EVALUATION OF LOCAL SORGHUM BEER RESIDUE IN BROILER CHICKENS

BY

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CERTIFICATION

This thesis by MOSES DOGARI, 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.

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DEDICATION

To my wife Suzie who because of this work got nothing like the love and care that is her due.

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ABSTRACT

Five growth studies and an ME study were performed to study the effects of replacing 0-80% of the maize fraction in broiler chicken diets with sorghum beer residue (SBR), The ME of the residue was determined to he 1764kcal/kg. The results of feeding trials obtained indicated that weight gains, feed efficiency were depressed with increasing levels of maize replacement. Feed consumption was increased in some trials and decreased in others while mortality was unaffected by varying levels of replacement. Feed cost kg gain was lowered in all the S.B.R, containing diets.

The adverse effects of the sorghum beer residue was more pronounced in the younger (0-6 weeks) than in the older (6-9 weeks) birds. The results suggest that up to *50%* of the maize can be replaced in broiler starter diets and 40% in finisher diets with S.B.R.

The effects of sorghum beer residue on the carcass characteristic were also evaluated. The weights of the liver gut, gizzard as well as caecal and intestinal lengths were compared in all the treatments as well as the dressing percentage. The results indicated that there are specific modifications of the alimentery canal to enable the bird handle the high fibre Sorghum Beer Residue diets.

INTRODUCTION

The use of industrial by-products for the feeding of livestock in general and poultry in particular has generated considerable interest in recent times. The conventional sources of feed can no longer adequately supply the needs of the fast growing poultry industry. Where the industry consumes directly the same type of food as man himself in the form of grains, animal and plant proteins, it is in direct competition with man. Reviewing grains production over the years 1946-1971, Wright (1976) stated that although there was an excess growth rate of cereal production over population increase during these twenty five years, it was not reflected by a similar increase in out of season stocks of grain in the main exporting countries. He attributed this to the massively increased needs of the livestock industry which has itself expanded massively in line with an almost universal rise in living stardards. The situation is made worse by occassional droughts leading to famine as in Ireland, 1846; East, Central and West Africa in 1973 and several times in India.

The ever increasing costs of poultry feeds is threatening many a producer. Most of the ingredients used in Nigeria including maize, the principal energy source have to be imported. With the present economic crisis necessitating the conservation of scarce foreign exchange nutritionists just have to explore areas hitherto neglected if they are to stay in business.

Fortunately, the fever of industrialization is gripping many countries including Nigeria and some of the by-products which are often obtained in large quantities have some potential in poultry nutrition. The use of agro-allied industrial by-products e.g. brewers dry grains, distillers, grains, bloodmeal, wheat bran and many others have intensively been investigated and some are being already used routinely. This study has been designed in view of the above problems and developments to ascertain the probable suitability of sorghum beer residue in poultry nutrition. The product is derived from the local breweries scattered all over Nigeria especially in parts of Kaduna, Benue, Bauchi, Borno and Gongola States.

The use of industrial by-products presents certain problems. Due to the particular nature of sorghum beer residue, the literature review, after discussing the use of industrial by-products generally, also contains discussions on tannin and also fibre in poultry nutrition. This became necessary as the material in question on analysis contained appreciable amounts of both tannin and fibre.

LITERATURE REVIEW

The Use of Industrial By-Products In Poultry Nutrition: General

The use of industrial by-products will continue to generate some interest in feed manfacturers and nutritionists. Many researchers have worked on different types of industrial by-products. Osuji (1978) highlighted some of the problems associated with the use of some industrial by-products. He stated that some industrial by-products are seasonal in availability and often are available only in small quantities. Some, he stated are distribted over large areas therefore incurring enormous collection costs. Those available in the wet state necessitate drying before use while others may contain toxic chemical residures. There is further a danger of fungal and bacterial contamination. Peck (1946) reported that feeding mouldy corn decreased body weight of chicks. Adams and Tuite (1976) cited by Rowland et al. (1978) stated that corn damaged by Gibberella spp could be harmful to broilers.

The performance of six strains of laying hens fed diverse industrial by-products was compared by Allen et al. (1975). The experimental diets were low in energy and methionine but high in fibre (wheatbran 19.9%, distillers grains, 14.9%, grass meal 10%). At peak lay, the experimental diet produced a slightly less number of eggs than the control while the production of brown stock was unaffected. Feed consumption and feed efficiency were higher in the experimental diets than in the control. Quintine et al. (1978) fed derindedsugarcone to poultry either whole, reground

or sieved to exclude the fibres at levels calculated to replace 40-50% of maize in broiler or finisher diets. The results showed that the dried substance regardless of its physical form, can replace 40-50% of the maize in poultry diets.

Osuji (1978) reviewed the use of molasses, ricebran and cassava in pig and poultry production. He stated that molasses is high in energy, calcium, iron, potassium and the B-vitamins especially niacin and pantothenic acid and is very palatable. However, it is particularly low in nitrogen. He stated that poultry are able to tolerate up to 10% citrus molasses in their diet. Osuji (1978) showed that by-products of cassava itself should be fed dry or cooked as wet cassava contains hydrocyanic acid which is poisonous to poultry. He also reviewed work done on rich bran and poultry by-products and also by-products from marine sources.

Kratzer and Payne (1977) stated that autoclaved rice bran is as good as bran from parboiled rice in poultry diets. Ethoxyquin fed along with rice bran did not improve growth rate. They concluded that the growth inibition of rice bran is not due to the effect of trypsin-inhibitor and further that lipase activity in rice bran is destroyed by autoclaving or parboiling.

Meat and bone meal preparations can be included at levels of 7.5-10% in poultry diets while poultry offals can also be used provided it is supplemented with lysine and methionine (Scott et al. 1974). Dewdney (1975) used poultry offals without methionine supplementation and obtained good results after feeding broiler or egg chickens.

Dry poultry waste can be fed to broilers at a level below 20% without serious consequences (Cunningham and Lilich, 1979).

They cited the work of Polin et al. 1971) who stated that dry poultry waste has a nutrient profile similar to other fibrous feedstuffs including bran and alfalfa meal.

Hedge et al. (1978) performed seven experiments with chickens. Their results showed that inclusion of 100g wheat bran per kg of diet resulted in improved growth, and in three experiments, feed efficiency was also significantly (P 0.05) increased. Supplementation of the diet with coarsely ground wheat straw to provide the same amount of carbohydrate resulted in poor growth. They stated that wheatbran has a growth promoting factor which is destroyed by heat sterilization or gamma radiation. Histomeric observation on small intestines of birds indicated that those fed coarse wheat-straw had longer villi and thickened muscularis layers and the caecal tonsils had a greater area of lymphoid tissue and more follicles.

The Use of Brewery By-products in Poultry Nutrition.

Brewery by-products are mentioned here in general as the by-product used in this study has been derived from the local beer industry. Ademosun (1983) evaluated the use of brewers dry grains in the diets of growing chickens. He stated that on the basis of feed consumption, weight grains and feed efficiency the concentration of brewers grains in starter diets should not exceed 10%. Growing birds from 8-18 weeks, should not be fed brewers dry grains in excess of 8%. He maintained that the limiting factor in brewers dry grains is the high crude fibre content. Ewing (1963) as quoted by Ademosun (1973) analysed trewers dry

grains and found as follows: crude protein, over 20%, ether extract, 6%, crude fibre, 15% and ash 4%. He stated that no more than 10% brewery by-products should be included in poultry diets. Almquist (1972) gave the amino acid profile of brewers dry grains as follows:- lysine 0.9%, methionie 0.4%, trypsin 1%, and valiue 1.6%. In his opinion, brewers dry grains is rich in essential amino acids.

Kienholz et al. (1963) reported that a diet containing 40% dry brewers grains supported excellent laying performance in caged layers. In a subsequent report, Kienholz et al. (1972) reported that birds receiving a diet containing 20 or 40% dried brewers grains produced smaller eggs. Egg size slowly increased when birds were fed the control diet without dried brewers grains. Harms et al. (1974) stated that the inclusion of up to 10% brewers dried grains in the diet is acceptable to laying hens if the diet formulation is based on the composition of brewers dried grains.

Harms et al. (1969) evaluated the use of distillers dried grains with solubles in the diet of laying hens and reported a linear response obtained with the addition of graded levels of sulphur containing amino acids. Bird performance were unaffected by the addition of dried distillers grains.

The potential usage of high levels of distillers residue in broiler diets was investigated by Waldraup et al. (1980). Their data suggest that distillers dried grains plus solubles could effectively be used in broiler diets at levels up to 25% of the diet. They stated that if the dietary energy level is allowed to decline as the level of distillers dried grains

increases, weight grains and feed efficiency will be reduced if the level of distillers dried grains is 15% or more. The work of Runnels (1966) demonstrated that 20% distillers dried grains with solubles was successfully incorporated into broiler diets with performance equal or superior to that of chicks fed control diets with corn, soyabean and fishmeal.

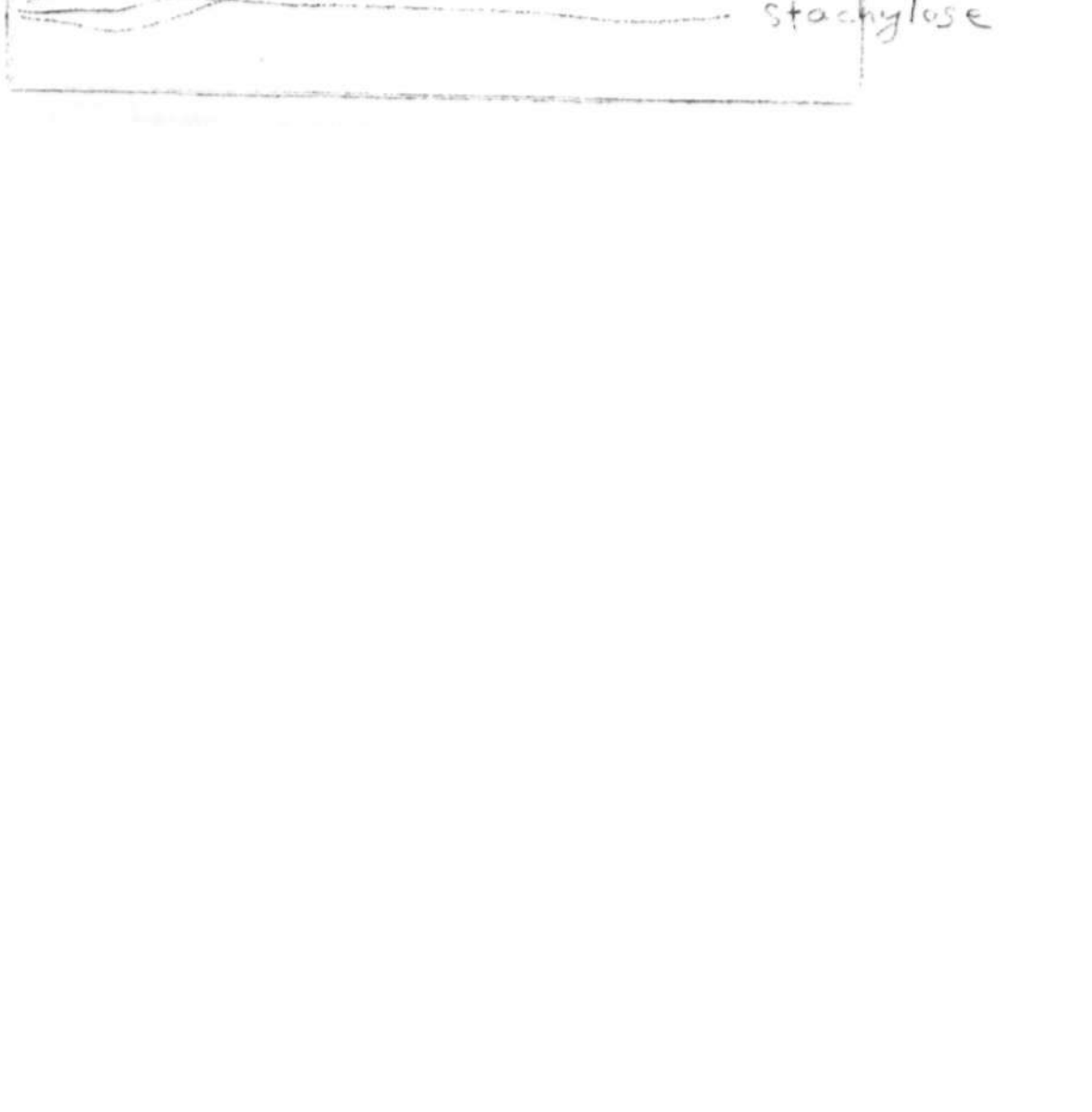
The energy, methionine, lysine and protein availability of solids concentrated from brewery brewery process effluent was determined by Kienholz and Moreng (1980). After feeding levels of 0-20% of the test product they stated that protein utilization was best when the by-product was fed at 50% of the diet. They maintained that 50% brewery product substituted for an unidentified growth factor. In conclusion, they stated that at 10% of the diet it provides usable protein and energy for early poult growth. Schruben and Rheilly (1979) expressed concern and interest regarding the use or disposal of the distillation residue from cereal grains considering the increasing interest in the distillation of ethanol to produce motor fuel.

The Burukutu Beer Industry

Some investigators have documented the processes of brewing the burukutu beer. Faparusi (1970) worked on the sugar changes during the preparation of burukutu beer. He analysed the sugar changes in the germinating sorghum from the first to the fourth day of germination. Figure 1 below summarizes his findings.

Figure 1.

Sugar changes during 4 days of germination of sorghum.



