birds are also less influenced by imbalance in nutrient of the feedstuffs.

Feed intake has been observed to influence ME values (Muztar and Slinger, 1980); Guillaume and Summers, 1970). This is because at low feed intake, endogenous urinary energy (EuE) and metabolic faecal energy (MfE) losses assume higher proportion of excreta losses, causing variation in ME values with the varying intake levels. It was in recognition of the effect of these endogenous energy losses that Farrel (1978) suggested that birds used in ME assay should consume at least 70 g of feed/bird/day, if these influences are to be minimised. However this was not readily achieved with White Leghorn cockerels (Schang and Hamilton 1982). On the other hand Guillaume and Summers (1970) also showed that birds should take in at least 45 g/day/bird in order to satisfy their maintenance requirements.

The errors associated with estimating the ME values of a test ingredient are determined by the level of inclusion in the diet. The higher the inclusion the smaller the error. Most often it is assumed that the ME value is constant for all levels of inclusion, and that the ME value of the diet is the sum of the values of its proportional parts. But the results of a number of multi-level assay to evaluate various materials have proved otherwise and varying values reported. (Sibbald et al, 1962b; Porter et al, 1962; Vohra and Kratzer, 1970; Rose et al, 1972). Nevertheless some reports indicate that apparent metabolizable energy (AME) values are not influenced by the level of inclusion for feed ingredients such as cereals, sunflower meal, rapeseed meal, and fish meal

(Sibbald et al, 1962a; Stutz and Matterson, 1964; Rao and Clandinin, 1970; Rose et al, 1972).

The highest level of inclusion of multi-level assays reported has been up to 45%, (Porter et al, 1961; Vohra and Kratzer, 1970). Much of the variation in ME values reported for individual feedstuffs can also be attributed to differences in experimental procedures and in the methods of calculating the result (Miller, 1974). This is because the precision achieved in the quantitative estimation of faeces voided corresponding to feed consumed is a factor that causes variation in ME values.

ME being a biological measurement is dependent on the interaction between the animal, its food and its environment. Therefore, factors that affect or enhance the digestion and assimilation of nutrients would in the final analysis influence ME values. Upon this basis, March et al (1972) found that antibiotics effect in the digestive system of the bird enhances ME values of feedstuffs.

Other factors which have been proved to influence ME are, nutrient imbalance (Sibbald et al, 1961, 1962b; Gardiner et al, 1968; Rojas and Scott, 1969; Nelson and Miles, 1973), and pelleting of test diet (Moran et al, 1968; Bayley et al, 1968b; Cave et al, 1965, 1968).

2.3 ENERGY AND PROTEIN SOURCES

i. SORGHUM AS A SOURCE OF ENERGY

Feed cost constitute the largest single cost in animal production and for many years accounted for 70-75% of poultry production cost (John, 1976). Consequently the objective of the animal nutritionist has been to find and recommend the most acceptable, properly balanced and least expensive ration available to feed animals.

Generally with poultry the diets offered are based on cereals with maize as the principal source of energy. But maize is also a more utilised staple food by man than sorghum which is the second highest cereal produced in this country (FAO,1988). The sole dependence on maize as the main energy source has become uneconomical due to scarcity and increased price level at certain periods of the year (ie February - June).

Though the production of sorghum is about 40% that of maize, presently, encouraging expansion of its production side by side with maize production could reduce the over reliance on maize to feed poultry and would be of much help to cut down poultry feed cost in the long run.

Grain sorghums are excellent feed for all classes of livestock (Kunkel, 1959). Thus, in large sorghum producing areas like the USA, it is extensively used as livestock feed (Kramer, 1959). The nutritional significance of sorghum is seen in its high content of energy in the form of digestible starch and its low fibre content (ie. 72-82% and 1.4 - 2.9% respectively Oyenuga, 1959;

Buamah, 1969; Watson, 1971; and Ncube, 1981).

Despite the nutritional value of sorghum, the full utilization of some of the varieties as a store of energy and protein is limited by certain factors inherent in the grain. These include the following:-

a. the presence of polyphenolic compounds (tannin) located in the testa layer of grain. They are known to have an astrigent taste which affects palatability and decreases feed consumption. Also the phenolic compounds act as enzyme inactivators and form complexes with proteins reducing their digestibility.

b. presence of phytic acid which is the form in which phosphorus is stored in sorghum (de Boland et al, 1975), chelates di-and tri-valent cations rendering them unavailable for use by the animal (Davies and Nightingale, 1975).

ii, SORGHUM GRAIN FEEDING TRIAL FOR POULTRY

Grain Sorghum is generally preferred for poultry rations by poultry producers in the grain sorghum producing areas (Kramer, 1959). Cost, availability of the grain and general good results from its use are major reasons for this preference (Rasper, 1967).

Tests by Berry (1954) and Adolph and Grau (1956) demonstrated that grain sorghum could successfully replace at least a part, if not all, of the maize in layer diets.

Ozment et al (1963) reported that sorhgum and maize were equal in nutritive value when fed to broilers on an equivalent nutrient basis.

Sanford (1963) also obtained non-significant differences in growth rate of broilers when maize and sorghum were used as energy sources. He however observed differences in acceptability by chicks between the cereals used and between the sorghum varieties. He recommended a combination of 25 parts sorghum and 30 parts of maize as giving the best growth rates.

Sykes (1967) reported on several feeding trials initiated with the objective of comparing the use of various protein supplements in layers rations based entirely on grain sorghum and maize as energy sources. The trials were conducted on light hybrid layers and the results related to the laying performance from either twenty to sixty weeks old (Trial 1) or from twenty to seventy weeks old (Trial II) hens. Results of the two trials showed that there was no difference in performance between birds on the grain sorghum ration and those of the maize. There was no evidence of reduction in feed intake by birds on sorghum ration. The author concluded from these trials that grain sorghum may be used in rations for layers as partial or complete replacement for other cereals on the basis of its known nutrient composition. Chavez, de Mathew and Reid (1966) reached the same conclusions that on equal nutrient basis, sorghum can replace other cereals completely.

Tests conducted to determine feeding value of different rations of corn and sorghum in pelleted and non-pelleted forms for broilers showed that there were no significant differences in growth rate of chicks fed diets containing corn, sorghum or any combination thereof, if only diets of the same physical form were taken into consideration. Pelleting however, gave additional growth response. Feed utilization was very similar for pelleted and non-pelleted feeds (Stephenson and Johnson, 1960).

Serban et al, 1978 studied the behaviour of biochemical values in serum of meat chicken when sorghum replaced maize in the diets. In this trial eight week old chickens were given diets based on rations of which 25%, 50%, 75% or 100% of the maize ration was replaced by sorghum alone, with lard or with lard and methionine supplements. When the birds were killed after 56 days there were no significant differences among groups in protein, glucose, total lipid, cholesterol chloride, phosphorus, calcium, sodium and potassium in the serum. Activity of aspartate aminotransferase and alanine aminotransferase in serum were generally similar for the groups.

The feeding value of grain sorghum in relation to their tannin content has been extensively studied in trials with chicks. In a series of experiment Chang and Fuller (1964) showed that tannin did lower the feeding value of grain sorghum. The high tannin content resulted in growth retardation which was similar in magnitude to that caused by feeding equivalent levels of tannic acid as such. Chang and Fuller (1964) also showed that a dietary deficiency of methionine and choline accentuated the growth depression caused by feeding high tannin grain sorghum; and that adding high levels of methionine and choline overcame this apparent toxicity.

The high tannin content of some varieties and hybrids of grain sorghum has very often been associated with the darker colour of seed coats. Grain sorghum varieties with brown seed colour and open heads, which are found to be suitable to growing conditions in humid areas, are characteristically higher in tannin than the red and yellow varieties which predominate in the more arid regions. Thayer et al, (1957) compared several varieties of grain sorghums, selected because of their seed colour, with yellow corn and found that most varieties tested were equal to corn in growth promoting value and efficiency of feed utilization for growing chickens. These results showed that seed colour was not a reliable measure in determining the relative feeding value of a given variety.

