INVESTIGATIONS INTO THE USE OF NATIVE BEER RESIDUES AND BREWERS GRAINS IN POULTRY FEEDS

T H E S I S

A thesis submitted in partial fulfillment for the degree of Master of Science in Agriculture at Makerere University, Kampala

By

MARION WILFRED OKOT

Palenga Odyak, Bobi, Gulu,

Republic of Uganda.

Director: O. J. Abbott, Ph.D.
Senior Lecturer in Animal Science
Makerere University, Kampala.

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DECLARATION

I hereby declare that to the best of my knowledge the work reported is original and that it has not hitherto been presented for any degree in any other University.

M. W. Okot

Dip. Agric. (Bukalasa), Dip. Agric. (E.A), B.Sc. Agric. (W.V.U).

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INTRODUCTION

Poultry production is becoming an important farm enterprise in Uganda despite myths and taboos still existing among certain tribes in rural areas against the consumption of chicken meat and eggs. Recently, Mukasa (1970) reported a dramatic increase of improved commercial poultry particularly near urban centres. Wankoko Cooperative Society Limited, organized in the Kampala area with facilities for processing poultry meat began operation in early 1971, initially processing 100 broilers per day. After only eight months, production increased to 1000 broilers per day and is expected to increase many-fold (Wankoko Cooperative Executive Committee Report, 1971). Meanwhile, Nsubuga (1969) reported that there are approximately ten million unimproved chickens providing an average of up to one chicken and twenty eggs per capita per annum in Uganda.

This rapid increase of improved poultry in Uganda has created a need for formulating high quality feeds at least expense. Feed cost is a major expense in poultry production amounting to as much as seventy percent or more of total cost in tropical areas (F.A.O., 1965).

In Uganda the cost of commercial poultry feeds has been essentially out of reach for most farmers (Report of the Committee on the marketing of Livestock, 1969). Surveys carried out in parts of Buganda (Sempiira-Lubega, 1969) indicated that feed costs was approximately 75 percent of total costs of egg production.

Data obtained at the University farm, Kabanyolo (Abbott, 1971) have shown that feed costs account for 60 percent of total costs for producing a meat type broiler bird weighing approximately 1.8 kg. at nine weeks of age.

High quality poultry feeds frequently are scarce in many areas of the country (Report of the Committee on the Marketing of Livestock, 1969). Even so, the poultry producer has no alternative but to use feeds of high nutrient content regardless of costs or scarcity since he cannot depend on pastures or other low cost, fibrous feed substitutes to support efficient production. Price and availability of feeds consequently are major constraints on the future expansion of the poultry industry and require urgent attention.

The potential for the production of feed ingredients in Uganda obviously is great. Production of cereal grains

and legume seeds is increasing (Report of Agricultural Statistics, 1968).

Waste products such as native beer residues and brewers grains are produced in considerable amounts in Uganda, and their use in feeds for poultry and other livestock should be considered.

Some brewers grains are fed to cattle in areas near the two major breweries in the country. Sometimes discarded native beer residues are consumed by scavenging village chickens and other local livestock, but this does not represent proper or efficient use of these waste products. Insanitary conditions created by the inadequate disposal of these products in most villages and urban areas would not occur if they were collected routinely and put to proper use such as in feeds for animals.

Brewers grains and fermentation by-products are used to advantage in animal feeds elsewhere. However, no research concerning the nutritional value of brewers grains or residues from native beers prepared from millet, maize, sorghum and so forth has hitherto been done in Uganda. Feed formulations including these waste products and other locally produced ingredients should reduce production

costs and subsequently the market price of poultry products to the consumer.

The experiments reported here were conducted to determine the nutritional value of native beer residues and brewers grains for poultry with a view to developing high quality feeds at least expense using local ingredients.

LITERATURE REVIEW

Introduction:

In the production of beer, distilled liquors and alcohols, potentially valuable by-products for use in animal feeds may be recovered after cereal grains or other raw materials have been fermented. These by-products include spent grains, distillers solubles, distillers grains with solubles and such residues. Their nutrient composition depend, to a large extent, on the nature of the raw materials used, the changes they undergo during fermentation and the techniques employed in the recovery of the by-product.

Feeding tests, as reviewed below, have shown that fermentation by-products contain unidentified nutritional factors in addition to known nutrients required for efficient poultry production. Ewing (1963) summerizing published literature on the value of fermentation residues in poultry feeds reported that the by-products recovered after alcoholic fermentation of cereal grains also contain appreciable amounts of the B-vitamins as well as most of the protein, fats and mineral present in the original products.

Unidentified Factor Responses In Poultry Nutrition:

Numerous investigations have shown that in addition to the known nutrients, poultry require several, as yet, unidentified factors for maximum and efficient production.