He also analysed the sugars in burukutu beer after two days of fermentation and found as follows:-

Sugar	amount (%)
Fructose	0.2
Mannose	0.65
Glucose	0.36
Galacturonic acid	0.48
Sucrose	0.20
Maltose	0.42
Isomaltose	0.38
Raffinose	0.68
Maltotriose	0.56
Stachylose	0.43

Holdt and Brandt (1966) reported that only glucose and sucrose were present in the ungerminated sorghum grains.

The Kaffir corn malting and brewing industry in South Africa was described by Schwartz (1956). He said that the plumule is allowed to grow to one inch after which the sorghum is dried and ground. Germination, according to him is not uniform because the top layers are least germinated. He stated that the beer is rich in B vitamins and lactic acid. The total solids he estimated at 4-10% and lactic acid 0.3.0.6%.

The extraction and nature of the insoluble amylases of Kaffir corn malts was investigated by Novellie (1970). He stated that the amylases are synthesized at the time of germination. The work of Dube and Nordin (1961) had however indicated that amylases

are present in insoluble form even before germination. The role of amylase gives to hydrolyse the starch into fermentable sugars. Platt and Weeb (1946) believe that molds which sometimes grow on the grain produce amylases which attack the starch.

Studies on the microbiology of Kaffir beer were carried out by Van Der Walt (1970). He found that Saccharomyces cerevisiae, Candida krusei and Kloekera apiculata are the dorminant yeast in both the malt and the beer with S. cerevisiae being the only organism of significance in terms of numerical predominance and fermentative ability. Acetobacter cultures (A. rancens and A. ascendens) was implicated in the production of acetic acid in old beer. The pleasant sour taste of lactic acid then givens way to the vinegar flavour due to acetic acid. Earlier, Schwartz (1956) reported the isolation of S. cerevisiae from Kaffir beer. The former is now marketed for the purpose. Chidoka (1983, unpublished) isolated four yeast species from burukutu beer brewed in Samaru, Nigeria i.e two species of Candida, one each of Schachromyces and Sacchromycoides.

In Nigeria, local beer is consumed in large quantities therefore with large quantities of by-products. The southern parts of the country largely consumes palm-wine which comes from the palm trees. Most of the northern states brew assorted types of local beer using cereal grains, mostly sorghum. Some of these types of beer which vary in alcoholic content, content of total solids and method of production include pito, mbal, wutawuta,

buza, gayamba etc. The method of production of burukutu beer in Samaru, Nigeria from where the test product is derived is described in appendix 6.

As has been stated in the introduction, the test material has characteristics that necessitate some bried mentioned (please refer to table 1). It is rather high in both fibre and tannin both of which affect the nutrition potential of a feed substance in no small measure. The effects of tannin and fibre in poultry performance will therefore be discussed in this review.

Fibre in Poultry Nutrition

Crude fibre refers to the residue of a feed that is insoluble after successive boiling with dilute acid and dilute alkali. It was initially supposed to represent an indigestible portion of the feed. It contains mostly cellulose and lignin and in materials analysed by Norman (1935) lignin and cellulose constituted 97%. Stallcup (1958) analysed the composition of the crude fibre in eleven different roughages and reported that of the constituents in the original materials, the crude fibre contained an average of 91% of the cellulose 38% of the lignin and 4.5% of the crude protein. Mitchel (1964) stated that cellulose is a carbohydrate consisting of glucose units while lignin consists of phenyl-1-propanoid units.

The digestibility of crude fibre from different sources vary considerably. Crampton and Harris (1968) getting their evidence from ruminants stated that although fibre from wheat shorts and bran are presumably the same material, digestibility ranges from 53-90%. Figures from monogastrics are considerably lower. Although monogastric animals do not have the necessary enzymes for degrading cellulose, nevertheless in some instances a considerable amount of the cellulose may be utilized. In this case bacteria present in the intestines produce celluloses capable of degrading cellulose (Albanese, 1963).

Crampton (1956) tabulated the extent to which each species can digest crude fibre. The table below summarizes his findings.

Table I. The Extent to Which Various Species Can Digest Crude Fibre.

Species	Where digested	% of contained fibre digested
Ruminants	rumen	50-90
Horse	caecum	13-40
Pig	caecum	3-25
Rat	caecum	34-46
Dog	caecum	10-36
Man	small and large intestine	25-62
Poultry	caecum	20-30

Many experiments have been performed to investigate various effects of fibre in poultry nutrition. Robert et al. (1977) showed that the feed efficiency in broilers fed a ration with 6% added cellulose was significantly (P 0.05) less than that of the control only during the fourth to the sixth week and not different during the seventh week of the experiment. Annison et al. (1977) found no differences in the number of organisms from the same region of the tract of birds of different ages. Those present at two days of age were similar to that of the month-old fowl. Since fibre digestion is as a consequence of bacterial fermentation (Albanese, 1963), this report suggests that fibre digestion is not a function of age and is at variance with the suggestion of Robert et al. (1977). Annison et al. (1967) stated that volatile fatty acids are the major endproducts of fibre digestion in the digestive tract of the fowl and that the caeca are the main sites of their formation. They maintained that the pattern (acetic acid produced in the greatest quantity with lesser amounts of propionic and butyric acids) is characteristic of anaerobic fermentation. Robert et al.(1977) stated that the crop by virtue of its physical rumen similarity may present the potential for digestion of lower quality fibre diets than are presently being fed to poultry.

Favourable effects of fibre inclusion in poultry diets have been documented. Fibre provides bulk in the feed. The necessity of making up a concentrate mixture so that it will have a certain amount of bulk has been stressed. This is to avoid the formation of a dough-like mass in the stomach which is not readily attacked by digestive enzymes Crampton (1959), King (1961) stated that fibre aids digestion because its bulk stimulates peristalsis and secretion. It also opens up

concentrated foods so that digestive juices can come in closer contact with them. Crampton and Lloyed (1959) considered bulk to be important also from the point of view that a certain distention of the digestive tract is desirable for the tract's most effective course. He believed that this distention can be brought about by a large intake of any kind of food but is particularly accomplished for the tract as a whole by digestible material such as crude fibre. He considered the influence of fibre in the elimination of feed residues as a laxative effect. The same author recognised that feeds high in fibre tend to be laxative and that fibre which readily absorbs water and swells is more laxative than one which does not. Eastwood (1974) reported that hemicelluloses and to a lesser extent cellulose can increase stool weight by absorbing water. He stated that the lignin component of the plant materials can absorb organic materials and so enhance the rate at which materials are lost in the stool. Eastwood (1974) however further maintained that bulk is not the only cause of laxative effect as many feeds are laxative because of specific chemical substances in them. He further stated that the degree of bulk that may be desirable depends on the species. In some species large intakes of fibre causes intentional irritation and gastro intestinal troubles. He also reasoned that fibre has cation exchange properties but how this affects colon function was not certain at the time. Mendeloff (1975) stated that plant fibres may play a role in counteracting the toxic effects of drugs, chemicals and food additives and not directly affect fat absorption.

Other effects of fibre in the diet that may not be favourable have been cited. The work of Woodman and Evans (1974a) showed that fibrous feeds might decrease the digestibility of crude protein and ether extract.

This is so they postulated because the greatly increased bulkiness of the ration consquent on the inclusion of fodder cellulose may lead to a more imperfect contact between proteolitic enzymes and the basal food. There is further the possibility that the presence of the fibre may speed up the rate of passage of food through the simple stomach of monogastrics. The authors further stated that fibrous feeds may increase the output of nitrogenous material into the feces thus causing a depression of the apparent digestibility of the basal ration. This is supported by the work of Ac'on et al. (1982) who working with fibre from wheat bran and the Great Northern bean obtained results which supported to the hypothesis that dietary fibre constituents may reduce protein digestibility and increase nitrogen excretion through ionic interaction matrix restriction and modifcation of filtration characterisitics of the fibre components.

Both copper and zinc were bound by fibre sources during invivo studies conducted by Thompson and Weber (1982). All the residues studied bound more copper than zinc. Ershoff (1974) believed that certain types of dietary fibre is partially responsible for impending zinc, calcium, phosphorus and probably iron absorption.

Cunha (1957) stated that a high fibre intake may mean low intake of food nutrients unless the roughage is fortified with these nutrients. Experiments with growing chickens carried out by Isa'aches et al. (1961), Lilie and Denton (1966) indicated that growing chickens on a high fibre diet exhibited a delay in sexual maturity and reduced body weights at maturity. Feed consumption and body weight gains especially in meat type birds were decreased when birds were fed a high fibre diet (Kandra et al. (1974). Deaton et al. (1979) found no significant differences in feed conversion, egg production, egg weights, shell breaking strength and mortality between birds when they substituted a high fibre sunflower meal for soyabean meal. However, gizzard weights and

intestine lengths were increased significantly (P 0.05). The work of Ewing (1950, 1963) indicated that chicks can perform well on diets with up to 9% fibre. El Abbady et al. (1970) worked with Balady white chicks up to the age of twenty weeks. They concluded that male chicks can perform well on 12% crude fibre and the females 4%. When the females are 8 weeks of age, they can tolerate up to 7% crude fibre without adverse effects. However feed consumption and mortality increased and growth rate was depressed when the male white Baladi chicks were placed on a diet of 17% crude protein. Mckay and Genter (1979) on the other hand believed that fibre dilution as a means of feed restriction for broiler breeder pullets is not practical.

Tannin in Poultry Nutrition

Some of the hazards involved in the use of industrial by-products have been highlighted by Osuji (1978) and referred to in the opening chapter. Some of these may include the presence of undesirable chemical substances that may have antinutritional effects. The residue under investigation is derived from sorghum and earlier workers have analysed most varieties of sorghum in Nigeria and reported their tannin contents. Okoh et al. (1981) reported the tannin contents of Nigeria sorghum varieties to range from 0.07% to 0.215%.

Tannin in sorghum grains and its residues may affect its feeding value for monogastrics. The protein of high tannin sorghum has lower nutritive value than the protein of low tannin sorghum. This according to Bagepalli et al (1980) is due to the harmful effects of tannin exerted on the digestibility of proteins. This is in agreement with

earlier work by Schaffort et al. (1974) who stated that the major factor responsible for low in vitro and presumable in vivo digestibilities in high tannin sorghum varieties is the low digestibility or availability of protein in those genotypes. Further, the effect of tannin they suggested could be overcome with adequate protein supplementation. From their work Hewitt and Ford (1981) concluded that tannins both in sorghum and coloured flowered varieties of field beans significantly reduced protein nutritional quality. Nelson et al. (1975) reported that the tannin content of feed had a greater effect on amino acid availability than the percentage of the gross energy utilized. They maintained that amino availability, is decreased by the high dietary tannin levels with little effect on the ME. The same views are also shared by Rostagno et al. (1973b) who reported lower availability of all amino acids in high tannin sorghum grain than in low tannin grain.

Featherstone and Rogler (1975) reported a considerable decrease in growth rate and feed efficiency due to dietary tannin when present in appreciable amounts. Depression of growth rate was also observed by Vohra et al. (1966). When tannic acids at levels of 0.5% of the diet was added there was depression of body weights and 70% mortality was recorded when the tannic acid level was increased to 5%. Ward et al. (1977) observed reduced feed intake negative weight grains, reduced feed grain ratios and reduced dry matter and amino acid retentions when a diet containing 3.9% purified condensed tannins was fed compared with a control diet without added tannin. The antinutritional effects of tannins were also reported by Harris et al. (1970). Connor et al. (1969) also reported a depression in testis weight and total lipid content while there was an individual bird variation in total liver weights.

Tannic acid at levels of up to 2% can cause egg yolk motling (Potter et al. (1966) . Connor et al. (1969) reported that apart from depression of food intake tannins also have a toxic effect. They concluded that the nature of tannin toxicity is not satisfactorily established and further investigatopm was needed.

A reduction in the amount of ionizable iron by food tannins was also reported by Bagepalli et al. (1980). They maintained that the addition of tannin of foods containing no tannin indicate that 1mg al food iron may be completely bound by 50mg of tannin.

The tannin contents of some common feedstuffs have been reported by Bagepalli (1980) and shown in table 2 below.

Table 2: Tannin Content of Foods

Feedstuffs	Tannin Mg/100g
Rice (Oryza sativa)	0
Wheat (Triticum avietirnum)	41
Sorghum (a) white	77
(b) red	973
Chickpea (cica aritnum)	27
Cow peas (phaseolus anreus	437
Soyabean (Glycine Max)	45

Correcting The Illeffects of Tannin

Considering many of the illeffects of tannin in monogastric nutrition and its wide occurence in sorghum grains and residues, investigations have been carried out with the objective of alleviating some of them. Treatment of ground, high tannin grain

with 0.1m aoqueous solution of potassium carbonate (K_2 $^{o}3$) resulted in considerable impnovement in weight grains and a substanital improvement in feed efficiencies (Price et al. (1971).

Treatment of the same grain with moisture and calcium oxide (CaO) gave an improvement of lesser magnituale. Further work of price et al. (1971) indicated that alkali obtained from wood ash is beneficial in reducing tannin levels although no feeding trials were conducted. The alkali was obtained by soaking 130g at hard wood ashes overnight in 350ml of water and filtering. Five grams of high tannin sorghum and 1ml of filtrate were mixed and stored for 3 days before analysing for tannin. They suggested that 68kg or less of ashes can detoxity a ton of grain. Bagepalli (1982) stated that the tannin content of legumes can be reduced by decortication. He maintained that the tannin content of legumes can be reduced by germination with consequent increase in iron availability. Price et al. (1971) suggested that growing high tannin sorghum in wood ash and malting, as is done in Rwanda and Uganda for human consumption, perhaps detoxifies all or part of the tannin.

Studies were conducted by Panda et al. (1980, 1981) on the use of raw magadi, soda (Rms, a sodium sesquicarbonate salt naturally occurring near lake magadi, Tanzania). Treatment of the grains with concentrations of 4g of sorghum per litre of Rms for three days reduced the levels of assayable tannins in the grains by 40-57%. The reduction was accompanied with an increase in digestibility of the crude protein and carbohydrate in poultry.