Therefore, local conditions, grains prices and feeding habits will determine the value of using grain sorghum in poultry rations. But indications are that in most cases grain sorghum can replace maize when adequate supplementation of vitamin A is made.

iii, SOYBEAN OIL MEAL AS A SOURCE OF PROTEIN

The protein needs of poultry are the sum of the minimal essential amino acids required and the additional digestible nitrogen for synthesis of non essential amino acids. Since birds cannot synthesise the essential amino acids on their own, the major feed ingredients serve as the source of these amino acids. Therefore the ability of a protein ingredient to supply essential amino acids needs of the bird makes it a quality protein source.

Well processed animal protein has over the years been regarded as an excellent protein source for poultry compared to plant protein. This is because protein from plant sources are characterised by deficiencies of some of the most required essential amino acids viz, lysine, sulphur aminoacids and tryptophan, hence limiting their use. But among the plant proteins, soyabean oil meal has been found to be unique in that it is rich in all the essential amino acids except the sulphur containing amino acids (Snetsinger and Scott, 1958; Cernyl et al, 1971; Scott et al, 1976). Thus the protein of properly processed soyabean oil meal is well utilized by all species of farm animals and may even be used as the sole source of protein when combined with protein of cereal grain and supplemented with the limiting amino acid ie. methionine (Almquist et al, 1942; Bornstein and Lipstein, 1975, Craven and Herder, 1976).

Despite the nutritional value of soyabean oil meal as a unique protein source, the full utilization of the meal is limited by the following nutritional defects:

a. Soyabean oil meal is essentially devoid of Vit B12 unlike fish meal. Supplements are therefore necessary when soyabean oil meal replaces commonly used animal products (Terrill et al; 1954).

b. The meal has low content of minerals. Though it has a fair source of phosphorus, much of it is in phytin form, thus it is not efficiently utilized by monogastrics (NAS-NCR, 1977).

c. The raw soyabean has a trypsin inhibitor present in it which can limit the utilization of the oil meal in poultry diets if the raw bean is not heat treated properly (Hayward, 1951).

iv, SOYBEAN OIL MEAL FEEDING TRIALS FOR POULTRY

Many investigations have indicated that inclusion of a minimal percentage of fish meal in a chicken ration, which has soyabean oil meal as the principal protein supplement is necessary for maximum chick growth and egg production.

Some of the early work on supplementing soyabean oil meal for chick growth was done by Christiansen et al (1940) who obtained exceptionally good growth of chicks when 3-4% of fish meal was combined with soyabean oil meal in the rations.

Heuser and Norris (1944) from their experiments, concluded that for optimum growth and feed utilization efficiency of chicks up to eight weeks of age, a ration deriving its supplementary protein chiefly from soyabean oil meal should contain a minimum of 2-3% of animal protein concentrates.

Patton et al (1946) failed to produce optimum growth in chicks on corn-soyabean oil meal diet supplemented with DL-methionine, and concluded that such a diet appeared to be lacking in an unknown growth factor which they felt was present in fish meal. Also a number of investigators have shown that the inclusion of 3-4% of sardine, whitefish meal or menhaden in an adequate ration with soyabean oil meal as the principal protein supplement causes significant improvement in growth of baby chicks (Whitson et al, 1945; McGinnins and Carver, 1947 as quoted by Hayward 1951).

On the other hand, Marvel et al (1945), found that a simplified ration of yellow corn, soyabean oil meal, distillers dried solubles, alfalfa leaf meal, vitamins and minerals, produced growth in chick equal to similar rations containing meat scraps and dried skim milk. They concluded that animal protein per se, was not needed as a supplement to soyabean oil meal in chick starter ration provided it contained essential mineral and vitamins.

Bird (1948) also concluded that a combination of properly heated soyabean oil meal and grain supplemented with minerals and vitamins was able to supply all the protein and other nutrient needs of the chicken.

In another investigation with layers, Whitson et al (1946) concluded that soyabean oil meal could serve as the sole protein concentrate in layer rations if its mineral and vitamin deficiencies were corrected.

Card (1942) found no significant differences in the hatchability of eggs produced by hens fed on a mash containing 25% of soyabean oil meal and those produced by hens without the oil meal in the mash.

Anderson et al (1968) obtained significantly greater weight gains and feed utilization efficiency in brioler chicken with corn-soyabean meal diet than with either herring or anchovy meal diets, when the fish meals provided 5% of the protein.

Other investigations have also proved that excessive use of anchovy fish meal in replacement of soyabean oil meal causes depressive effects on growth of chicks. For example, Waldroup et al., (1965) replaced 25, 50, 75 and 100 per cent of the soyabean oil meal in a practical diet with anchovy fish meals and menhaden fish meal. No significant differences were observed in body weight or feed utilization when 25 and 50 per cent of the soyabean protien was replaced with fish meal. Replacement of 75% of the soyabean with fish meal significantly depressed body weight of broilers at eight weeks of age. All the types of fish meals significantly depressed growth when they replaced all the soyabean meal protein in the diet.

Janssen (1971) reported that gizzard erosion was found in groups of chicks receiving rations with high percentage of Peruvian anchovy fish meal, with the effect proportional to the percentage of fish meal in the ration. Higher levels of the fish meal also depressed body weight.

At present anchovy fish meal, though expensive is more available than soybean meal and widely used in all parts of the country in the formulation of poultry feeds. For this reason, availability and cost would be the determinant factors in the sole use of soyabean oil meal as a source of protein.

CHAPTER 3

EXPERIMENT ONE

DETERMINATION OF PROXIMATE COMPOSITION OF SOME POULTRY FEED INGREDIENTS

3.1 INTRODUCTION:

Feed is the largest single cost in animal production, and it accounts for 70-75% of poultry production cost (John, 1976). To reduce feed input cost, one has to use more accurate and reliable chemical composition values to estimate requirements and to formulate rations. This is only possible by having adequate knowledge of the chemical composition of feed ingredients that are produced and available locally.

Therefore the main objective of this study was to determine the proximate composition of some feedstuffs which are locally produced and or are available in Ghana.

3.2 MATERIALS AND METHODS

i, Feed Ingredients:

The feed ingredients used in the study were white maize, yellow maize,sorghum, wheat bran,rice bran,maize bran,fish meal (anchovy, spp),soyabean oil meal (solvent extraction), groundnut cake(mechanical extraction) and copra cake (solvent extraction).

ii, Sources of Feed Ingredients

White and yellow maize, copra cake, fish meal and imported Soyabean oil meal were obtained from the Agricultural Research Station, Legon. However the white and yellow maize were obtained from Techiman in the Brong Ahafo region. Sorghum was obtained from the "Timber market" in Accra but it actually came from Bimbilla in the Northern region. The groundnut cake was obtained from Secap Vegetable Oil Mill (Labadi-Accra). The wheatbran was obtained from Tema Food Complex Company, the rice bran was obtained from Agricultural Research Station, Kpong, and the maize bran from a corn milling shop at Nima-Accra.

iii, Laboratory Analysis

Samples of the feed ingredients were first ground in a hammer mill, to enable the ground samples pass through 1 mm sieve. The samples were stirred to mix well and then stored in labelled containers in the deep freezer. The samples were only removed when analyses were to be carried out. The ingredients were analysed for moisture content, crude protein (CP), crude fibre (CF), ether extract, ash, calcium and phosphorus according to the methods of A.O.A.C. (1975). Triplicate analyses were done and the average recorded.

3.3 RESULTS

i, Energy concentrates

White maize, yellow maize and sorghum were similar in their proximate composition (Table 1).

All the three feed ingredients had high nitrogen free extract (NFE) (80-81.6%), low crude protein (9.9 - 11.3%) and low crude fibre (2.01 - 2.73 %).