The mechanism by which moist alkaline conditions detoxify high tannin sorghum is not known Price et al. 1971). They suggested that

tannin may become altered in some manner so as to become unreactive nutritionally. Alternatively, they reasoned that tannins may become permanently bound to some nearby component in the grain, perhaps protein during treatment rendering both substances nutritionally inert. They observed that available protein in the treated high tannin sorghum grain increased but not to levels found in the non-tannin sorghum grain even though the effects of tannin on weights grain was completely overcome. They concluded that this observation lends some support to the idea of the formation of indigestible tannin-protein complex during treatment.

Other workers have reported various means of alleviating the effects of tannin. The depression of growth rate can to some extent be alleviated by administration of a dietary mixture of methionine, choline and arginine (Chang and Fuller 1964.).

Fuller et al. 1966, Connor et al. (1969) in agreement with the former observed improvement in weight grain and feed efficiency when a 1% tannin diet was supplemented with choline and methionine.

SECTION ONE

THE METABOLIZABLE ENERGY (ME) STUDY

INTRODUCTION:

The ME of a feed is the difference between the gross energies of the feed eaten and that of the faeces voided from such feed. In poultry where the faeces and urine are mixed together it is the difference between the heat of combustion of the feed eaten and the excreta. To determine the ME of a feed, measurements of the quantity of excreta output relative to feed intake is done. This can be achieved through direct records of feed eaten and excreta output over a suitable period of time. It can also be done through the use of an indigestible substance in the feed. This method was described as the indicator method (Miller, 1984). By measuring the relative concentrations in the feed and excreta of the indigestible substance, the feed eaten and excreta can be calculated. This method is preferred by Sibbald et al. (1960) who found it to be more precise. Miller (1974) stated that the indicator method reduces the amount of excreta which has to be stored for analysis consequently reducing errors in procedure. Part of the energy lost in the faeces and urine are from products originating from the body (Mitchell, 1964, Harris, 1966). It is because of that that ME determined in the conventional way should be termed "classical ME" as opposed to ME corrected to N-equilibrium (, Harris, 1966). The object of correcting ME values to nitrogen equilirium is to eliminate the variations arising from variable nitrogen retention (Miller, 1974). This may be appropriate when the object is

to assess the value of a particular feedstuff for varying circumstances of feeding but not when the object is to assess the ME intake in a particular animal feeding test (Mitchell, 1964). Sibbald and Slinger (1962b) used the factor 8.73 kcal/g N as being representative of the combustible energy of the urinary excretory products. Hill and Anderson (1958) however had suggested the use of the factor 8.22 kcal/g N as reported by Miller (1974).

The significance of ME can be appreciated by the fact that the daily feed consumption of the chicken is adjusted within some range of intake to maintain a suitable energy consumption (Well , 1963 and Morris, 1968). Further, in diets containing adequate amounts of all nutrients, the efficiency of feed utilization depends on the ME (Scot et al. 1954). In addition, the level of ME determines the minimum levels of inclusion of amino acids and to a lesser extent minerals and vitamins in poultry rations (Sibbald, 1979). There is therefore an optimum level of energy concentration for best performance (Farrell et al. 1973). Combs et al. (1962) stated that as the energy level is raised the protein level should also be raised to achieve satisfactory performance in chicks. Feed consumption is decreased when there is an increase in the amount of energy in the diet (Williamson and Gran, 1956). Donaldson et al. (1956) found that feeding broilers diets of high energy content lead to fatty carcasses in such broilers.

Various recommendations have made on the optmum ME requirements in broiler chicks. Some of these recommendations include 3200 kcal/kg (National Research Council, 1971), 2850 kcal/kg (Agricultural Research Council, 1975) and 2800 kcal/kg (Olomu, 1976).

The variability in the recommendations may be due to some of the factors that affect ME requirements of chicks and factors that affect the ME content of feeds. These factors have been reviewed. Sugandy et al. (1975) presented evidence with layers that suggested that ME requirements in the tropics is less than in temperate areas. Sell et al. (1978) stated that the energy requirement of turkeys is inversely proportional to the environmental temperature. In the laying hen, Davies et al. (1973) showed that there was a linear relationship between energy intake and increase in ambient temperature. Experiments were performed with fowls at varying temperature, 7.2-23.9C (Dvorak and Bray, 1978), 21.1-26.7 C, (Smith, 1971), and 25-35 (Reid, 1979).

The results all indicated that energy intake in birds is depressed with increase in ambient temperature. Sykes (1977) stated that the conventional explanation of the fall of ME intake with increase in temperature is that the energy requirement for maintenance is reduced. He mentioned that extremes of temperature depress ME intake presumably due to shock. Leeson et al. (1973) calculated that the ME requirement of laying fowls decrease by 9 Kcal for each degreee Centigrade rise above thermal neutrality (27 C).

The factors that affect the ME content of a feed ingredient have also been reviewed. Mentioning nitrogen retention as one of such factors Miller (1974) stated that nitrogen retention in 10-day old chicks receiving a practical diet is 56-58% while the average over the normal age span of broilers is 35-39% (Summers et al. 1964). In laying hens receiving diets containing from 13-19% crude protein, Reid et al. (1965) stated that nitrogen retention varied from 33%-23%.

Environmental temperatures was found to slightly affect ME values (Davis et al. 1972). Lei and Slinger (1970) and Olson et al (1972) however stated that ME values were not affected by environmental temperature.

The plane of feeding did not affect the ME value of an ingredient (Hill and Anderson, 1958). Brown et al. (1967) however reported slight differences with laying hens.

Studies performed by Zelenka (1968) indicated that ME in young chicks was highest when birds were 50 days of age. Carew et al. (1963) observed that the ME value of a diet containing 20% corn oil was higher for 3-week old than for 2-week old birds. Other reports by Lohdi et al. (1969), Ra O and Clandinin (1970) and Burlacu and Baltac (1971) also show that ME is affected by age.

The strain and species of birds may affect the ME values of diets (Sibbald and Slinger, 1963b, Slinger et al. 1964). The differences however were small and in some other studies (Brown et al. 1967, Begin et al. 1969) there were no observed differences. Hill (1965) in marked

contrast with some of the work already cited stated that ME value of feeds is unaffected by the level of feed intake, rate of growth or egg production, breed, sex and wide differences in the nutritional balance of the chick.

EXPERIMENTAL:

Objective:-

The aim of this study is to determine the apparent and N-Corrected ME values of sorghum beer residue.

The Birds:-

The fowls used in the study are 90 Ross broilers at 5-week old. They were obtained at day old and maintained on a conventional broiler starte feed before the commencement of the study.

The Feed:-

The feed used in this study was a practical type corn-groundnut cake based broiler diet control diet of table 5. The treatment diet was formulated in such a way that the test material substituted 20% of the standard feed. The beer residue from two sources were used in the study.

Management of Chicks.

The birds were placed in groups of ten in special cages designed for the study. Trays were placed below each group to collect all the excreta. At the commencement of the study the birds were fed their various treatment diets for one week to get them accustomed to it. Thirty birds in groups of ten were fed the unsubstituted diet. Another thirty birds in groups of ten were fed the control diet in which 20% had been substituted with the test material from one source. The last 30 birds were fed the conventional diet with 20% substituted with the test material from a different source. The birds were put on these diets for four days to stabilize them and to enable a determination of the daily intake.

At the beginning of the collection period the feed levels were kept very low to avoid spillage. Water was provided ad libitum.

Collection of Faeces

The faeces from each group of birds was collected over a period of 3 days at 24 hour intervals. Each day, the faeces was collected and then oven-dried and weighed. At the end of the collection period, the faeces were bulked and mixed together and representive samples taken for analysis. Care was taken not to include impurities like feathers in the faeces. Records of feed consumption were taken. Representative samples of the feed and excreta were analysed for gross energy values with the use of a bomb calorimeter.

Results and Disccusion

After calculating the gross energies of the feed and the faeces, the apparent metabolizable energy of the substituted feed was calculated using the formula of Hill and Anderson (1958):

$$\text{AME/g feed} = \frac{(Fi - GE_f) - (E \times GE_e)}{Fi}$$

where AME = the apparent metabolizable energy value of the substituted feed (Cal/g).

Fi = feed intake (g),

E = excreta output (g),

$GE_{(f)}$ = gross energy of the feed (Cal/g),

$GE_{(e)}$ = gross energy of the excreta (Cal/g).

The apparent metabolizable energy of the test material was then calculated using an algebraic equation with an example shown below:-

If the ME of the basal ration X was A Cal/g and that of the substituted ration Y was B Cal/g.

$$100\ x = A\ \text{Cal.}$$

$$x = A/100\ \text{Cal.}$$

$$80\ x + 20y = B\ \text{Cal.}$$

$$\frac{80\ (A)}{100} + 20y = B\ \text{Cal.}$$

$$0.8\ A + 20y = B\ \text{Cal.}$$

$$y = B - \frac{0.8A}{20}$$

$$100\ y = B - \frac{0.8A\ \ 100}{20}$$

From these equations the ME of the test material was calculated to be 1764 Cal/g. The ME_n was 1760.50. During the brewing process much of the starch and the more soluble of the other constituents are removed leaving the spent-grain residue (Ewing 1955). Practically all the fiber and much of the protein, fat and minerals of the original grains is left in the residue stated the same author. This increase in fiber and decrease in soluble carbohydrates will account for the relatively low ME value compared with that obtained in the original grains.

THE FEEDING TRIALS

The Experiments General

The Birds:-

All the birds used in these experiments were Ross 1 broiler chickens obtained at day-old from a local hatchery. For each experiment, the broiler chickens used were weighed and randomly allocated to

six treatments each of three replicates on the basis of the average bird weight. The chicks for the second and third experiments weighed 38.5, 40.0 and 45.0g respectively. For the finisher experiments the average weight of the bird at the beginning of the first and second experiments were 1442.0g and 1043.0g respectively. The birds in the third experiment weighed on the averaged 660.2g at six weeks of age when they were fed the finisher diet.

Management of Chicks:-

All the chicks used in this experiments were kept on deep litter. Each pen had a dimension of 1.22 x 3.048 metres. This space can accommodate up to fifty birds and meets the space recommendation of 0.074^2m per broiler chicken for tropical conditions recommended by Olomu and Offiong (1978). The house for the first trial was not open sided but had large wire gauze windows for ventilation. Subsequent trials were performed in half-walled, open sided and wire gauzed houses which were covered with plastic sheets during the cold harmattan periods. Heat for brooding of chicks was provided by kerosene lamps and at least two were used in each pen. In the first trial a few kerosene stoves were also used. Both feed and water were given ad libitum. The birds and feeds were weighed weekly. Mortality records were taken daily. Consequently, at the end of each trial the cummulative weekly feed consumption, weight gains, feed efficiency, feed cost and mortality were computed. The data collected were analysed according to the methods described by Steel and Torrie (1960).

Feeds:-

The feeds were all isonitrogenous at 23% crude protein for the starter trials and about 20.5% crude protein for the finisher. No attempt was made to control the metabolizable energy (M.E.) of the diets. Olomu (1976, 1978) had recommended the stated levels of crude protein and the M.E. level of 3000 cal/kg of diet for broiler chickens raised in the tropics. The proximate chemical composition of the major ingredients is shown in table 1.

Source of Sorghum Beer Residue

Sorghum beer residue is derived as a by product of the local beer industry. After the preparation of burukutu beer (described in the appendix) a filtration process leaves behind. the browish residue. It is largely odourless when properly dried and has a sour taste. The pH is often around 4. All the test materials used in the experiment were collected and air dried before incorporation in the feed. Some were collected in the dry state and used directly.

The experiments are treated in four sections. The first section had described the M.E. study on sorghum beer residue. The second section reports on the broiler chicken starter experiments (0-4 or 5 weeks). The third section describes the broiler finisher experiments (6-9 weeks) while the fourth section deals with a continous growth study which lasted 10 weeks. The evaluation of relative organ weights and carcass characteristics was done after the experiments in section 3 and 4.

SECTION TWO

The Broiler Starter Experiments

Trial 1

Objectives.

The objectives of this study were:-

(a) To determine whether sorghum beer residue can be used in broiler starter diets.

(b) To determine to what levels sorghum beer residal can be used to replace maize in broiler starter diets.

(c) To compare wheatbran and sorghum beer residue when each replaced 10% of the maize on the basis of chick performance.

(d) To assess the economics of the use of sorghum beer residue in practical type broiler starter diets.

Materials and Methods

Five hundred and fourty Ross 1 broiler chicks were randomly allocated in groups of thirty to 18 pens. Three of such pens were fed one of the six experimental diets. The control diet (diet 1) used in the study consisted of a maize groundnut cake practical broiler starter diet. In compounding the various treatment diets (2, 3, 4, 5 and 6) the following levels of the maize fraction of the control diet were replaced with either wheat offal or sorghum beer residue. In diet 2, 10% of the maize fraction was replaced with wheat offals while diets 3, 4, 5 and 6 of the maize fraction was replaced at 10, 20, 30 and 40% levels repsectively with sorghum beer residues. The per cent and calculated nutrient compositions of the diets are shown in table 2.

The management of the birds and analysis of results were done as described under experimental at the end of five weeks.

Results

The result obtained from this trial are summarized in table 3.

Table 3.

The proximate, calcium, phosphorus and tannin composition of the major ingredients used in the diet formulations.