Though sorghum was very similar in composition to maize, it contained slightly more protein but less oil than maize. The ash content of sorghum (1.92%) was lower than the range of 2.2 - 3.5 % reported in the literature (Crampton and Harris, 1969; Buamah, 1969; NAS-NRC, 1977; Fetugah et al, 1979 and Ncube, 1981). The 0.21 % level of phosphorus obtained was similar to values obtained by Buamah, (1969); Watson, (1971) and Ncube, (1981) carried out in Ghana but lower than the 0.31-0.35% reported by Crampton and Harris, (1969); Owusu-Domfeh et al; (1970), NAS-NRC, 1977; Fetugah et al, (1979).

ii. Cereal Brans

The moisture content of maize bran was 15.79%. This is higher than values ever recorded in Ghana.

The protein value of 13.8% for the maize bran was similar to that reported by Buamah (1969) but higher than that reported by Crampton and Harris (1969). Maize bran also had a high nitrogen free extract, and coupled with its relatively low fibre content, makes it a good energy source for poultry.

The wheat bran is higher in protein, ether extract, ash and calcium values but lower in crude fibre, nitrogen free extract and phosphorous than values reported in literature especially those

TABLE 1

PROXIMATE COMPOSITION OF POULTRY FEED INGREDIENTS (DRY MATTER BASIS) g/100g

FEED INGREDIENTS	DRY MATTER	CRUDE PROTEIN	ETHER EXTRACT	CRUDE FIBRE	ASH	NITROGEN FREE EXTRACT	CALCIUM	PHOSPHORUS
1. WHITE MAIZE	87.9	9.9	4.40	2.70	1.40	81.60	0.023	0.33
2. YELLOW MAIZE	87.5	10.1	4.24	2.30	1.80	81.56	0.020	0.30
3. SORGHUM	89.3	11.3	3.85	2.01	1.92	80.92	0.034	0.21
4. MAIZE BRAN	84.2	13.8	11.20	5.30	4.42	65.29	0.120	0.44
5. WHEAT BRAN	87.7	19.7	4.52	10.19	5.33	60.20	0.170	1.17
6. RICE BRAN	90.1	14.1	19.00	6.70	10.45	49.75	0.110	1.19
7. FISH MEAL	85.6	74.9	5.75	0.64	16.29	2.42	3.180	2.42
8. SOYBEAN OIL MEAL	88.4	46.8	0.72	11.45	7.90	33.13	0.340	0.75
9. GROUNDNUT MEAL	89.0	53.7	8.96	2.90	4.75	29.69	0.218	0.43
10. COPRA MEAL	94.1	22.1	13.40	10.00	7.00	47.50	0.217	0.65

reported by (Crampton and Harris, 1969; NAS-NRC, 1977).

Rice bran has very high ether extract value (19.02%) compared to 3.3% reported by Buamah, (1969) in Ghana and 13% reported by NAS-NRC, (1977). The fibre content of rice bran (6.7%) was quite low compared to value of 12% and 11.4% reported by Lynn (1969) and NAS-NRC (1977) respectively. The value obtained in the present study was similar to the value of the unadulterated rice bran obtained by Buamah (1969) in this country. The value of 1.1% for phosphorus in rice bran obtained is lower than the 1.5% reported in the literature (Buamah, 1969; NAS-NRC, 1977).

iii. Protein Concentrates

Among the ingredients in this group, fish meal (Anchovy sp) was clearly the best protein and mineral concentrate. Its high protein (74.9%) and mineral contents (16.29%) and the low fibre and nitrogen free extract values were similar to values recorded by Crampton and Harris, (1969); Owusu-Domfeh et al, (1970); NAS-NRC (1977). The protein value was however higher than those reported by Fetugah et al, (1977) and Ncube, (1981).

Among the vegetable protein sources analysed copra cake by its composition, was the least nutritious. It had the least protein content (22.1%) and a high fat content (13.4%).

Soybean oil meal used in the present study had a higher level of fibre content (11.5%) than values (5.6 - 7.3%) reported in the literature reports (Crampton and Harris, 1969; NAS-NRC, 1969, 1977; and Fetugah et al, 1979). The other proximate component values obtained for soybean meal were however in agreement with those reported by Crampton and Harris, (1969), NAS-NRC, (1969, 1977), Fetugah *et al.*, (1979) and Ncube, (1981).

Groundnut cake was also characterised by higher crude protein (53.7), lower ether extract (8.96%) and lower fibre content than values reported by Buamah, (1969) and Owusu-Domfeh *et al*, (1970). It also had lower values for phosphorus (0.43%) and higher values for calcium (0.22%) than those reported by NAS-NRC, (1969, 1977), Buamah (1969) and Owusu-Domfeh *et al*, (1970).

DISCUSSION

Cereal grains are by far the most important energy sources for livestock feeding. This is due to their high nitrogen free extract and low fibre content. Among the cereal grains , maize is the most commonly used for poultry. Its energy and proximate composition is commonly used as a standard with which other energy sources are compared.

In this study, the nutrient composition of sorghum compared favourably with that of maize and can therefore serve as an alternate energy source to maize. However, some varieties of sorghum contain tannins which affect their nutritional value and also negatively correlate with their metabolizable energy content (Equiarte, 1976).

The low phosphorus content of sorghum obtained was similar to values reported in Ghana (Buamah, 1969; Watson, 1971 and Neube, 1981) and this could be attributed to the low phosphorus level in soils in Ghana (Acquaye, 1963 and Ahenkorah, 1967).

Though the nutrient composition of yellow and white varieties of maize are similar, the high carotene content in the former makes it preferable for use in the preparation of layer's feed, if it is more avialable, as it will enhance the yellowness of egg yolk.

The moisture content of maize bran was quite high, and might pose a problem if it is to be used on a large scale; if it is not properly dried, it cannot store well. This is because feeds containing more than 14% of moisture easily grow mouldy, and this affects their nutritive value (Crampton and Harris, 1969). The high nitrogen free extract coupled with relatively low fibre content of maize bran makes it a good source of energy for poultry.

Wheat bran had a high content of protien and minerals, making it a good feed ingredient for livestock. However, the fibre content of 10.0% obtained was high enough to limit its use in monogastric nutrition. Buamah (1969) pointed out that wheat bran has been used up to 5% in chick starter ration and 15% in chicken layer and breeder rations without decrease in feed efficiency.

Rice bran mostly obtainable on the Ghanaian market has been observed to be very high in crude fibre content. In an analysis Boamah (1969) reported the following values for this type of rice bran: crude protien (5.8%); crude fibre (26.7%); ether extract (5.8%). But the composition of true rice bran reported in literature (Lynn, 1968; Crampton and Harris, 1969; NAS-NRC, 1977) were as follows: crude protein (14-14.8%); ether extract (14-16%) and crude fibre (12-12.5%). The levels of nutrient composition obtained in this study were comparable to values reported elsewhere in literature outside this country. The only exception was crude fibre content of 6.7% which was low about half of the value cited in the literature for true rice bran.

The low crude fibre value obtained for rice bran in this study might be attributed to excessive polishing of the grain. The study has also proved that true and unadulterated rice bran is obtainable on the Ghanaian market for use in poultry and livestock feeding.

With regards to the protein concentrates, the main outstanding feature of fish meal (Anchovy spp) in this study was its high moisture content, which was higher than those reported in literature (Crampton and Harris, 1969; Buamah, 1969; Owusu-Domfeh et al, 1970; NAS-NRC, 1977; Ncube, 1981). The high miosture level might be due to inadequate processing before storage. This can therefore limit the storage period.

The high fat content of copra cake obtained in this study has confirmed the reports of Buamah (1969). This could be predispose copra cake to oxidative rancidity. It may therefore be necessary to add some anti-oxidant to feeds containing copra cake at high levels, to prevent the risk of destruction of vitamins due to the oxidative rancidity.

The soybean oil meal in this study was an imported feed ingredient and the very high fibre content obtained is not a common feature of the ingredient (NAS-NRC, 1977). It was therefore difficult to ascertain reasons for the high fibre level.

The high protein, relatively low fat and fibre content of groundnut cake make it a valuable protien supplement for all livestock and poultry. This ingredient can therefore be used at high levels in poultry rations without serious ill-effects except for the risk of afflatoxin toxicity in contaminated products.