Ingredients	DM %	CP %	E.E %	CF. %	Ash %	Ca %	P. %	Tannin %
Maize	92.1	8.9	4.02	2.20	1.60	0.02	0.25	-
Groundnut cake	93.2	44.9	6.6	5.50	5.5	0.16	0.49	-
Bonemeal	99	2.86	0.01	2.15	90.1	35.6	17.98	-
Sorghum beer residue	91.0	22.01	4.6	8.40	8.61	0.13	0.16	3.4
Wheat Offals	94.0	16.1	3.90	7.40	6.10	0.11	0.21	-

Table 4

The amino acid profile of sorghum beer residue, g/16gN.

Lysine	0.54
Histidine	0.63
Arginine	0.83
Aspartic acid	1.52
Threonine	0.92
Serine	1.13
Glutamic acid	3.75
Proline	2.29
Glycine	0.77
Alanine	1.90
Cystine	0.49
Valine	1.27
Methionine	0.34
Isolucine	1.09
Leucine	2.65
Tyrosine	1.11
Phenylalanine	1.46

Table 5 : Percentage composition of broiler starter diet in trial 1.

Ingredients	Treatments					
	1	2	3	4	5	6
Maize	57.95	52.15	52.15	46.35	40.55	34.75
Groundnt cake	33.90	32.45	30.60	27.30	23.95	20.55
Sorghum residue	-	-	9.1	18.20	27.35	36.45
Wheat bran	-	7.25	-	-	-	-
Bone meal	3.0	3	3.0	3.0	3.0	3.0
Bloodmeal	4.0	4.0	4.0	4.0	4.0	4.0
Salt	0.30	0.30	0.30	0.30	0.30	0.30
D.L Methionine	0.25	0.25	0.25	0.25	0.25	0.25
L. lysine	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin premix[1]	0.30	0.30	0.30	0.30	0.30	0.30
	100	100	100	100	100	100
Calculated nutrient levels, (%).						
Crude protein %	23	23	23	23	23	23
M.E. cal/kg	3004	2842	2879	2757	2632	2508
Lysine %	1.265	1.27	1.25	1.23	1.21	1.20
Methionine %	0.547	0.518	0.523	0.53	0.546	0.561
Methionine + cystine %	0.891	0.871	0.852	0.936	0.03	1.173
Calcium %	1.138	1.142	1.144	1.15	1.156	1.161
Phosphorus %	0.861	0.897	0.844	0.828	0.811	0.806
Crude fiber %	3.30	3.82	3.72	4.14	4.56	5.01
Tannin[2] %	-	-	0.309	0.62	0.93	1.23

[1] premix[1] Vitamin premix (zoodry VM 101. Roche Ltd) Supplied per kg of feed vitamin A (stabilized 15600 iu, D3 3120 E(stabilized) 12 i.u., menadione sodium bisulfite 2.4mg, vitamin K 2.4mg, BI(stabilized) 3mg, B_2 6mg, B6 4.8mg nicotinic acid 42mg, Ca-d-pantothenate 12mg, vitamin H (biotin) 0.06mg, B12 0.024mg, folic acid 12mg, choline chloride 600mg chlortetracycline 30mg, manganese 80mg, iron 60mg, zinc 54mg, copper 2.88mg, Iodine 1.68mg, cobalt 0.24mg, selenium 0.096, methionine 240mg, ethoxyquine 120mg.

[2] tannin is of beer residue origin.

Table 6: The effects of replacement of maize with different levels of either sorghum beer residue or wheat bran in broiler chicks (0-5 weeks).

Treatment No.	1	2	3	4	5	6	SEM
Maize levels (%)	57.95	52.15	52.15	46.35	4.55	34.75	-
Maize replacement levels with wheat bran	0	10	6	0	0	0	-
Maize replacement levels with sorghum beer residue	0	[illegible]	10	20	30	40	-
Parameters							
Total weight gain	781.8^{ab}	852.7^{a}	831.8^{a}	781.8^{ab}	792.2^{ab}	742.3^{b}	26.01
Total feed consumption (g)	2486	2353	2345	2349	2388	2404	55.17
Feed efficiency kg feed/kg gain	3.179	2.759	2.817	3.00	3.01	3.21	0.793
Feed cost/kg gain	1.103^{a}	0.933^{b}	0.94^{b}	0.951^{b}	0.900^{b}	0.913^{b}	0.034
Mortality %	1.20	0.94	0.84	1.10	0.91	1.12	0.205

All means in the same row with different superscripts are significantly different ($P < 0.05$).

The results in table 6 indicate that replacement of the maize in a broiler diets with sorghum beer residue did not affect the performance of the birds with regard to total weight gain as compared with the control diet. The birds in treatment 2 and 3 corresponding to 10% replacement of maize with wheat bran and sorghum beer residue performed better than the control and indeed better than the other treatments. There were no significant differences (P 0.05) between wheat bran and sorghum beer residue when they each replaced 10% of the maize in the broiler starter diet. Weight gains were not depressed significantly in comparison to the control diet when up to 40% of the maize was replaced by the sorghum beer residue.

With regard to feed consumption, there were no significant differences (P 0.05). Generally, the birds given the control diet are slightly more feed than those on the other diets. The birds in treatment 6 where 40% of the maize was replaced by sorghum beer residue are slightly more feed than the others except those fed the control.

Feed efficiency was not significantly (0.05) different between treatments. Feed efficiency was better but not significantly (0.05) in treatments 2 and 3 where birds were fed the treatment diets in which 10% of the maize was replaced with wheat offals and sorghum beer residue respectively. There was little difference between wheat offals and sorghum beer residue with regard to feed efficiency when each replaced 10% of the maize in the experimental diets.

Feed costs per kilogram of gain (₦) was significantly lower (0.05) when the control diet was compared to each of the other diets. There were however, no significant differences between sorghum beer residue and wheat bran when each replaced 10% of the maize in the experimental diets. Increasing the levels of the beer residue in the experimental

diets decreased the costs per unit of gain but not significantly (P 0.05) with the lowest costs being realized when 30% of the maize was replaced by the residue. The cost increased slightly again when 40% of the maize was replaced by the residue.

Mortality records on the experiment showed no trend and seemed not to be affected by the treatments.

Summary.

An experiment with broiler chicks (0-5 weeks) was performed to evaluate the feeding value of wheat bran and sorghum beer residue when they each replaced 10% of the maize in broiler starter diets, results show that :-

(a) Weight gains were not significantly (P 0.05) depressed even when sorghum beer residue replaced up to 40% of the maize in the control diet.

(b) Total feed consumption was unaffected by the dietary treatments.

(c) Feed efficiency was not affected by the dietary treatments.

(d) Feed costs/kg gain was significantly lower (P 0.05) in favour of all the dietary treatments compared with the control.

(e) Mortality was unaffected by the dietary treatments.

(f) There was no significant difference (0.05) between wheat offals and sorghum beer residue in all the variables considered when each replaced 10% of the maize in the control diet.

Trial 2.

Objectives

Having established that sorghum beer residue can indeed be used, this second trial was designed to:-

(a) Reinvestigate the optimum levels of replacement of maize this time to levels of up to 60% in broiler chick diets and

(b) To investigage whether the tannin content of the residue will have an effect at the higher level.

Materials and Methods.

Four hundred and fifty Ross 1 broiler chicks were obtained at day old and randomized into six treatments each made up of three replicates with 25 chicks per replicate. The average weight of the chicks was 40.0g. The management of the chicks was the same as in trial 1. The dietary treatments involved the replacement of the maize compoment of the practical maize groundnut cake basal diets at 20, 30, 40, 50 and 60% levels with sorghum beer residue. The diets so formulated and fed in the experiment are shown in table 7. The results are shown in table 8.

Results

The results in table 8 show that total weight gain was not significantly affected by the dietary treatments even when up to 60% of the maize was replaced by the sorghum beer residue (P 0.05). The birds fed the control diet had the highest numerical weight gain followed by those fed diets in which 50% of the maize was replaced by the residue.

Table 7. Percentage Composition of Diets Fed to Birds in Trial 2.

	Treatment No.					
% maize replaced with sorghum beer residue	1	2	3	4	5	6
Ingredients %	0	20	30	40	50	60
Maize	55.7	44.56	33.42	33.42	27.85	22.28
Groundnut cake	40.20	33.73	30.62	27.44	24.25	21
Sorghum beer residue	-	17.61	26.29	35.03	43.79	52.68
Bone meal	3.0	3.0	3.0	3.0	3.0	3.0
Salt	0.30	0.30	0.30	0.30	0.30	0.30
D.L. methionine	0.25	0.25	0.25	0.25	0.25	0.25
L-lysine	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin permix[1]	0.30	0.30	0.30	0.30	0.30	0.30
	100	100	100	100	100	100
Calculated nutrient levels						
Crude protein %	23.0	23.0	23.0	23.0	23.0	23.0
Lysine %	1.20	1.0	0.97	0.95	0.94	0.91
Methionine %	0.50	0.51	0.52	0.53	0.54	0.55
Methionine + cystine %	1.70	1.52	1.50	1.49	1.48	1.46
Calcium %	1.13	1.15	1.15	1.16	1.16	1.17
Phosphorus %	0.87	0.85	0.83	0.82	0.80	0.78
ME(kcals/kg) %	2870	2736	2612	2492	2404	2256
Crude fibre %	4.45	5.32	5.73	6.13	6.56	6.97
Tannin (from S.B.R.%)	-	0.60	0.89	1.2	1.48	1.79

1 Vitamin premix, composition as shown on page 34.

Table 8: The effects of replacement of maize by sorghum beer residue in broiler starter diets (0-4 weeks).

Treatment No.	% maize replaced by S.B.R.	Total weight gain (g)	Total feed consumption (g)	EFC	FEED cost/ kg gain	Mortality
1.	0	431.7	919^{b} [2]	2.127^{b}	0.75	9.10
2.	20	383.0	927^{ab}	2.42^{b}	0.77	13.60
3.	30	411	1020^{ab}	2.481^{b}	0.75	4.50
4.	40	373.9	964^{ab}	2.58^{b}	0.73	4.50
5.	50	418	1082^{ab}	2.587^{b}	0.69	4.50
6.	60	380.7	1130^{a}	2.97	0.75	6.10
	SEM	21.34	55.99	0.10	0.026	2.60

(1) EFC = Efficiency of feed conversion.

Means in the same column with different superscripts are significantly different (P 0.05).

The feed efficiency of the birds was affected by the dietary treatments. The trend indicated a non-significant (P 0.05) constant decline in feed conversion as more maize is replaced by increasing levels of the beer residue. However, at the 60% level of replacement the feed efficiency was significantly lower than in all the other diets. The best feed conversion was obtained with the control diet.

There were no significant (P 0.05) differences in the feed cost/kg gain. There were numerical differences in feed cost. After a slight increase in treatment 2 over the control there was a decrease in feed cost with increasing levels of replacement reaching a peak at the 50% level of replacement. After a slight rise was indicated.

Mortality in birds did not show a consistent trend and differences were not significant (P 0.05) although the highest was recorded for the birds fed diet 2 (20% level of maize replacement) and the lowest in those fed diets 3, 4 and 5 corresponding to 30, 40 and 50% levels of maize replacement respectively.

Summary

In an experiment with broiler chicks fed diets in which 0, 20, 30, 40, 50 and 60% of the maize in a corn-groundnut cake based diet was replaced by sorghum beer residue, the following results were obtained:

(a) Total weight gain eas not affected by dietary treatments.

(b) Total feed consumption numerically increased with increasing levels of maize replacement though not reaching significant levels (P 0.05).

(c) There were significant differences in feed efficiency between treatments.. Feed conversion efficiency generally decreased with with increasing levels of replacement. At the 60% replacement

this decrease was significant (ᵥ.P 0.05) when compared to other diets.

(d) The feed cost/kg gain was unaffected by dietary treatments.

(e) There were no significant differences in mortality (P 0.05) between treatments.

SECTION THREE

The Broiler Finisher Experiments

General

This section describes the broiler finisher experiments and the carcass and organ weights evaluation. The birds were fed ordinary commercial type diets until they were six weeks old. They were then randomly selected and weighted in groups and alloted randomly into one of 18 pens. Three such pens were fed one of the six dietary treatments. The management of the birds and variables studied are the same as described in section 2. The experiment was terminated when the birds were 9 weeks old. Data collection and analysis were the same as described in section 2.

For the carcass evaluation four birds, two males and two females were selected at random from each replicate in trial 4. Each was weighed, sacrificed, defeathered and eviscerated. The liver and the cleaned gizzard, were isolated and weighed and the results were expressed as absolute or as percent of live weight.

Also, the lengths of the small intestine and caeca were measured. The weights of the intestines were taken. All the results were statistically analysed for mean differences as stipulated in Steele and Torrie (1960).

Trial 3

Objectives

The objectives of this study were:-

(a) To determine the effect of replacement of maize in broiler finisher diets with various levels of sorghum beer residue.

(b) To compare wheat bran and sorghum beer residue when they each replaced 10% of the maize in broiler finisher diets with regard to the variables afore-mentioned.

(c) To assess the economics of the use of such test material.

Materials and Methods

Four hundred and fifty birds at six weeks of age were randomly alloted to 18 pens in groups of 25. Three pens picked at random consituted a treatment and were fed one of the six experimental diets. Diet 1 was the control and did contain neither wheat bran nor sorghum beer residue. In diets 2 and 3 10% of the maize was replaced by sorghum beer residue respectively. Diets 4, 5 and 6 were formulated such that the maize fraction was replaced by 20, 30 and 40% by sorghum beer residue respectively. The composition of the diets fed in this trial is shown in Table 6. The birds were fed the experimental diets when they were six weeks old. Weekly records of average weight gain, feed consumption, and feed efficiency were taken. Mortality records were taken daily. At the end of the experiment at nine weeks, the cumulative records of the above mentioned variables were calculated. The feed cost per unit of weight gain was also calculated. The results were then analysed as described under general.

Results

The results of this trial are shown in table 10.