CHAPTER 4

EXPERIMENT TWO

BIOLOGICAL DETERMINATION OF METABOLIZABLE ENERGY (ME) OF SOME POULTRY FEED INGREDIENTS

4.1 INTRODUCTION :

Of all the nutrient components that constitute the feed of poultry, energy component alone forms about 70% of the feed. This amounts to over 40% of the total cost of production of poultry. More so energy has been the basis for estimating the requirements of the other nutrients for proper feed formulation (Crampton, 1964). This is so because many animals eat to satisfy their energy requirements.

Thus reduction of the bioavailable energy input cost, through the use of more accurate bioavailable energy value to estimate requirements and to formulate rations, offers the greatest potential for decreasing production cost. In addition improved diet formulation will increase the efficiency with which other nutrients are utilised thereby leading to further cost reductions.

In Ghana, data on bioavailable energy of the local feed ingredients for poultry is limited. This has led to overreliance on National Academy of Science and National Research Council data or those quoted from outside the country for feed formulation. Obviously, this procedure is not the best and could lead to discrepancies in nutrient composition of the feed formulated for poultry in the country (Adarkwah-Ntiamoah, 1985).

Therefore to enable one to have control over productivity of poultry it is necessary to continue to investigate the bioavailable energy of poultry feed stuffs, because it is by so doing that detailed and accurate knowledge of the necessary data would be available for use.

Hence, the objective of this study was to determine the ME values of the poultry feedstuffs listed in experiment one.

4.2 MATERIALS AND METHOD

i, Diets : A basal diet was formulated. Forty percent of the basal diet was substituted for the test ingredients listed in experiment one. because this level of inclusion was within the range of levels used by other workers (Porter *et al*, 1961; Vohra and Kratzer, 1970). The composition of the basal diet and eight test diets are shown in Table 2.

ii, Birds and Management:

Adult roosters, of Shaver starcross (SX) 288 and 579 strains weighing 2kg to 3.2kg were used in this experiment. They were first trained to consume their daily ration in one hour each day. This was accomplished by feeding the roosters on a mash diet for decreasing time intervals over a period of four weeks. At the end of the training period five of them were put in individual cages, for a week to get used to the cages, before feeding of the assay diets started. The feeding of the assay diets usually took place between 7am and 8am daily. Sheets of paper were spread beneath each cage during feeding time to collect spilled feed. Amount of feed consumed was estimated everyday for each bird.

Each assay test diet was fed to the five birds for four days. Faeces were collected during the last three days. The feeding of the assay test diets followed one after the other through to the ninth diet.

Table 2

COMPOSITION OF TEST DIETS FOR THE ROOSTERS

	Basal Diet	Sorghum	Rice bran	Maize bran	Wheat bran	Copra meal	soybean meal	white maize	fish meal
White Maize	88.5	53.10	53.10	53.10	53.10	53.10	53.10	53.10	53.10
Fish meal	8.0	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80
Dical PO_4	1.25	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Vit/Min Mix	1.00	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Salt	0.25	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Oyster shell	1.00	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
White Maize	-	-	-	-	-	-	-	40	-
Sorghum	-	40	-	-	-	-	-	-	-
Rice bran	-	-	40	-	-	-	-	-	-
Wheat bran	-	-	-	-	40	-	-	-	-
Maize bran	-	-	-	40	-	-	-	-	-
Copra meal	-	-	-	-	-	40	-	-	-
Soybean meal	-	-	-	-	-	-	40	-	-
Fishmeal	-	-	-	-	-	-	-	-	40
Total	100	100	100	100	100	100	100	100	100

iii. Experimental design:

The randomised complete block design was used with five replicates as blocks. Each bird was regarded as a block. The treatment consisted of the various test diets.

iv. Faeces: Collection and Treatment:

At the end of each day's feeding period, the papers spread beneath the cages were withdrawn and replaced with polythene sheets for faecal collection. The faeces associated with the previous day's feeding were collected over the next 24 hours, weighed, wrapped in polythene and stored in a deep freezer until analysis were done. Between 80-100g of the pooled samples were later dried in an oven at 45°C after adding few drops of concentrated sulphuric acid to acidify the samples, and thereby help minimise nitrogen and energy losses (Fleischer *et al*, 1981). The moisture content was determined after drying at 45°C for one week.

vi. Gross Energy Analysis (GE).

Gross energy was later determined on the fresh faeces using a polyethylene film (pef) primer (Fleischer *et al*, 1981). Gross energy was also determined on the test diets and test ingredients using an adiabatic oxygen bomb calorimeter.

vii. Calculation of ME :

The ME value of diets were computed from gross energy values of test diets, faeces together with urine and feed intake as:

$$ME_{Diet}(kcal/g) = \frac{GE_{intake} - GE_{faeces}}{\text{Feed Intake (FI)}} \qquad -(1)$$

$$ME_{ingredient}\ (kcal/g) = \frac{ME_T - ME_B\ (1-P)}{P} \qquad -(2)$$

where ME_T = Metabolizable energy of test diets
ME_B = Metabolizable energy of basal diet

P = level of inclusion of ingredients in the basal diet.

4.3 RESULTS

i. Feed Intake of Test Diets:

The mean values of feed intake of test diets are shown in Table 3. Feed intake per rooster was least for copra cake test diet (37.25 g/bird/day) and highest for white maize (78.34g/bird/day). Generally the cereal grains (maize and sorghum) recorded higher feed intake values (ie 78.34 and 71.18 g/bird/day) than the other diets. Among the cereal brans, wheat bran recorded the lowest intake. (44.84 g/bird/day). With regard to the protein concentrates, copra cake was least eaten, however the feed intakes for the cereal brans and protein concentrate diet were similar.

Statistical analysis of feed intake values indicated significant differences between roosters and between assay diets ($P<0.01$) shown in Table 3. For most of the assay diets feed intakes by SX 579 roosters were higher than those of SX 288 roosters Appendix 1).

ii. ME of Test Diets and Test Ingredients

The values of ME of assay diets and ingredients are shown in Table 3. There were significant differences ($P<0.05$) of ME values between diets and non-significant differences of ME values of diets between roosters. Also there were significant differences of ME

TABLE 3

Mean Feed Intake and ME of basal and Test Diets and ME of Test Ingredients

Diet/Ingredient	Feed Intake of Diet	ME of Assay Diet ± SD Kcal/g	ME of Ingredient ± SD Kcal/g
Basal	56.18	3.024 ± 0.07	-
White Maize	78.34	3.384 ± 0.08	3.835 ± 0.21
Sorghum	71.18	3.321 ± 0.02	3.768 ± 0.14
Maize bran	55.52	3.031 ± 0.09	3.042 ± 0.17
Rice bran	62.04	2.770 ± 0.16	2.389 ± 0.34
Wheat bran	44.84	2.495 ± 0.27	1.702 ± 0.66
Fish meal	54.08	2.915 ± 0.09	2.752 ± 0.12
Soybean oil meal	61.52	2.829 ± 0.31	2.352 ± 0.42
Copra cake	37.28	2.417 ± 0.22	1.508 ± 0.45

values between test ingredients and non-significant of ME values of ingredient between roosters (Appendix 4 and 5).

The ME values of the cereals in this experiment ie, white maize and sorghum were higher than those of the cereal brans and the protein ingredients. These high ME contents reflected their high NFE values reported in experiment one.

Among the brans studied, maize bran registered the highest ME value, (3.042 kcal/g) and this was largely because of its high NFE and low fibre content compared to those of rice bran and wheat bran, and also its high ether extract compared to that of wheat bran.

Whilst the ME value of fishmeal was similar to values reported in literature, those of copra cake and soybean oil meal were lower than values reported in literature (Crampton and Harris, 1969; NAS-NRC, 1969, 1977).

DISCUSSION

Level of feed intake influences metabolizable energy values obtained by ME determination (Guillamme and Summers, 1970; Farrel, 1975; Muztar and Slinger, 1980). This is because at low feed intake ie. below maintenance requirements metabolic faecal energy losses assume a higher proportion of excreta losses causing a reduction in ME value of feedstuffs. But at high level of feed intake, ie. above maintenance requirement, it ceases to have effect on ME values (Farrel 1975).