The results presented in table [10] show that body weight gain were significantly descreased ($P \leq 0.05$) when sorghum residue replaced more than 30% of the maize in the diet.

Table 9: Composition of the diet fed to broiler finishers in trials 3 (6-9 weeks)

	Treatments					
	1	2	3	4	5	6
% maize replaced by sorghum beer residue	0	0	10	20	30	40
% maize replaced by wheat bran	0	10	0	0	0	0
ingredients (%)						
maize	62.9	56.6	56.6	50	44.03	37.73
groundnut cake	33.13	31.7	29.8	26	22.47	18.89
sorghum residue	-	-	8.6	20	29.5	39.38
wheat bran	-	7.72	-	-	-	-
bone meal	3.0	3.0	3.0	3.0	3.0	3.0
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
salt	0.35	0.35	0.35	0.35	0.35	0.35
premix[1]	0.25	0.25	0.25	0.25	0.25	0.25
calculated nutrient levels (%)						
crude protein %	20.50	20.50	20.50	20.50	20.50	20.50
lysine %	0.86	0.87	0.85	0.83	0.81	0.79
methionine + cystine%	0.73	0.72	0.82	0.83	0.98	1.06
calcium %	1.13	1.12	1.13	1.14	1.14	1.15
phosphorus %	0.86	0.84	0.84	0.82	0.80	0.79
crude fibre %	2.86	4.47	0.30	4.91	5.32	5.80
ME (kcals/kg)	3049	2875	2898	2775	2646	2512
tannin (from sorghum beer residue %	-	-	0.29	0.68	1.00	1.33

premix[1] the composition is shown on page 34.

Table 10: The effects of replacing maize with graded levels of sorghum beer residue or wheat bran in broiler finisher diets (6-9 weeks).

Treatment No.	% of maize replaced by S.B.R.	% of maize replaced by wheatbran	Total weight gain (g)	Total feed consumption (g)	EFC	Feed cost/kg gain (r)	Mortality
1	0	0	852^{ab}	2972	3.48^{c}	1.18	1.3^{b}
2.	0	10	770^{ab}	2887	3.75^{c}	1.04^{b}	4.0^{b}
3.	10	0	953^{a}	3405	4.96^{b}	0.994	6.7^{b}
4.	20	0	750^{b}	3368	4.53^{b}	1.17	13.3^{a}
5.	30	0	725^{b}	3398	6.48^{a}	1.08	15.0^{a}
6.	40	0	518^{c}	3317	6.40^{a}	1.20	6.7^{b}
	SEM		58.15	160.1	0.30	0.07	1.73

Means in the same column with different superscript are different statistically (P 0.05).

SEM = standard error of the mean.

EFC = efficiency of food conversion.

The highest weight gains were realized among the birds fed the diet in which 10% of the maize was replaced by sorghum beer residue and the lowest weight at the 40% level of maize replacement. There were no significant (P 0.05) differences in total weight gain between birds fed diets 2 and 3 where 10% of the maize was replaced by wheat offals and sorghum beer residue respectively although the latter had a substantial although not a significant edge over the former.

The results also indicate that there were no significant differences (P 0.05) between treatments with regard to the total feed consumption. Generally, feed consumption was higher for the sorghum beer residue diets when compared with the control or when 10% of the maize was replaced with wheat offals.

The feed efficiency indicated a consistent decline with increasing levels of maize replacement with sorghum beer residue. As low as the 20% level of replacement brought about a significant (P $<$ 0.05) decrease in feed efficiency. There were no significant differences between the birds fed wheat offals and sorghum beer residue when either replaced 10% of the maize in the diet although there was a slight difference in favour of wheat offals. Neither of these two diets varied significantly (P $\neq$ 0.05) from the control.

The treatment differences in feed cost/kg gain were evident mainly in treatment 3(10% of the maize replaced by sorghum beer residue) which recorded the lowest cost. The highest cost was at the 40% level of maize replacement with the residue which was significantly (P $<$ 0.05) higher than all the other diets in this variable. Sorghum beer residue exhibited a numerical lower cost over wheat offals when each replaced 10% of the maize.

The mortality records indicated no discernible treatment trends though they were significantly ($P \leq 0.05$) higher in the wheat offal and sorghum beer residue diets than in the control.

Summary.

In an experiment with broilers (6-9 weeks) fed a corn-groundnut cake based control diet and treatment diets in which the corn was replaced at varying levels with either sorghum beer residue or wheat offals, the results showed that :-

(a) There was no significant difference between sorghum beer residue and wheat offals with regard to total weight gain when each replaced 10% of the maize in the diet.

(b) Total weight gain significantly ($P \leq 0.05$) decreased with further increase in the level of replacemt of maize by sorghum beer residue beyond 30%.

(c) There were no significant differences between treatments in total feed consumption.

(d) Feed efficiency was depressed significantly when up to 20% of the maize was replaced by sorghum beer residue. In this respect however, both sorghum residue and wheat offals gave similar results when each replaced 10% of the maize.

(e) Feed cost/kg gain was least for the diets in which 10% of the maize was replaced by sorghum beer residue. The diets containing SBR up to 30% were cheaper than the control.

(f) The mortality observed did not follow any consistent trend.

Trial 4.

Objectives:-

(a) This study was designed to reinvestigate the potentials of sorghum beer residue in diets for broiler chicken finishers (6-9 weeks).

(b) To determine the economics of the use of sorghum beer residue (SIR) in broiler finisher diets when up to 60% of the maize was replaced with SBM.

(c) To determine the effects of the dietary treatments on the carcass characteristics and organ weights of the birds.

Materials and Methods

Five hundred and twenty two broiler chicks at six weeks old were randomly alloted to 18 pens in groups of twenty nine. Three of such pens were randomly allocated one of the six treatment diets. In the formulation of such diets based mainly on corn and groundnut cake, the treatment diets contained sorghum beer residue which replaced 0, 20, 30, 40, 50 and 60% of the maize fractions in treatments 1, 2, 3,4, 5 and 6 respectively. The composition of the diets so formulated is shown in table 11.

Results

The data collected from the trial are reported in Table 12. The carcass and organ weight results are shown in table 13.

The results in table 12 show the trend that total weight gain decreased with increasing levels of maize replacement by the beer residue. However, the weight gains for the 20, 30 and 40% of maize replacements were not statistically different from the control ($P > 0.05$).

Table 11: Percent composition of diets diets fed to birds in trial 4

	Treatment Number					
% maize replaced by sorghum beer residue	1 0	2 20	3 30	4 40	5 50	6 60
Ingredients						
maize	62.9	50	44.03	37.74	31.45	25.16
groundnut cake	33.13	25.88	22.47	18.89	15.27	11.68
sorghum beer residue	-	20.11	29.5	39.4	49.3	59.16
bone meal	3.0	3.0	3.0	3.0	3.0	3.0
dl-methionine	0.20	0.20	0.20	0.20	0.20	0.20
L-lysine	0.20	0.20	0.20	0.20	0.20	0.20
salt	0.35	0.35	0.35	0.35	0.35	0.35
vitamin mineral premix	0.25	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100	100
calculated nutrients levels						
crude protein %	20.50	20.50	20.50	20.50	20.50	20.50
lysine	0.86	0.87	0.82	0.79	0.78	0.76
methionine	0.44	0.45	0.45	0.47	0.48	0.49
methionine + cystine	0.73	0.90	0.98	1.06	1.15	1.23
calcium	1.12	1.11	1.14	1.15	1.16	1.17
phosphorus	0.86	0.82	0.80	0.78	0.77	0.76
crude fibre	3.2	4.2	4.7	5.2	5.7	6.2
tannin	-					
ME kcals/kg	3119	2775	2646	2512	2377	2243

premix[1] - composition of premix is as shown on page 34.

Table 12: The effects of replacement of maize with various levels of sorghum beer residue in broiler finisher diets.

Treatment No.	% maize replaced by S.B.R.	Total weight gain (g)	Total feed consumption (g)	Feed efficiency	Feed cost/kg gain (₦)	Mortality
1.	0	798^{ab}	2712^{a}	3.39^{b}	1.15^{a}	0.00
2.	20	853^{a}	2826^{a}	3.3^{b}	0.99^{b}	0.00
3.	30	787^{ab}	2750^{a}	3.47^{b}	0.97^{b}	0.00
4.	40	751^{b}	2626^{ab}	3.5^{b}	0.90^{b}	0.00
5.	50	623.3^{c}	2507^{b}	4.03^{a}	0.93^{b}	0.00
6.	60	553.3^{c}	2471^{b}	4.46^{a}	0.90^{b}	1.15
	SEM	32.4	51.6	0.165	0.046	

Means in the same column with different superscripts are statistically significant ($P < 0.05$).

Table 13a: The effects of replacing maize with different levels of sorghum beer residue on the organ weights and dressing percent of broiler chicks (6-9 weeks).

Treatment No.	% maize replaced with SBR	Gizzard weights	Gizzard as % live weight	liver weights (g)	liver weights as % live weight	intestinal weights (g)	intestinal weights as % live weight
1	0	45.4	2.60	44.8	2.56	119.2^{b}	6.80^{b}
2	20	50.0	2.70	43.10	2.48		7.20^{b}
3	30	53.6	3.02	40.8	2.28	124.0^{b}	7.20^{b}
4	40	48.8	2.87	44.4	2.76	133.1^{a} 117.0^{b}	6.79^{b}
5	50	51.0	3.00	40.7	2.28	148.0^{a}	8.33^{a}
6	60	55.0	3.42	38.1	2.36	146.0^{a}	9.61^{a}
	SEM	0.35	0.35	2.50	0.16	7.11	0.72

Means in the same column with different superscripts are significantly different ($P < 0.05$).

Table 13b: The effects of replacing maize with different levels of sorghum beer residue on the dressing percent, intestinal and caecal lengths of broilers (6-9 weeks).

Treatment No.	% maize replaced by SBR	Intestinal lengths (cm)	caecal lengths (cm)	Dressing percent
1	0	119.2	22.2	64.0
2	20	124.0	22.0	63.0
3	30	133.1	25.9	64.0
4	40	117.0	24.3	61.0
5	50	148.0	26.2	61.0
6	60	146.0	24.3	61.0
	SEM	7.11	1.09	1.40

Means in the smae column with different superscripts are different significantly ($P < 0.05$).

However, from the 40% levels of maize replacement and above, feed consumption was significantly ($\angle$ 0.05) depressed. The highest feed consumption was exhibited by birds fed diet 2 (20% of the maize replaced by sorghum beer residue and the lowest by those fed diet 6 (60% of the maize replaced by sorghum beer residue.

The feed efficiency was depressed with increasing levels of maize replacement though this was not significant from the control diet up to 40% maize replacement. When up to 50% more of the maize was replaced with the sorghum beer residue, the depression was significant.

The feed cost/kg gain showed that feed cost was significantly higher ($P \angle 0.05$) in the control than in all the other treatment diets. There were no significant ($\neg$ 0.05) differences in feed cost/kg gain when the other treatment diets were compared. The lowest cost were recorded in treatment 6.

There were no significant ($\neg$0.05) differences in mortality between the various treatments indeed the only mortality of 1.15% was recorded in treatment six.

Table 13a and 13b show the effects of the dietary treatments on the organ weights and carcass dressing per centage of the sacrificed broilers. The gizzard weights, whether compared as absolute figures or expressed as a per centage of the live weight exhibited a non significant ($\neg$ 0.05) tendency to increase as more of the maize was replaced by sorghum beer residue.

This trend was consistent except for a drop in weight recorded at the 40% level of maize replacement.

The liver weights were not affected by the dietary treatments whether they were expressed as percentages of the weight or were analysed independently of the latter.

There were significant ($P < 0.05$) differences in the intestinal weight of birds ($P < 0.05$) between some treatments. Intestinal weight generally increased with increase in the levels of maize replacement. The increase was significant (< 0.05) when more than 30% of the maize was replaced by the residue. When the results were expressed as absolute gut weights there was a significantly low ($P > 0.05$) gut weight at the 40% level of replacement thus disrupting the trend slightly.

The caecal lengths of birds increased significantly ($P < 0.05$) compared with the control when the level of replacement of maize by sorghum beer residue was up to 30%. The increase did not however persist for all the treatments as the birds fed the diets with more than 30% of the maize replaced with the residue did not differ significantly (> 0.05) among each other.

The gut lengths of the birds were not affected by dietary treatments. The dressing percentage of the birds were not significantly (> 0.05) affected by the treatments. However, the trend showed a gradual decline in dressing percentage as more of the maize was replaced by increasing levels of the sorghum beer residue.

Summary

In an experiment with five hundred and twenty two broiler chickens (6-9 weeks fed six treatment diets in which the maize fraction was replaced with increasing levels of sorghum beer residue (0-60%), the results indicate the following:-

(1) Total weight gain was significantly depressed when the level of maize replacement exceeded 40%.

(2) Feed consumption was depressed significanty ($P < 0.05$) when the levels of maize replacement was above 40%.

(3) Feed efficiency was depressed when more than 40% of the maize was replaced by the sorghum beer residue.

(4) The feed cost per unit of weight gain was significantly ($P < 0.05$) higher in the control than in all the other diets although the SBR diets did not differ from each other.

(5) Mortality was unaffected by the dietary treatments.

The results of the carcass and organ weights show that the

(1) Gizzard weights were unaffected by the dietary treatments.

(2) The liver weights were not affected by the dietary treatments.

(3) Gut weights had a tendency to increase significantly with increase in levels of maize replacement above 40%.

(4) Caeca lengths increased significantly ($P < 0.05$) when more than 20% of the maize was replaced by the beer residue.

(5) The gut lengths were not significantly affected by the dietary treatments.

(6) The dressing percentages was not significantly ($P \angle 0.05$) affected by the dietary treatments although the tendency was to decrease with increasing levels of maize replacement.

The Uninterrupted Starter/Finisher Experiment

Objectives.

The objectives of this experiment were:-

(a) To determine the effects of feeding diets in which the maize fraction has been replaced by graded levels of sorghum beer residue at levels of up to 80% to broilers 0-10 weeks of age.

(b) To determine the effect of feeding the diets described above on the carcass characteristics of broilers.

Trial 5.

Materials and Methods

The experiment was a continous one running from 0-10 weeks of age. The source of chicks and management is as described for previous trials. The formulation of the diets were done such that all were isonitrogenous at 23% crude protein for the starter stage (0-5 weeks) and 20.5% for the finisher stage (6-10 weeks). There were 8 treatments. Sorghum beer residue progressively replaced 0, 20, 30, 40, 50, 60, 70 and 80% of the maize in treatments 1, 2, 3, 4, 5, 6, 7 and 8 respectively.

One thousand two hundred Ross 1 broiler chicks were obtained at day old and weighed. On the basis of the average chick weight (45.0g) they were allocated to 24 pens in groups of 50. Three of such pens which were randomly selected constituted a treatment and were assigned one of the eight treatment diets.

The starter diets were fed to five weeks while the finisher diets were fed from six to ten weeks. The composition of the starter diet is shown in table 14 and the finisher diet in table 15.

Feed and water provided ad libitum. After the brooding period of four weeks no supplemental lighting was provided. Data were collected on body weight gain, feed intake, and mortality. Variables measured therefore included average and cumulative body weight changes, feed intake and efficiency, mortality and feed cost per unit of gain at the ends of the fifth and tenth weeks.

At the end of the experiment an evaluation of some carcass characteristics of the experimental birds was done. The procedure for this evaluation was similar to that used in trial 4.

All data obtained wefe summarized and statistically analysed as described by Steele and Torrie (1960).

Results.

The results for the first 5 weeks of the experiment are shown in table 16. The results after 10 weeks of the experiment are shown in table 17.

The results in table 13 for the first 5 weeks of the experiment indicate that the total weight gain is significantly ($P < 0.05$) affected by the dietary treatments. Birds fed diets 2, 3, 4 and 5 (where the maize fraction was replaced from 20-50% show no significant ($P > 0.05$) body weights differences among themselves or when compared to the control (diet 1). However, when the maize fraction replacement was 60% or more, there was a significant ($P < 0.05$) decline in weight gain over the control.

Table 14: Diet Composition of Broiler Starter Fed to Birds in Trial 5.

% maize replaced by sorghum residue	1 0%	2 20%	3 30%	4 40%	5 50%	6 60%	7 70%	8 80%
Ingredients								
Maize	55.70	44.46	39.00	33.42	27.85	22.30	17.31	11.54
Groundnut cake	40.20	33.73	30.60	27.44	24.26	21.06	18.20	14.72
Sorghum residue	-	17.61	26.30	35.04	43.79	52.54	60.39	69.64
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Dl-methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
L-lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Mineral vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100	100	100	100
Calculated nutrient levels								
Crude protein %	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
lysine %	1.0	0.97	0.95	0.94	0.94	0.92	0.89	0.87
Methionine %	0.55	0.56	0.57	0.58	0.59	0.60	0.61	0.61
Methionine + cystine %	0.88	0.92	0.95	0.97	0.99	1.02	1.04	1.06
Calcium %	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Phosphorus %	0.46	0.43	0.41	0.40	0.38	0.37	0.35	0.33
Crude fibe %	3.49	4.37	4.8	5.23	5.68	6.13	6.50	6.96
Tannin %	-	0.59	0.89	1.19	1.48	1.78	2.05	2.36
ME (kcals/kg)	2870	2731	2612	1492	2404	2256	1895	1819

Premix[1] = composition of premix as shown on page 34.

Table 15: Diet Composition of Broiler Finisher for Trial 5.

% of maize replaced by sorghum residue	1 0%	2 20	3 30%	4 40%	5 50%	6 60%	7 70%	8 80%
Ingredients								
Maize	62.9	50	44.03	37.7	31.4	25.1	18.5	12.6
Groundnut cake	33.1	25.9	22.5	18.9	15.3	11.7	7.9	4.5
sorghum residue	-	20.1	29.50	39.4	49.3	59.2	69.7	78.9
Bone meal	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
Lysine	0.20	0.20	0.25	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix[1]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100	100	100	100
Calculated nutrients analysis.								
Crude protein %	20.50	20.50	20.50	20.50	20.50	20.50	20.50	20.50
Lysine %	0.76	0.87	0.82	0.80	0.78	0.76	0.74	0.73
Methionine %	0.44	0.45	0.46	0.47	0.48	0.49	0.50	0.51
Methionine + % cystine	0.74	0.79	0.81	0.84	0.86	0.89	0.91	0.94
Calcium %	0.86	0.83	0.80	0.79	0.77	0.75	0.74	0.72
Phosphorus %								
Crude fibre %	3.20	4.22	4.70	5.20	5.70	6.22	6.73	7.20
Tannin %	-	0.68	1.00	1.33	1.67	2.10	2.36	2.68
ME (kcals/kg)	3049	2775	2646	2512	2377	2243	1990	1911

Premix[1] = The composition of the premix is as shown on page 34.

Table 16: The effects of replacing maize with sorghum beer residue on broiler chicks (0-5 weeks)

Treatment No.	Replacement level (%)	Total weight gain (g)	Total feed consumption (g)	Feed eff.	Feed cost /kg gain ₦	Mortality %
1.	0	485.6^{a}	1392^{a}	2.80	1.01^{a}	0.67
2.	20	433.0^{ab}	1186^{b}	2.70	0.88^{a}	0.67
3.	30	505.6^{a}	1189^{b}	2.40	0.78^{b}	2.00
4.	40	441.50^{ab}	1207^{b}	2.70	0.78^{b}	2.00
5.	50	484.5^{a}	1199^{b}	2.50	0.67^{c}	2.00
6.	60	388.6^{b}	1206^{b}	3.10	0.68^{c}	0.00
7.	70	415.5^{b}	1184^{b}	2.80	$.665^{c}$	0.00
8.	80	460.1^{ab}	1248^{b}	2.70	0.60^{c}	0.00
SEM		21.0	29.8	0.14	0.03	0.98

Means in the same column with different superscripts are different significantly.

Table 17: The effects of replacement of maize with various levels of sorghum beer residue in broiler (0-10 weeks)

Treatment No.	% maize replaced with sorghum beer residue	Total weight gain (g)	T/F. consumption (g)	Feed effiency	Feed cost/kg/gain (₦)	Mortality %
1.	0	1579^{a}	5391^{a}	3.23^{b}	1.105^{a}	18.70
2.	20	1409^{ab}	4544^{b}	3.22^{b}	1.042^{ab}	4.70^{b}
3.	30	1448^{ab}	44773^{b}	3.30^{b}	0.936^{ab}	4.00^{b}
4.	40	1362^{b}	4646^{b}	3.41^{b}	0.900^{b}	2.00^{b}
5.	50	1327^{b}	4942^{ab}	3.70^{b}	0.891^{b}	4.70^{b}
6.	60	1296^{b}	4513^{b}	3.48^{b}	0.800^{b}	4.00^{b}
7.	70	1032^{c}	3984^{c}	3.85^{ab}	0.812^{b}	5.30^{b}
8.	80	923^{c}	4045^{bc}	4.38^{a}	0.864^{b}	2.96^{b}
	SEM	64.29	173.96	0.1851	0.053	2.962^{b}

Means in the same column with different superscripts are significantly different ($P \leq 0.05$).

Increasing the sorghum beer residue levels of replacement beyond 60% did not however result in any further significant ($\not\sim$ 0.05) body weight decreases as the birds on diet 6, 7 and 8 showed similar weight gains statistically.

The total feed consumption was significantly depressed ($<$ 0.05) for all beer residue diets when compared to the control diet. There were no significant ($\not\sim$ 0.05) differenes between treatments 2 to 8. There was no established pattern in feed consumption from treatments 2 to 8.

As more of the maize fraction was replaced by the beer residue the feed cost per unit of gain decreased correspondingly. Feed cost was highest in the control and this was significantly ($<$ 0.05) different from all the beer residue diets. This was followed by treatments 2 to 4 which were not significantly (P $\not\sim$ 0.05) different from each other but were different (P $\not\sim$ 0.05) from both the control diets 6 to 8. The lowest values were for treatments 6-8 corresponding to 60-80 levels of maize replacement and these were not significant (P $\not\sim$ 0.05) among themselves.

The mortality of the broilers did not consistently follow treatment lines and was highest in the control and lowest in the 60-80% levels of replacement. The differences were significant (P $<$ 0.05).

The results shown in table 17 for the whole course of the experiment depict that the total weight of each bird decreased progressively as the level of maize replacement by sorghum beer

residue increased. The depression became significant (P $<$ 0.05) when the level of maize replacement exceeded 30%. The highest weight gains were in birds fed the control and the lowest in those fed diet 8 where 80% of the maize was replaced by the residue.

There were significant ($<$ 0.05) differences in feed consumption. The birds fed the control diet ate more feed than those feed the other diets. This was followed by those fed treatments 2-6 where from 20 to 60% of the maize was replaced. Above the 60% level of replacement, feed consumption was further significantly (P $<$ 0.05) depressed.

The feed efficiency is affected by the various treatments. A trend indicating a gradual decrease in feed efficiency as more of the maize is replaced by sorghum beer residue was obtained. However, the efficiences for the maize replaced diets were not significantly different from the control diet when the maize replacement was 60% or lower. Beyond this the differences were significantly lower than the control.

Feed costs/kg gain were high in the control and treatment 2 compared with the other treatments. It gradually decreased significantly (P $<$ 0.05) with increase in the level of replacement reaching the lowest value at the 60% level of replacement and gradually increasing again thereafter.

Table 18 (a): The effects of replacement of maize with various levels of sorghum beer residue on the Organ weights of broilers (0-10 weeks).

Treatment No.	% maize replaced with SBR	Gizzard weights (g)	Gizzard as % L.W.	Liver weights	Liver as % L.W.	Intestinal weights (g)	Intestinal weight as % L.W.
1	0	82.6	4.77^{ab}	55.4	4.31	117.3	6.80^{b}
2	20	82	4.73^{ab}	60.6	4.43	125.1	61.6^{b}
3	30	76.6	4.48^{a}	62.0	4.46	133	7.30^{ab}
4	40	78.1	5.38^{b}	55.20	4.22	125	7.67^{b}
5	50	76.7	3.60^{b}	56.10	4.41	148	7.53^{a}
6	60	77.7	4.10^{b}	51.80	4.80	146	8.47^{a}
7	70	80.5	4.32^{b}	55.30	4.75	148	9.03^{a}
8	80	72.2	4.0	51.10	5.30	133	9.22^{a}
SEM		6.25	0.36	2.60	0.416	7.41	0.547

means in the same column with different superscripts are different significantly ($P < 0.05$)

Table 18b: The effects of replacing maize with different levels of sorghum beer residue on the dressing percent, intestinal and caecal lengths of broilers (0-10 weeks).

Treatment No.	% maize by sorghum beer residue	Dressing percent	intestinal lengths	caecal lengths
1	0	62.3^{a}	172,5	23.5
2	20	60.6^{a}	165.0	23.4
3	30	61.8^{a}	170.5	24.6
4	40	59.9^{a}	172.0	23.0
5	50	61.2^{a}	168.5	24.1
6	60	59.9^{a}	161.5	22.5
7	70	55.4^{ab}	166.1	23.3
8	80	54.5^{b}	166	22.4
	SEM	2.6	11.73	1.71

means in the same column with different superscripts are different significantly ($\angle$ 0.05)

Mortality records indicate a significantly ($\angle$ 0.05) high mortality control than in the treatment diets. The other treatment were not significantly different from each other.

The results for the organ weights, lengths and dressing percentage shown in table 18 indicate that gut lengths between the various treatments were not different significantly (P $\neg$ 0.05). There were no consistent trends established among treatments. Caeca lengths were not affected by dietary treatments.

The gizzard weights of birds when expressed as absolute values were not significantly ($\neg$ 0.05) different between treatments (P $\angle$ 0.05). The liver weights whether expressed as absolute values or as a function of body weight were unaffected by dietary treatments ($\neg$ 0.05).

The dressing percentage of the birds fed SBR diets were significantly (P $\angle$ 0.05) lower than the control when more than 70% of the maize was replaced by the sorghum beer residue.

Summary

An experiment was performed with broiler chicks (0-10 weeks). The birds were fed a broiler starter during the first 5 weeks and a finisher diet during the last 5 weeks. In the various diets, the maize fraction was replaced at 0, 20, 30, 40, 50, 60, 70, and 80% by sorghum beer residue in treatments 1, 2, 3, 4, 5, 6, 7 and 8 respectively.

In the variables considered during the first 5 weeks:-

(a) The total weight gain was decreased with increase in levels of maize replacement.

(b) The total feed consumption was depressed significantly ($\angle$ 0.05) as the maize was replaced by the sorghum residue.

(c) Feed efficiency was generally unaffected by dietary treatments till at the 80% level of replacement where it was significantly (P $\angle$ 0.05) depressed.

(d) Feed cost/kg gain was significantly lowered (P $\angle$ 0.05) as the maize was progressively replaced by sorghum residue.

(e) Mortality was unexpectly high in the control.

The results for the whole course of the experiment (0-10 weeks) indicated the following:

(a) Total weight gain was significantly depressed when the level of replacement of maize by sorghum beer residue exceeded 30% when compared to the control diet.

(b) Total feed consumption was significantly depressed (P $\angle$ 0.05) when up to 50% of the maize was replaced by residue.

(c) The total feed consumption decreased with increase in the level of replacement attaining significance (P $\angle$ 0.05) at above the 60% level of replacement.