To overcome the effect of endogenous urinary and metabolic faecal losses Farrel (1978), suggested that an average weight of 3 kg assay bird should consume about 70 g of feed per day. Shang and Hamilton (1982), found that this was not readily achievable with light birds like White Leghorn cockerels.

In the present study mean feed intake of four out of five birds used fell below the 70g suggested by Farrel (1978). This is because the SX 288 strain of birds used were light weight birds and hence they ate less. Also with the exception of copra cake diet, the birds ate enough of the other diets to satisfy their maintenance requirements of 45 g/bird/day as suggested by Guillaume and Summers (1970). The value 71.18 g of sorghum diet intake in this study was similar to the 71.63 g recorded by Ncube, (1981) who also used the same procedure, similar basal diet and similar size birds.

The non-significant differences on ME values between the assay birds agreed with published results (Sibbald and Slinger, 1963;

Foster, 1969) which indicated that there were no differences of ME values between different strains and breeds of layer birds. It was also observed that though differences in feed intake between the assay birds were highly significant, differences in ME values between the birds were non-significant. This observation shows that variation in feed intake did not have any significant effect on ME values obtained which is contrary to the observations of either Guillaume and Summers (1970) or Muztar and Slinger (1980). These two groups of authors demonstrated that AME values diminished with increasing feed intake. Nevertheless, the variation in feed intake which did not have any significant effect on ME values obtained agreed with findings of Hill and Anderson (1958) who reduced chick feed intake to as little as 30% of ad libitum and found no change in dietary ME values. The possible explanation to these contrasting reports is that at very low level of feed intake dietary ME value is influenced but as feed intake rises, within a certain range, the influence of feed intake on dietary ME diminishes (Farrel, 1978). Therefore the level of feed intake recorded in this study may have fallen within the range where influence of feed intake on ME is minimal.

Among the outstanding ME values of the ingredients was the high ME of maize bran. This was largely because of its high nitrogen free extract and low fibre content compared to the other brans (ie. wheat and rice brans). And also its high ether extract compared to that of wheat bran. Considering the rice bran and wheat bran their ME contents were found to be higher than values obtained in literature (NAS-NRC, 1969, 1977). The proximate composition of these brans also showed that rice bran had higher values found in literature (NAS-NRC, 1969, 1977;Crampton and Harris, 1969). The lower value of ME of soybean oil meal and copra cake could be related to their higher fibre and lower NFE content reported in Experiment one in this study compared to what was reported in literature (Crampton and Harris, 1969; Owusu-Domfeh et al, 1970; NAS-NRC, 1969, 1977). This is because a feedstuff must first be digested and absorbed to be a useful source of energy. And since fibre is not digested to any appreciable extent by poultry, high fibre content of an ingredient is most likely to affect the level of its ME (McDonald et al 1987).

CHAPTER 5

EXPERIMENT THREE

BROILER PERFORMANCE ON DIETS WITH SORGHUM AND SOYBEAN OIL MEAL AS ENERGY AND PROTEIN SOURCES.

5.1 INTRODUCTION

In Ghana maize and fish meal have been the major feed ingredients that serve as sources of energy and protein for poultry. The overreliance on these ingredients has led to spiralling cost of feed production during the lean periods when they are in short supply. Often cheaper ingredients ie. cereal bran and copra cake are also used to cut down cost of producing feed but their use is also limited due to their nutrient composition. Sorghum and soybean oil meal have been suggested as good substitutes for maize and fishmeal respectively because sorghum has a high content of available energy and soybean oil meal is also high in essential amino acids.

Many investigations have shown that there are no significant differences between the growth rate of chicks fed with diets containing sorghum and those fed with maize or with a combination of sorghum and maize (Stephenson and Johnson, 1960; Chavez et al, 1966; Sykes, 1967).

Other investigations have also indicated that animal protein per se is not needed as supplements to soybean oil meal in poultry ration provided the limiting amino acid in such diets ie. methionine and minerals and vitamin are well supplied, (Marvel et al, 1945; Bird, 1948; Anderson et al, 1968; Bonstein and Lipstein, 1975). Nevertheless, some investigations had contrasting views as far as the use of sorghum (Chang et al, 1964) and soybean oil meal (McGinnins and Carver, 1947) were concerned.

For this reason, the purpose of this study was to observe the response in growth and feed efficiency of broiler when part or all of corn and fish meal were replaced with sorghum and soybean meal.

5.2 MATERIALS AND METHODS

i, Location of the Experiment : The feeding trial was carried out on the University of Ghana, Agricultural Research Station (ARS) Legon.

ii, Diets : The composition of the treatment diets as well as their calculated ME, Crude protein, lysine and methionine values are shown in Table 4. Treatment diets had maize and/or sorghum as the main energy sources and fish meal and/or soybean oil meal as the main protein sources. The diets were formulated to be iso-nitrogenous and iso-caloric with an average energy: protein ratio of 131.8 kcal/kg/% CP, which has been recommended for poultry by Nesheim et al, (1969). Methionine which is the most limiting amino acid in soybean oil meal diets was included at levels indicated to satisfy the requirements of the birds. The requirements of calcium and phosphorus were also met by including appropriate levels of oyster shell and dicalcium phosphate. Minerals and vitamins mixture and salt were also added to fortify the diets with most of the required vitamins and mineral elements. Soybean oil was added to some of the treatment diets to help bring the energy level of those diets to the required energy level, thus making the diets iso-caloric.

iii, Birds and Management

Since space was limited the trial was carried out one replicate at a time. Broiler birds were used as the experimental animals. They were brooded until they were twenty-five day old, before they were put on the experimental diets. There were nine treatment diets with ten birds per treatment. Each feeding trial lasted 4 weeks. At the start of each trial the birds were weighed and distributed into groups of ten so that the average weight per group was similar. The treatment diets were randomly assigned to the groups.

Each group was put in a pen, 1.5 m x 3.5 m in dimension. Feed and water were provided *ad libitum*. Faecal material was removed from the feeders every morning before fresh feed was added. The birds were weighed in groups at weekly intervals and average weight gains calculated. Records were also taken of the weekly feed consumption and from this feed conversion efficiency was calculated. The birds were given the usual preventive medication as required for healthy growth.

iv, Experimental Design: A 3x3 factorial in a randomized complete block design was used.There were three replicates (blocks). The treatment consisted of all combinations of three levels of sorghum

Table 4

The composition of treatment Diets in Experiment 3

	MAIZE			MAIZE +SORGHUM			SORGHUM		
	Fish meal FM	FM + Soybean	Soybean Meal	Fish meal FM	FM + Soybean	Soybean Meal	Fish meal FM	FM + Soybean	Soybean Meal
Soybean oil	-	-	1.25	-	-	1.40	-	-	1.70
Maize	61	60	55	33	32.5	30	-	-	-
Sorghum	-	-	-	29	28.5	25	63	62	54.4
Wheatbran	15.75	6.65	-	14.75	5.65	-	13.75	4.65	-
Fishmeal	21	10.5	-	21	10.5	-	21	10.5	-
Soybean meal	-	19	38.25	-	19	38.10	-	19	38.40
Oyster shell	.25	.50	.75	.25	.50	.75	.25	.50	.75
Dical PO_4	.75	2.0	3.25	.75	2.0	3.25	.75	2.0	3.25
Vit/Min Mix	1	1	1	1	1	1	1	1	1
Salt	.25	.25	.25	.25	.25	.25	.25	.25	.25
Methionine	-	.10	.25	-	.10	.25	-	.10	.25
Total	100	100	100	100	100	100	100	100	100
M.E.(kcal/kg)	2838.9	2837.1	2849.7	2842.8	2842	2844.6	2843.7	2844.5	2839.5
C.P.%	21.5	21.5	21.67	21.5	21.5	21.65	21.5	21.5	21.8
ME/CP(kcal/kg)	132	132	131.5	132.2	132.2	131.4	132.3	132.3	130.3
Lysine %	1.27	1.25	1.25	1.26	1.24	1.24	1.25	1.24	1.25
Methionine %	.55	.56	.61	.53	.53	.59	.50	.51	0.56
Calcium %	1.07	1.08	1.10	1.07	1.08	1.09	1.07	1.08	1.10
Phosphorous %	1.00	.99	1.00	.99	.98	1.00	.98	.98	1.00

and three levels of soybean oil meal in the diets. The levels were:-

Sorghum: 0%; 46%; 100%

Maize : 100%; 54%; 0%

Soybean oil meal: 0%; 50%; 100%

Fish meal : 100%; 50%; 0%

v, Data Analysis : The data on live weight gains, feed consumption and feed conversion were subjected to analysis of variance. Treatment means between various protein diets which showed significance were differentiated using Duncan's multiple range test. All tests of significance were based on 5% level of probability.

5.3 **RESULTS**

ii. Weight Gain: Average daily weight gains of chicks as influenced by energy and protein are shown in Table 5. Birds on maize, sorghum and the combination of the two had mean weight gains of 39.4, 38.9 and 40.0 g/bird/day respectively. The differences obtained between diets were small and not significant ($P<0.05$).

Marked differences in daily weight gains based on protein sources (ie. 37.5 g for fish meal, 40.1 g soybean oil and 40.6 g for the combination of the two sources) were obtained and found to be statistically significant ($P<0.05$). It was observed that chicks fed fish meal diet consistently had lower weight gain than either

Table 5

Daily Weight Gains, Feed Intake, Feed Conversion Efficiency, Cost per Kilogram weight gain and cost per kilogram of feed as influenced by Energy and Protein Sources.

Parameters	ENERGY SOURCES			PROTEIN SOURCES		
	Maize	Maize + Sorghum	Sorghum	Fish meal	Fish meal + Soybean meal	Soybean meal
Daily Weight Gain(g/bird/day)	39.4_a	40.0_a	38.9_a	37.6_b	40.6_a	40.1_a
Feed Intake (g/bird/day)	107.6_a	107.0_a	107.1_a	106.2_a	108.3_a	107.8_a
Feed Conversion Efficiency	0.37_a	0.38_a	0.37_a	0.36_a	0.38_a	0.38_a
Cost per kg weight gain ¢	467.20	445.71	443.36	472.62	438.60	445.09
Feed cost per kg of feed ¢	170.76	166.26	161.04	168.04	164.58	165.44

NOTE: All figures bearing the same subscripts are not significantly different. Cost per kg wt gain and feed cost per kg of feed do not have subscripts because they were not subjected to analysis of variance.

soybean diets or soybean - fish meal combination diets. Statistically non-significant differences (P<0.05) of weight gains (Appendix 6) were observed for the interaction effect of energy and protein sources.

ii, Feed Consumption : Average daily feed intake as influenced by energy and protein sources is shown in Table 5. The feed intake by birds on maize, sorghum and maize-sorghum combination were 107.6, 107.1 and 107.0 g/bird/day respectively. The differences obtained were small and non-significant (P<0.05).

Differences in feed intake based on protein sources (ie. 106.2, 107.8 and 108.3 g/bird/day for fish meal soybean oil meal and fish-soybean meals respectively) were non-significant (P>0.05). However fish meal diet alone showed lower feed intake which agrees with the results of Avila and Balloun (1974) who observed low levels of feed intake were non-significantly associated with high levels of anchovy fish meal.

Non significant difference of feed intake were also recorded for energy and protein interaction.

iii. Feed Conversion Efficiency: Feed conversion efficiency of the birds as influenced by energy and protein sources is shown in Table 5. No significant (P>0.05) differences were found among the energy sources (.37, .38, .37 for maize, sorghum-maize and sorghum respectively). With regard to protein sources, the results were not statistically significant (P>0.05) (.38, .38, .36 for soybean,

soybean-fish meal and fish meal respectively).

iv. Cost Analysis: The cost per kilogram weight gain and per kilogram of feed are shown Table 5. With regard to the energy source, it costs more for the chicks on maize diet to gain 1 kilogram of live weight (₵467.20) than for those on sorghum (₵443.36). Also with regard to protein sources, gain of 1 kilogram live weight was more expensive for fish meal diets (₵472.62) than with soybean oil meal diets (₵445.09). It was therefore observed that it costs more for chicks on maize and fish meal diets to gain 1 kilogram of live weight than chicks on sorghum and soybean oil meal diets. Analysis of cost of 1 kilogram of feed showed that 1 kg of the maize diet was more expensive (₵170.76) than sorghum diet (₵161.04). And 1 kilogram of fish meal diets also cost more (₵168.04) than soybean oil meal diets (₵165.44).

v. Mortality: During the period of the trial, three birds died. Two died as a result of snake bite and the third through fowl pox disease.

DISCUSSION

In this study, maize was compared with sorghum, while fish meal was compared with soybean oil meal as alternative sources of energy and protein respectively.

The non-significant differences in weight gain obtained between sorghum and maize diets agreed with the findings of Ozment et al (1963) and Sanford (1963) who reported similar observation with a similar treatments. The ratio of weight gained by birds on sorghum diet to those on maize diet was .987. This ratio is higher than the range of values (.90 - .95) reported in literature (Peo and Hudman, 1958; Schruben, 1959). High tannin sorghum is known to retard growth rate of chicks and this effect is only overcomed by inclusion of high levels of methionine and choline in the ration (Chang, Sang and Fuller, 1964). Since growth rates in this study for maize and sorghum were similar, perhaps the variety of sorghum used was the low tannin type, or the inclusion of methionine which helped to limit the tannin effect if it was present at all.

The differences in feed intake obtained for sorghum and maize diet were small and non-significant. This was expected since diets were formulated to be iso-caloric and iso-nitrogenous. Chicks normally tend to regulate their feed intake primarily on the basis of dietary energy content provided other factors such as palatability, physical states, nutrient adequacy and accessibility to the feed are not limiting. All this factors did not appear to have posed any problem to the birds.

The non-significant differences of feed conversion effeciency of the sorghum and maize diet was expected since weight gained and feed intake of these diets did not differ from each other.

With regard to the protein sources, significant differnces were recorded between fish meal and soybean oil meal diet for weight gained but the differences in feed in fish intakeand feed conversion efficiency were non-significant. This growth depression observed in birds on fish meal diets agreed with the findings of Waldroup et al (1965); Avila and Balloun (1974), who also reported of a depression in the growth of chicks fed diets containing only anchovy fish meal as the main source of protein compared to those fed on soybean oil meal diet. On the contrary, Griffith and Schexnailder (1971) indicated that growth of chicks recieving anchovy fish meal was significantly greater than that of chicks fed on corn-soybean oil meal diet.

The good performance of birds on soybean oil meal diet agreed with the findings of Bonstein and Lipstein (1975) who observed that adequate inclusion of methionine in cereal soybean oil meal diet, makes such diets nutritionally adequate and complete to supply all the necessary essential amino acids required by the chicken. The results of this study indicated that methionine supplemented soybean oil meal protein was superior to anchovy fish meal as a protein source.

Differences in feed intake based on protein sources, were non-significant. However, fish meal alone showed lower feed intake which agrees with the results of Avila and Balloun (1974), who observed that low levels of feed intake were non-significantly associated wilth high levels of anchovy fishmeal in the diet.

The non-significant differences in feed intake recorded for energy and protein interaction, showed that the utilization of sorghum was not limited by its combination with a particular protein source. Similarly, the consumption of methionine supplemented soybean oil meal was also not linked to a particular type of energy source.

Observations from this experiment showed that the sole use of achovy fish meal as a source of protein for broiler chicken, was not very helpful to their body weight gain and feed efficiency. It may be better to use well supplemented soybean oil meal as the sole source of protein. This is because when anchovy fish meal is fed at high dietary concentrations, it tends to increase feed required per unit weight gained (Waldroup et al, 1965; Avila and Balloun,1974). This was why it was more expensive for birds on fish meal diet to gain one kilogram of live weight than with birds on supplemented soybean oilmeal diet.

Though maize and fish meal diets are more expensive than sorghum and soybean oil meal diets, they are the most used in the country as poultry feed ingredients. This may be because regardless of cost, they are more available. Thus, an increased availability of sorghum and soybean is a necessary prerequisite if they are to replace maize and fish meal as ingredients in broiler diet.