(d) The feed efficiency showed a significant ($\angle$ 0.05) response to increasing levels of replacement. Feed efficiency however was not affected significantly ($\not\angle$ 0.05) when compared to the control until more than 70% of the maize was replaced by SBR.

(e) The feed cost/kg gain showed an initial decline with increasing levels of replacement up to the 60% maize replacement. Thereafter, the cost indicated an upward but non significant ($P > 0.05$) trend.

(f) Mortality was significantly high in the birds fed the control diet. There were no differences between the other treatments.

The result for the organ lengths, weights and dressing percentage show that :-

(a) Gut lengths were unaffected by dietary treatments.

(b) Caeca lengths were not affected by dietary treatments.

(c) Gizzard weights were not affected by the various dietary treatments. Even when results were expressed as a percentage of the live weight there was no trend established.

(d) Intestinal weights were slightly increased in all the SBR diets when the results were expressed in absolute terms. However, the weights showed a significant ($P < 0.05$) increase above the 50% level of replacement when the results were expressed as the percentage of the liveweight.

General Discussions

Broiler Starter Trials

In the broiler starter experiments:- The results in trial 1 indicated that weight gains were not significantly ($\angle$ 0.05) depressed when up to 40% of the maize was replaced by the sorghum beer residue. In the second trial terminated at 4 weeks, even when the level of replacement was 60% corresponding to a fibre level of 7%, the maximum recommended by El-Abbady (1970), there were no observed differences in weight gains. In the third trial lasting 10 weeks, the results analysed during the growing phase (5 weeks) indicated that significant (P $\angle$ 0.05) depression body weights were obtained when up to 50% of the maize was replaced by the sorghum beer residue. These results suggest that there may be differences in the birds ability to utilize the test material. The observation that young birds (0-4 weeks) could use the fibrous material with satisfactory gains up to a level where it replaced 60% of the maize is in agreement with the views of Dvorak and Bray (1978) who stated that the young chick (0-4 weeks) has a high capacity to accommodate large volumes of feed substituted with ceilulose. Ewing (1955), working with chicks (0-4 weeks) concluded that as much as 40% of oat meal (which contains practically no energy) can be incorporated in a starting mash without reducing growth below that obtained with a high energy ration in the first 4 weeks. It appears, he said, that young chicks do not require rations of extremely high energy value and that the greatest benefit of concentrated rations is obtained near the end of the broiler growth period.

This is probably true is deduced from the results of the finisher experiments (6-9 weeks). During the first trial (0-5 weeks), depression of body weight was not evident compared with the control even at the 40% level of maize replacement. In older birds (6-9 weeks) fed similar levels of replacement, significant depression was observed at the 40% level. During the second trial (0-4 weeks) depression of body weights were not observed even when up to 60% of the maize was replaced by the beer residue. Older birds (trial 4, 6-9 weeks) fed similar levels of replacement exhibited significant ($P < 0.05$) depression when the level of replacement exceeded 40%.

In the third trial where birds were exposed to the treatment feeds for 10 weeks, the results for the first 0-5 weeks indicated that weight gains were significantly ($P < 0.05$) depressed when the level of maize replacement with beer residue exceeded 50%. When the results were analysed at the end of the 10-week period, significant (< 0.05) depression of weight gain as affected by maize replacement was realized above the level of 30%. All the trials indicate the capacity of the young chick to utilize low energy feeds with satisfactory gains compared with the older chicks.

The reduction in body weight with increasing levels of maize replacement in both starter and finisher chicks could be due to the fibre content per se or the fact that the more fibrous feeds are low in energy. In these present series of experiments where the fibre level even in the highest level of maize replacement was

not more than 8%, the observed differences in weight gains were most probably due to the low energy in the feeds. Mraz et al (1956), Richardson et al (1958) found that animal performance was more closely related to dietary energy concentration than to dietary fibre level. Panda and Comls (1950), Dansky and Hill (1951) stated that growth depressions associated with crude fibre were apparently due to its low energy content. That crude fibre per se is less important than energy levels and perhaps some effects of tannin could be deduced from the report of Begin (1961) who stated that when dietary energy was constant, food conversion and live weight gain were not affected in broilers even wneh the diet contained up to 18% cellulose. At higher levels however, growth was depressed because, according to him, of the low physical density of the diet. In practical poultry rations, Ewing (1963) stated that birds can still perform well if the fibre content did not exceed 9%. The depression of body weights in growing chickens fed high fibre diets have been documented by Isa'achs et al, 1961, Lilie and Denton, 1966, Kandra et al, 1979).

With regard to feed consumption during the starter phase, the first two trials indicated that trend that feed consumption was increased with increase in the level of maize replacement with the beer residue. During the second trial, the trend was significant. High levels of the beer residue implies lowered energy levels of feed. Birds have been known to increase their feed intake in order to consume an appropriate ME level (Hill, 1956, Wells, 1965). This

results is in comformity with the report of Williamson and Gran (1956) who stated that increase in the energy levels of the feed resulted in decreased feed consumption and vice-versa. The starter phase of the 10-week starter/finisher experiment (trial 5) indicated a different trend. In this case, birds fed the control diet ate significantly ($P < 0.05$) more feed than those fed the other treatment diets. All the other treatment diets did not differ from each other with regard to feed consumption. The decrease in feed consumption observed with all diets that contain the test material is clearly at variance with the trend in the two previous trials. There could have been strain differences in the response to the test material. The apparent unpalatability of all diets containing sorghum beer residue in this trial has - little resemblance with the type that can be induced by tannin. Vohra et al. (1966) observed depression of growth when tannic acid up to 0.5% of the diet was added. In the present case, tannic acid levels ranged from 0.59% to 2.36%. Tannin alone cannot explain the results obtained in this trial , as the previous trials exposed to similar tannin levels did not show such a response. The environment may be a factor. When diets of varying energy densities were fed to broilers the response in weight gains and feed consumption was greater in crowded (0.037^{m2}/bird) than in non crowded (0.074^{m2}/bird, Andrews and Goodwin, 1969). In the present experiment, the space allowances for the two broiler starter experiment and the starter phase (0-5 weeks) of the continuous starter/finisher experiment were 0.12^{m2}, 0.144^{m2} and 0.072^{m2} per bird. The birds in trial 5 are clearly more crowded than those in trials 1 and 2.

Mention may also be made of the environmental temperatures. Although heat was provided by kerosene lambs during the experiments, trial 5 was conducted during the cold harmattan period compared with the other trials. Reviewing the reports of Mickelberry et al.(1966) and Olson et al.(1972), Fisher and Wilson (1974) concluded that results suggest that environmental temperature may have some effect on the assessment of energy levels.

During all the starter phase experiments, the variations in feed efficiency as affected by the dietary treatments except in trial 2 were not significantly different ($P > 0.05$) from the control. In trial 2, replacing the maize up to the level of sixty percent depressed feed efficiency. In trial 1, the highest level of replacement was 40% and up to that level, there was no established trend. It would appear that in young chicks feed efficiency is relatively not much affected by dietary crude fibre levels at least up to the levels of 8%. Furthermore, it confirms young chicks ability to utilize low energy feed with remarkable efficiency as stated by Ewing (1955). The same author stated that feed capacity in relation to size and energy decreases with age. This is also in comformity with the views of Fisher and Wilson (1974) who stated that in responding to energy concentrations, younger birds show smaller variations in weight gains and feed efficiency.

These views are contrary to that expressed by Robert et al (1977). Their results show that the feed efficiency in broilers fed a ration with 6% added cellulose was significantly ($P < 0.05$) less than that of the control only during the fourth to the sixth

weeks and not during the seventh and eighth weeks of the experiments. In their own case however, the birds were given the basal diet during the first two weeks of their lives. Their results would indicate that older birds can utilize fibrous feeds more efficiently than younger birds.

Some factors that affect feed efficiency have been reviewed. Fisher and Wilson (1974), Ewing (1955) stated that males are more efficient converters of feed to meat than females. Furthermore, the latter also stated that cro breds are more efficient than purebreds, fast growers more efficient than slow growers and that inbreeding disadvantageous with regard to feed efficiency. However, as stated by Bird (1950) in a personal communication to Ewing (1950) the feed efficiency cannot be taken to be the final evidence of an ingredient's value. The feed costs per unit of gain would be a better evidence.

The feed cost per unit of weight gain in all the broiler starter experiments all indicate that certain levels of maize replacement with the sorghum beer residue will be advantageous with regard to the cost per unit of body gain. In trial 1, the cheapest costs was at the 30% level of replacement. At the higher levels, although still cheaper than in the control, there was the tendency for it to rise. Since feed cost per unit of weight gain is a function of feed efficiency, the recorded tendency of cost increase rise after some level was as a result of deteriorating feed efficiency. The results comparing wheatbran and sorghum beer residue when they each replaced maize at the 10% level of replacement showed that wheat bran was cheaper but only slightly at that level.

Though the residue was cheaper in price, the birds seemed to have utilized wheat bran more efficiently. It may be more appropriate, therefore to use higher levels of the residue for maximum benefit.

With younger birds (0-4 weeks in trial 2, the results show that the cheapest level to use in terms of cost per unit of weight gain was 50%. This further suggests that younger birds can economically use sorghum beer residue and perhaps other fibrous industrial by products.

Data obtained on feed cost/kg gain for the starter phase of the starter/finisher (0-10 weeks) experiment showed as in previous trials that all the diets containing the beer residue were cheaper than the control which did not contain any beer residue. The birds all indicated no variations in feed efficiency. Variations in feed cost per unit of gain above the 50% level of replacement therefore were not significant ($\neg$ 0.05). It may be appropriate to recommend the use of not more than 50% replacement of the residue in this kind of circumstance because at levels much higher than this, the weight gain is not encouraging. One may have to wait for quite some more days to let the birds achieve market weights.

The mortality records in all the trials involving broiler starters show that there were no significant ($\neg$ 0.05) differences in mortality between treatments even when up to 80% of the maize was replaced by sorghum beer residue. Mortality levels of up to 70% was observed when Vohra 1977 fed diets containing 5% tannic acid. The highest level of tannin in these trials was 2.36% and any mortalities observed could hardly be attributed to tannin as the trends in mortality did not follow treatment lines.

Broiler Finisher Trials.

The parameters described in the starter trials are also discussed in the finisher experiments in trials 3 and four and also the finisher experiment of trial 5. The weight gains were significantly ($P < 0.05$) depressed when the level of maize replaced by the beer residue was up to 40%. In trial 4, where the levels of replacement of maize was up to 60%, body weight gains were significantly ($P < 0.05$) depressed when the level of replacement of the maize also exceeded 40%. This agreed well with the results obtained in trial 3. In the uninterrupted starter/finisher experiment in trial 5 where birds were fed the experimental diets for 10 weeks, results obtained indicated like in the two previous trials (3 and 4), significant ($P < 0.05$) depressions of weight gains were obtained when the levels of replacement of maize by sorghum beer residue was up to 40%. It will be safe to assume that with older birds above five weeks of age, up to 40% of the maize can be replaced by sorghum beer residue without adverse effects with regard to weight gains. It seems also that longer exposure to the fibrous material has little effect on the results obtained. The results obtained with younger birds in trials 1, 2 and the starter phase of trial 5 indicate that the adverse effects of inclusion of higher levels of test material in younger birds (0-4 or 0-5 weeks) are more pronounced at the higher levels of replacement than older birds. In older birds, this is not the case. This can be seen from the fact that in younger birds fed diets with similar levels of maize replacement, depressions of body weight were realized

only when the levels of replacement reached above 50%. That was obtained only in trial 5. In that trial, performance was generally poor and may not be representative of the actual strain performance. In other trials (1 and 2), younger birds performed well even when the level of maize replacement was up to 60%.

The results obtained is in comformity with the views expressed by Ewing (1955) that the greatest benefit of high energy rations are realized near the end of the broiler growth period. The decrease in ME is that results from the increase in the levels of maize replacement by the test material might be responsible for the observed decreases in body weight at the higher levels of replacement.

There were no significant ($P \longrightarrow 0.05$) differences in performance between wheat bran and sorghum beer residue when each replaced 10% of the maize in the diets in trial 3. The residue was slightly better than wheat bran with regard to weight gains. The fibre levels seem too low to account for the difference (4.47% for the wheat bran based diet and 4.3% for the sorghum beer residue diet.

The feed consumption data in trial 3 indicated that there were no significant ($P \longrightarrow 0.05$) differences in feed consumption even when the levels of maize replacement was up to 40%. There were slight increases in consumption at the higher levels of replacement indicating that because of the lower energy of the diets, birds ate slightly more inorder to meet their energy needs. In trial 4 where the level of replacement was up to 60, feed consumption slightly increased compared with the control up to the 30% level of replacement and then decline thereafter. The physical nature

of feed might have contributed to the fall in food consumption. Birds have been known to select feed on the basis of colour, texture and taste (Ewing 1955). The maize fraction was usually eaten first in these experiments and the beer residue taken reluctantly.

There are variations in feed efficiency between the various treatments. In all the trials, feed efficiency decreased with increase in the level of replacement of maize by the beer residue. The effects of a high fibre diet in decreasing the feed efficiency has been documented (Robert et al 1977, Woodman and Evans 1974). The latter explained that the increased bulkiness of the feed consequent on the increase of the fibre levels in the feed may lead to a more imperfect contact with especially proteoltic enzymes leading to lesser digestibility. Also the rate of passage of the fibrous feed may also increase so that the feed does not stay long enough in the relatively simple alimentary canal of the fowl for proper digestion. On account of tannin alone, reports cited indicate that dietary tannic acid which is present in the test material can decrease the feed efficiency (Featherstone and Rogler, 1977, Paischal et al. 1976). Whether the depression of feed efficiency in this case is due to the tannin, fibre or both is not easy to assess. On the other hand, the fibre may decrease the effects of the tannin as fibre might bind toxic substances hence decreasing its harmful effects in the animal (Mendeloff, 1975).