CHAPTER 6

GENERAL DISCUSSION AND CONCLUSION

The major nutrients that constitute the bulk of rations fed to poultry are carbohydrate and protein. Though other nutrients such as vitamins and minerals are also very important, they only form a very small proportion of the diet. As such, they may be ignored when substituting one feed-stuff for another under practical feeding conditions (Ashton and Olsen, 1971). In addition, there are commercially prepared vitamins-mineral premixes which are not too expensive and are available for obviating any problem that may arise as a result of the substitution effects of feed ingredients.

Most often, animal nutritionists aim at finding cheaper but acceptable energy and protien feedstuffs that may be acceptabdle for replacing more expensive ones in the diets of animal. Thus, to get an effective and suitable feedstuffs for use as a substitute demands a thorough knowledge of their nutritive value. Three main levels of nutritive assessment are recognised: First is the chemical composition, which is a measure of the ingredients potential usefulness. Second, is the bioavailability of the nutrient which estimates the ability of the animal to digest, absorb and metabolise nutrientls. And finally, feeding trial which gives an indication of the performance of the animal (Preston, 1986).

It was in this regard that experiment 1 in the present studies was structured to determine the proximate composition of some poultry feed ingredients locally available in Ghana. Observations from this study showed that most of the chemical composition values obtained were found to be similar to values reported in literature (Buamah, 1969; Crampton and Harris, 1969; NAS-NRC, 1969, 1977; Owusu-Domfeh et al, 1970 and Ncube, 1981). However, some differences were obtained regarding the ash and phosphorus contents of sorghum; high moisture and NFE contents of maize bran; high ether extract of rice bran; high moisture content of fish meal; high fibre content of soybean oil meal and the low fibrle and fat contents of groundnut cake.

For a better and detailed understanding of the nutritive value of the feed ingredients, their energy content was also required. This is because proximate composition of a feedstuff is known to correlate with its bioavailable energy content. Hence, Experiment 2 was undertaken to biologically determine the ME of the feed ingredients whose chemical compositions were determined in Experiment 1. The results however, showed that with exception of the higher ME of maize bran, lower ME of copra cake and soybean oil meal, most of the ME values were similar to what was obtained in literature (NAS-NRC, 1969, 1977). The variations observed for maize bran, copra cake and soybean oil meal, could be related to the levels of their nitrogen free extract and fibre contents.

The results also showed the high nutritional significance of sorghum as seen in its high content of ME which was very much similar to that of maize. This information helped in choosing sorghum as as an alternative energy source to replace maize in the diets in Experiment 3 which sought to evaluate the performance of broiler chickens fed diets containing sorghum and soybean oil meal.

It was also realised from the earlier work in Experiment 1 that soybean oil meal being a plant protein source compared to fish meal had very low calcium and phosphorus contents. It was for this reason that when it had to be used to replace fish meal very high levels of the two minerals, calcium and phosphorus were included in the diets to overcome any effects that might arise.

Results from this Experiment showed that one kilogram of maize diet was more expensive than one kilogram of sorghum diet. Consequently, it cost 23.84 Cedis more for birds on maize diet to gain one kilogram live weight than birds on sorghum diet. Furthermore, fish meal diet was more expensive than soybean oil meal diet and it cost 27.54 Cedis more for birds on fish meal diet to gain one kilogramlive weight than birds on soybean oil meal diet.

CONCLUSION:

Observations from the results showed that most of the nutritive values obtained for the feed ingredients were similar to values obtained in literature. Nevertheless, some of the values were also significantly different from these literature values. Therefore, it is very important to continue to analyse the locally available feedstuffs, since some do show considerable nutritive variability. Observations from the feeding trial, also confirmed the possibility of sorghum and methionine supplemented soybean oil meal replacing maize and fish meal respectively as ingredients in broiler diets.

RECOMMENDATIONS:

Since there are different varieties of sorghum in Ghana, further experiments should be carried out to investigate their tannin levels. The purpose should be the identification of varieties with low tannin levels. This would make possible the cultivation of these varieties on a large scale to provide the poultry and livestock industry in the country with an adequate and available alternate source of energy feedstuff.

It is also recommended that further studies be carried out aimed at finding out possible ways of ameliorating the poor growth promotion of anchovy fish meal, since it is available in sufficient quantities in the country.

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APPENDIX 1

Appendix 1

Daily FeedIntake(g/bird/day) and ME(kcal/g) of Assay Diets in ME Determination

ROOSTERS

ASSAY DIETS		1	2	3	4	5	Mean
BASAL	Feed Intake(g) ME (kcal/g)	57.40 2.997	70.30 3.117	48.20 2.916	56.00 3.031	49.00 3.058	56.18 3.024
WHITE MAIZE	Feed Intake(g) ME (kcal/g)	98.90 3.381	107.90 3.427	59.90 3.333	84.10 3.379	40.90 3.221	78.34 3.348
SORGHUM	Feed Intake(g) ME (kcal/g)	66.30 3.334	88.60 3.319	63.00 3.335	73.30 3.325	64.70 3.294	71.18 3.321
MAIZE BRAN	Feed Intake(g) ME (kcal/g)	53.70 2.998	74.30 3.166	53.80 2.972	52.50 3.070	46.30 2.948	55.52 3.031
RICE BRAN	Feed Intake(g) ME (kcal/g)	62.10 2.521	73.20 2.895	50.00 2.720	60.70 2.888	64.20 2.826	62.04 2.770
WHEAT BRAN	Feed Intake(g) ME (kcal/g)	60.00 2.781	55.30 2.718	42.90 2.394	40.40 2.465	25.60 2.118	44.84 2.495
FISH MEAL	Feed Intake(g) ME (kcal/g)	56.50 2.877	68.00 3.015	41.50 2.794	61.70 2.973	42.70 2.917	54.08 2.915
SOYBEAN MEAL	Feed Intake(g) ME (kcal/g)	66.80 3.368	75.30 2.606	52.00 2.701	57.80 2.782	55.70 2.686	61.52 2.829
COPRA MEAL	Feed Intake(g) ME (kcal/g)	38.70 2.550	48.80 2.650	23.60 2.077	37.10 2.380	38.20 2.429	37.28 2.417
MEAN	Feed Intake(g) ME (kcal/g)	62.30 2.979	73.50 2.990	48.00 2.805	58.20 2.921	47.50 2.833	57.90 2.906

ROOSTERS <———— SX 579 ————> <———— SX 288 ————>

Total Feed Intake, Gross Energy Excreta and Metabolizable Energy of Assay diets

	Roosters	1	2	3	4	5
BASAL	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	172.20 640.07 124.06 2.997	210.90 784.29 126.25 3.117	146.60 537.43 115.81 2.916	168.00 624.46 115.31 3.031	147.00 546.40 96.92 3.058
WHITE MAIZE	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	296.70 1146.66 143.83 3.381	323.70 1251.04 142.00 3.427	179.70 694.72 95.77 3.333	252.30 975.78 122.84 3.379	122.70 474.36 79.17 3.221
SORGHUM	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	198.90 768.36 105.50 3.840	265.80 1026.93 145.17 3.622	189.00 730.10 100.41 3.964	219.90 849.53 118.61 3.766	194.10 750.00 110.79 3.648
MAIZE BRAN	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	161.10 640.40 155.36 2.998	222.90 882.24 176.50 3.166	152.40 603.60 150.35 2.972	157.50 623.00 139.72 3.070	138.90 552.93 141.03 2.948
SOYBEAN OIL MEAL	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	186.30 774.36 99.83 3.368	219.60 873.13 284.72 2.606	150.00 603.48 181.79 2.701	182.10 669.98 187.82 2.782	192.60 646.01 197.11 2.686
WHEAT BRAN	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	180.00 710.10 209.44 2.781	165.90 654.87 203.73 2.718	128.70 507.33 159.49 2.394	121.20 478.13 179.39 2.465	76.80 302.98 142.00 2.118
RICE BRAN	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	200.40 747.35 277.76 2.521	225.90 881.95 246.53 2.895	156.00 602.30 193.97 2.720	173.40 731.28 205.71 2.888	167.10 773.47 229.43 2.826
FISHMEAL	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	169.50 623.05 135.72 2.877	204.00 749.94 135.99 3.015	124.50 457.91 110.10 2.794	185.10 681.17 130.50 2.973	128.10 471.15 97.49 2.917
COPRA CAKE	Total F.I.(g) GE Intake (kcal) GE Excreta(kcal) ME Diet (kcal/g)	116.10 455.16 158.85 2.550	146.40 573.45 185.49 2.650	70.30 277.72 130.48 2.077	111.30 435.57 170.86 2.380	114.60 448.89 170.51 2.429