The depression of feed efficiency was not immediately followed by a decrease in weight gains at the same level of replacement.

This might be due to the fact that the birds might have increased their efficiency of net energy utilization (Fisher and Wilson, 1974). The same authors stated further reasons why feed efficiency should decrease with decreasing levels of ME intake. They mentioned that since growth increases with increasing ME intake, a smaller proportion of the ingested energy will be used for maintenance.

The feed cost per kg of gain in all the broiler finisher trials were reduced at certain levels of maize replacement with the beer residue. In treatment 3, the lowest cost was at the 10% level though it could be increased up to 30% and it will be numerically though not statistically cheaper than in the control. At levels higher than 30%, feed cost substantially ($P \leq 0.05$) increased over the control because of the decrease in feed efficiency. Though the price per kg of feed was lower, the birds had to eat more to gain a unit weight. In trial 4, the lowest feed costs were exhibited in birds fed diets in which 40-60% of the maize was replaced by the test material; levels of replacement much above 40% does not seem attractive because above that level, most of the birds will have to take longer to reach market weight, hence decreasing the returns on labour. Fisher and Wilson (1974) stated that differences in rate of response do not necessarily lead to different optima since level of production may modify or even cancel out their effects. Considering such variability in the lowest costs and the effects on body weight gains, a safe limit of not more than 30% of the maize can be replaced by the sorghum beer residue. Even in trial 5 where the lowest cost per

unit of gain was at the 60% level of maize replacement, the weights of the birds at 10 weeks of age was only 1.3kg and cannot be said to be the optimum level. The same 30% level of replacement can be recommended because at that level feed costs were significantly lower than in the control but body weight gains were not significantly depressed.

The mortality of birds as affected by treatments was unrelated to the levels of replacement of the maize by the beer residue. Thus in trial 3, the highest mortality was recorded at the 30% level of replacement, in trial 4, there were no significant ($p \leq 0.05$) differences while in trial 5, the highest mortality was in the control an unexpected result. It is possible in the case of trial 5 that something unknown had accidentally got into the feed because all the replicates were affected. In the 10 week experiment, mortality was noticed after the 6th week of the experiment. It is safe to assume that the levels of maize replacement therefore has little to do with the observed mortality.

The Carcass Characteristics

The organ weights considered in this investigation were the gizzard, liver and gut weight compared both as absolute figures and expressed as a percentage of the live weight. Also analysed were the dressing percentage and the lengths of the gut and the caeca.

The gizzard weights did not show a consistent trend when absolute figures between treatments were compared in trial 4. When the results were expressed as a percentage of the live weight a trend which was consistent but not significant ($P > 0.05$) was established which indicated that the weight of the gizzard increased with increase in the level of maize replacement by sorghum beer residue. This increase might be due to the fibrous nature of the beer residue. This is consistent with the findings of Deaton et al (1979) who reported that gizzard weights were significantly increased when a high fibre sun-flower meal was substituted for soyabean meal. They cited the work of Kubena et al. (1974) who reported that the gizzard weights of broiler raised in cages was significantly less than those raised on the floor despite the same nutritional regime. Those broiler raised on the deep litter floor had access to the fibrous litter and had apparently consumed it leading to an increase in the gizzard weight.

The gut weights were also significantly ($P < 0.05$) increased with increasing levels of the fibrous material. The increase in the bulk of the feed that the the birds had to cope with might

have led to the significant development of the gut in relation to other parts of the body to enable the latter to cope with the more fibrous feed. The combined increases in the weights of the gut and gizzard might have lead to the slight decreases in dressing percentage observed in the birds fed the diets where above 40% of the maize was replaced by the beer residue.

The gut lengths were not affected by the dietary treatments in trial 4. This contrasts with the findings of Deaton et. al. (1979) who reported significant increases in intestine lengths as a result of feeding a fibrous sun-flower meal to broilers. Perhaps as stated by Crampton and Harris (1968), the source of the fibre can influence results as well as the amount of fibre.

The caecal lengths were increased significantly ($\angle$ 0.05) compared with the control when more than 20% of the maize was replaced by the beer residue. The caeca are the sites of fibre digestion (Crampton and Harris, 1968; Ewing 1956). The fibrous nature of the feed where high levels of maize are replaced by the beer residue may stimulate the development of the caeca. The liver weights were not affected by the dietary treatments. It would seem that the organs most affected by the dietary treatments are those in direct physical contact with the feed.

The organ weights in trial 5 showed different trends in some cases from results obtained in trial 4. The intestinal lenghts were unaffected by dietary treatments. This is in agreement with the results obtained in trial 4. The caeca lengths also were unaffected by the dietary treatments. The birds were exposed to

the feed for a longer time (10 weeks) than those in trial 4 (3 weeks). Perhaps because at the high fibre levels, feed consumption was depressed there was no stimulation of caecal development.

The gizzard weights were not affected by the dietary treatments when the results were analysed as absolute figures. When expressed as a percentage of the live weight there were no consistant trends observed. The longer adaptation of the birds to the diet may account for some of the observed differences from earlier trends observed in trial 4.

SUMMARY

Five trials were conducted with Ross 1 broiler chickens obtained locally in an attempt to assess the feeding value of sorghum beer residue. The residue itself is a fibrous substance obtained as a by product of the local burukutu beer industry. It is fairly high in protein content but low in energy.

The diets fed to the birds were isonitrogenous, 23% crude protein for the broiler starters and 20.5% crude protein for the finishers. The five trials consisted of two broiler starter experiments (trial 1, 0-5 weeks, trial 2, 0-4 weeks), and two broiler finisher experiments (6-9 weeks). The fifth trial was a continous 10-week experiment (0-10 weeks). The results in trial 5 were analysed at the end of week 5 and also at the end of experiment at 10 weeks. The parameters studied in all the trials were weight gains, feed consumption, feed efficiency, feed cost/kg gain and mortality. At the ends of trials 4 and 5 a representative number of birds were sacrified in order to determine the dietary influence on the weights of the gizzard, gut, and liver as well as the dressing percentage. The lengths of the gut and caeca were also measured and analysed. The data collected were all statistically analysed according to the methods of Steele and Torrie (1960).

The results for trial 1 showed that there were no differences in weight gain, feed consumption, feed efficiency and mortality when up to 40% of the maize was replaced by the beer residue.

Feed cost per kg gain was however significantly ($P < 0.05$) reduced at all levels of replacement especially at the 40% level.

Results obtained in trial 2 (0-4 weeks) showed that there were no significant ($P > 0.05$) differences between treatments where 0-60% of the maize was replaced by the beer residue with regard to total weight gains, feed costs and mortality. Feed consumption however increased while feed efficiency decreased with increasing levels of the test material.

In trial 3 (6-9 weeks), weight gains and feed efficiency were depressed above the 30% and 20% levels of maize replacement by the beer residue respectively. Feed consumption was unaffected while mortality did not indicate a consistent trend. Feed costs were significantly ($P < 0.05$) lower in the SBR diets than in the control of the 20%- 50% level of replacement but was lowest at the 10% level.

The results for trial 4 indicated that weight gains, feed consumption and feed efficiency all decreased significantly (< 0.05) when more than 40% of the maize was replaced by the sorghum beer residue. Feed cost was significantly ($P < 0.05$) lower in all the treatments containing the test sorghum beer residue but were lowest between the 40%-60% levels of replacement; mortality was unaffected.

The gizzard and gut weights of birds in this trial increased, the latter significantly ($P < 0.05$) with increasing levels of the test material. Caecal lengths were also significantly

($p < 0.05$) increased. Dressing percentages were slightly decreased at the higher levels of replacement.

In trial 5, the parameters analysed at the 5th week of the 10 week experiment showed that while mortality and feed efficiency were not significantly (< 0.05) different from that obtained in the control total weight gains were depressed significantly ($P < 0.05$) after the 50% level of replacement. Feed cost/kg gain was also reduced above the 20% level of replacement.

The same parameters analysed at the end of 10 weeks showed that weight gains were significantly (< 0.05) depressed at 40% levels of replacement, feed consumption at 20% and feed efficiency was depressed when the level of replacement was above 70%. The feed cost/kg gain were significantly lowered above the 30% level of replacement but was lowest at the 60% level. Mortality was unexpectedly high in the control compared with the other treatments. The carcass and organ weights showed that gizzard and liver weights, caecal and gut lengths were not affec+ ($P > 0.05$) by the dietary treatments. Gut weights were significantly increased while dressing percentages were significantly decreased (< 0.05) at the higher levels of replacement.

CONCLUSION

The principal objective of the study was to establish whether a cheaply available local beer by product as described else where in this thesis can be used to replace a portion of the maize fraction of the feed. It was also to determine to what extent this can be done without affecting weight gains and economic returns. Despite the high fibre content, the views of Bird (1950) may be cited here who stated that though a high fibre ingredient may reduce the number of units of gain per unit of cost but if it is priced low enough and does not retard growth it may really increase the number of units of gain per unit of cost. He continued that in this case, the high fibre feedstuff will be a desirable ingredient. The initial skepticism with the use of this ingredient was with the rather high tannin content. The results obtained did not indicate most of the symptoms associated with dietary tannin levels. The tannin contained in this ingredient therefore is not of an important consideration in broiler feed.

Most of the results in this study were explained on the basis of the high fibre and low energy of the sorghum beer residue.

The age of the birds may be an important factor in the practical consideration of the use of the beer residue. When weight gains are considered it may be practicable to replace up to 50% of the maize in the diet of young chicks (0-5 weeks).

In older broiler (6-9 weeks), where energy levels may be a limiting factor, levels of replacement of maize not exceeding 40% may be suggested. This level in some of the trials also coincides with the optimum in terms of costs. However, one may go higher or lower than these levels depending on total costs of production and levels of production. Farrel et al. (1973) found that the time to reach a fixed weight varied as much as 5 days and concluded that responses in live weight gain become important if total costs are considered.

The investigations on organ weights did not greatly affect the unit values of production and is unlikely to be practical importance. It however did establish some modification, particularly in the alimentary canal, as the level of the SBR increased in the diet.

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APPENDIX 1.

TRIAL 1

ANOVA

VARI variables	source of variation	D/F	m.s.
Total weight gains	T	5	6567.12
	E	12	1340.64
Total feed consumption	T	5	5793.26
	E	12	2658.8
EFC	T	5	0.222
	E	12	0.6645
Feed cost/kg gain	J	5	0.0718
	E	12	0.00298
Mortality	T	5	21.33
	E	12	2.89

APPENDIX 2 (TRIAL 2)

ANOVA

Variable	Source of variation	D/F	M/S
Total weight gains	T	5	1675
	E	12	1367
Total feed consumption	T	5	22288
	E	12	9405
Feed cost/kg gain	T	5	0.002165
	E	12	0.002090
EFC	T	5	0.22526
	E	12	0.03262
Mortality	T	5	40.45
	E	12	25.26

APPENDIX 3.

TRIAL 3

variables	source of variation	D/F	mean squares
Total weight gains	T	5	72012
	E	12	10147
Total feed consumption	T	5	161832
	E	12	76890
EFC	T	5	3.6909
	E	12	0.2828
Feed costs/kg gain	T	5	0.07738
	E	12	0.01808
Mortality	T	5	93.87
	E	12	80.89

APPENDIX 4 (TRIAL 4)

ANOVA

Variable	Source of variation	D/F	M/S
Total weight gains	T	5	28050
	E	12	3151
Total feed consumption	T	5	58633
	E	12	7988
EFC	T	5	0.31955
	E	12	0.08232
Feed cost/kg gain	T	5	0.0263
	E	12	0.00644
Mortality	T	5	0.65742
	E	12	0.65742
Gizzard weights (absolute)	T	5	102.9
	E	22	105.6
Liver weights (absolute)	T	5	38.62
	E	23	43.10
Dressing %	T	5	10417
	E	24	9959
Gut weights (% L.W.)	T	5	7.21
	E	24	1.554
Gizzard weights (% L.W.)	T	5	0.3319
	E	18	0.3682
Caecal lengths	T	5	18.967
	E	28	3.597

variable	source of variation	D/F	M/S
Gizzard weights (absolute)	T	5	70.93
Liver weights (absolute)	E	30	97.41
	T	5	32.09
	E	30	37.65
Gut weights (absolute)	T	5	1037.57
	E	30	303.54

APPENDIX 5 (TRIAL 5)

variable	source of variation	D/F	M/S
Total weight gains	T	7	159085
	E	16	12399
Total feed consumption	T	7	630865
	E	16	90788
EFC	T	7	0.4684
	E	16	0.1028
Feed cost/kg gain	T	7	0.0351
	E	16	0.0087
Mortality	T	7	80.74
	E	16	26.33
Gizzard weights (absolute)	T	7	105.10
	E	69	117.40
Liver weights (absolute)	T	7	203.5
	E	62	181

APPENDIX 6.

The Preparation of Burukutu Beer

Burukutu beer as mentioned in the text is prepared in the Samaru area as follows: Sorghum grain, often of the kaura variety is soaked overnight. It is then thickly spread and covered with a wet sack. Germination is allowed for 3 days by which time the plumule would be about 2 inches, the radicle much longer. The grain is then dried, ground and soaked. About 30 kg of ground grain is soaked in an iron drum containing about 180 litres of water. The substance is then boiled for several hours, cooled overnight and boiled again. After cooling and settling, the lighter liquid of the top is decanted into a separate container. The heavier fraction is left in the drum. Both liquids are then seeded with froth from a previous brew. The containers are covered. Fermentation takes place in 48 hours. The substance used in the study is obtained through the filteration of the fermented brew using a soft cloth.