Appendix 3

Analysis of variance of Feed Intake of Assay Diets in Experiment 2

SS	df	S.S	MS	Fcal	Ftab 1%	
Roosters Diets Error	4 8 32	4230.46 6216.788 2303.38	1057.62 777.10 71.98	14.69 10.80	3.97 3.13	Sig. Sig.
Total	44	12750.63				

Appendix 4

Analysis of variance of ME of Assay Diets in ME determination of Experiment 2

SS	df	S.S	MS	Fcal	Ftab 5%	
Roosters Diets Error	4 8 32	0.254 4.149 0.805	0.6035 0.5186 0.0268	2.37 19.35	2.67 2.24	NS Sig.
Total	44	5.208				

Appendix 5

Analysis of variance of ME of Test ingrediences in Experiment 2

SS	df	S.S	MS	Fcal	Ftab 5%/1%	
Roosters	4	0.809	0.2023	1.66	2.71	NS
Diets	7	25.855	3.694	30.28	2.36/3.36	S
Error	28	3.403	0.122			
Total	39	30.067				

Appendix 6

Daily Weight Gain as influenced by Energy and Protein Sources in Experiment 3

WEIGHT GAIN (g/bird/day)

ENERGY SOURCE	PROTEIN SOURCE	REPLICATION			
		I	II	III	MEAN
MAIZE	Fish meal (FM)	41.6	32.3	40.2	38.0
	FM+Soybean meal	44.3	35.7	41.8	40.6
	Soybean meal (SB)	45.5	32.8	40.2	39.5
MAIZE & SORGHUM	FM	39.9	31.4	40.3	37.2
	FM + SB	44.7	39.3	38.8	40.9
	SB	49.0	37.5	39.2	41.9
SORGHUM	FM	41.2	35.9	35.4	37.5
	FM + SB	48.6	33.8	38.9	40.4
	SB	43.8	36.0	37.0	38.9

Analysis of Variance for weight gain in Experiment 3

Source of Variation	df	SS	MS	F	P*	
Energy (E)	2	5.0807	2.5404	0.42	0.6640	NS
Protein (P)	2	48.5610	24.28	4.02	0.0386	S
E x P	4	11.2590	2.8148	0.47	0.7601	NS
Rep	2	329.81	196.40	32.48	0.0000	S
Error	16	96.737	6.0461			
Total	26	554.45				

* All levels of probability (p) below 5% (0.05) are significant and those above 5% (0.05) are not significant.

Appendix 7

Daily Feed Intake as influenced by Energy and Protein Sources in Experiment 3

FEED CONSUMPTION (g/bird/day)

ENERGY SOURCE	PROTEIN SOURCE	REPLICATION			
		I	II	III	MEAN
MAIZE	Fish meal (FM)	100.5	111.4	109.1	107.0
	FM+Soybean meal	100.9	105.0	117.1	107.7
	Soybean meal (SB)	100.6	109.8	114.3	108.2
MAIZE & SORGHUM	FM	99.5	101.8	113.1	104.8
	FM + SB	103.2	108.4	112.8	108.1
	SB	102.9	101.6	119.8	108.1
SORGHUM	FM	99.8	104.8	110.9	105.2
	FM + SB	109.3	105.8	112.3	109.1
	SB	101.6	109.3	110.0	107.0

Analysis of Variance for Feed intake in Experiment 3

Source of Variation	df	SS	MS	F	P*	
Energy (E)	2	7.9622	3.9811	0.30	0.7483	NS
Protein (P)	2	21.136	10.568	4.78	0.4735	NS
E x P	4	26.142	262.75	19.49	0.7468	NS
Rep	2	525.50	6.5356	0.43	0.0001	S
Error	16	215.74	13.48			
Total	26	796.484				

* All levels of probability (p) below 5% (0.05) are significant and those above 5% (0.05) are not significant.

Appendix 8

Daily Feed Conversion Efficiency as influenced by Energy and Protein Sources in Experiment 3

FEED UTILISATION EFFICIENCY

ENERGY SOURCE	PROTEIN SOURCE	REPLICATION			
		I	II	III	MEAN
MAIZE	Fish meal(FM)	0.41	0.29	0.37	0.36
	FM+Soybean meal	0.44	0.34	0.36	0.38
	Soybean meal(SB)	0.45	0.30	0.35	0.37
MAIZE & SORGHUM	FM	0.40	0.31	0.36	0.36
	FM + SB	0.43	0.36	0.34	0.38
	SB	0.48	0.37	0.33	0.39
SORGHUM	FM	0.41	0.34	0.32	0.36
	FM + SB	0.44	0.32	0.35	0.37
	SB	0.43	0.33	0.34	0.37
		0.43	0.33	0.35	

Analysis of Variance for Feed Conversion Efficiency in Experiment3

Source of Variation	df	SS	MS	F	P*	
Energy (E)	2	5.8519E-04	2.9259E-04	0.54	0.5940	NS
Protein (P)	2	2.1407E-03	1.0704E-03	1.96	0.1729	NS
E x P	4	9.9259E-03	2.4815E-04	0.46	0.7675	NS
Rep	2	5.4941E-02	2.7470E-02	50.37	0.0000	S
Error	16	8.7259E-03				
Total	26	6.7385E-03				

* All levels of probability (p) below 5% (0.05) are significant and those above 5% (0.05) are not significant.

Appendix 9

Cost price of individual ingredients used in Experiment 3

INGREDIENT	UNIT COST (₵)
1. Maize	150/kg
2. Sorghum	130/kg
3. Wheat bran	40/kg
4. Fish meal	250/kg
5. Soybean meal	140/kg
6. Oyster shell	20/kg
7. Dical PO_4	70/kg
8. Salt	80/kg
9. Vit/ Min Premix	2,200/kg
10. Methionine	283.33/kg
11. Soybean oil	666.70/kg

Appendix 10

COST ANALYSIS

	MAIZE			MAIZE+SORGHUM			SORGHUM		
	FM	FM+SB	SB	FM	FM+SB	SB	FM	FM+SB	SB
Corn oil	-	-	25.25	-	-	28.25	-	-	33.96
Maize	274.13	271.40	249.94	145.25	147.56	136.21	-	-	-
Sorghum	-	-	-	110.63	112.14	98.37	241.24	246.22	211.88
Wheatbran	18.87	8.02	-	17.31	6.84	-	16.20	5.68	-
Fishmeal	157.29	79.16	-	154.06	79.45	-	154.65	80.19	-
Soybean meal	-	80.21	162.23	-	80.51	161.45	-	81.26	161.06
Oyster shell	0.15	.30	.45	.15	.30	.45	.15	.31	.45
Dical PO_4	1.57	4.22	6.88	1.54	4.23	6.88	1.54	4.27	6.81
Vit/Min Pre.	65.91	66.35	66.66	64.55	66.59	66.59	64.81	67.21	65.91
Salt	.60	.60	.61	.59	.61	.61	.59	.61	.60
Methionine	-	.86	2.14	-	.86	2.14	-	1.01	2.12
Total Cost /bird/4 wks ₵	518.52	511.12	514.16	494.08	499.09	500.95	479.18	486.76	482.79
Total weight Gain (kg)	1.064	1.137	1.106	1.042	1.145	1.173	1.050	1.131	1.089
Cost of 1 kg gain weight ₵	487.33	449.53	464.88	474.16	435.89	427.07	456.37	430.38	443.33