The mode of action of these unknown factors have not been clearly established. Couch, et al. (1955) attributed part of the unidentified factor response secured from corn distillers solubles to the mineral components. On the contrary, Scott (1957) was not able to observe any significant chick growth response when the ash of distillers solubles was added to a diet otherwise adequate in known nutrients. Allen, et al. (1959) theorized that the unidentified factors appear to promote growth through modification of the microflora of the gut.

Early attempts to isolate and identify these factors have been reported, and Rasmusen, et al. (1954) reviewed the literature on this subject. Morris (1955) reported that the factors were composed of organic as well as inorganic substances. More recently Scott (1957) divided these unidentified factors into three catergories: (a) the "fish factor" found in fish meal and also in dried whey, (b) "fermentation soluble factor" found in brewers yeast

and (c) the "protein factor" supplied by casein.

Meanwhile, many other authors have demonstrated that the unidentified nutrients could stimulate growth, egg production and improve reproductive efficiency when added to diets considered adequate with regard to known nutrients.

Chick Responses

Carrick, et al. (1940) reported the presence of a chick growth factor in crude commercial casein which could be extracted with ethanol or ether. Schumacher and associates (1940) demonstrated the presence of unidentified growth factor(s) for chicks in brewers yeast. Similar observations were later reported by Hill, et al. (1944). Whey solubles were found to contain chick growth promoting factors by Berry, et al. (1943).

Scott and co-workers (1947) suggested that the growth factor for chicks in crude commercial casein was identical to the factor previously reported to be present in brewers yeast by Hill, et al. (1944).

Other studies including that of Carlson, et al. (1949), Combs (1951), Couch (1951), Heuser and Norris (1951), Kohler

and Graham (1951), Reed, et al. (1951), Couch, et al. (1952) Arscott and Combs (1953) have shown that dried whey, grass juice concentrate, fish meal, liver preparations and brewers yeast can promote chick growth when added to diets fortified with all the essential known nutrients.

It has been suggested that the chick requires at least two distinct unidentified factors for optimum growth. Menge, et al. (1952) reported that one of these factors is found in liver preparations and brewers yeast, while the other occurs in dried whey or whey products. Norris, et al. (1953) also noted that there are at least two unidentified growth factors or groups of factors for chicks. Penicillin mycelia meal and fish meal appeared to provide one while the other is found in distillers solubles and dried liver.

Laying Chicken Responses

Evidence has been presented to show that laying hens also require unidentified nutrients for optimum performance. Couch, et al. (1950) found that a liver fraction "L" was required for normal hatchability of eggs when the hens were maintained in wire cages and fed semi-purified diets containing

sucrose, soybean protein and adequate levels of minerals and vitamins. Stephenson and Clower (1952) reported that condensed fish solubles contained factors necessary for hatchability and embryonic development. Arscott and Combs (1953) obtained better hatchability when the ration containing fish solubles was fed to pullets kept on wire floors. Chicks from hens fed all-vegetable diets showed decreased hatching weight and impaired growth.

Meanwhile, Grau and Zweigart (1952) and Jensen and McGinnis (1957) as reviewed by Couch (1964) were unable to find any supplementary value for fish solubles, liver fraction "L", dried whey or liver meal when added to a breeder diet.

An attempt to explain the above conflicting reports was made by Waibel, et al. (1955). They suggested that there was a carry over of unidentified growth factor activity from the hen through the egg to the chick when the breeder diet contained sources of these factors.

Turkey Responses:

The beneficial effects of unidentified nutritional factors in turkey nutrition also have been reported.

Data presented by Scott, et al. (1948), Combs and Shaffner (1950), Atkinson and Couch (1951), Combs (1951), and Couch, et al. (1952) indicated that turkey poults require unidentified factors for optimum growth.

Atkinson, et al. (1953) demonstrated that a liver fraction and dehydrated alfalfa meal contain unidentified factors for proper hatchability of turkey eggs. Scott (1957) also reported that diets for turkey hens should be supplemented with unidentified factor sources in order to support optimum hatchability.

Fermentation By-products as Sources of Unidentified Factors:

Corn Distillers Solubles

Novak and Hauge (1948) reported the presence of an unidentified factor in distillers solubles. Other investigators including Austin and Boruff (1949), Scott (1951a; 1951b), Couch, et al. (1952), Couch, et al. (1954), Rasmussen, et al. (1954), Norris (1954), Reid, et al. (1955), Couch (1961), Luthy, et al. (1963) and Couch (1966) also reported data showing that distillers solubles contain unidentified growth factor(s) as well as various known nutrients for chickens and turkeys.

Morgan (1951) obtained better growth in broilers when distillers solubles was included at 2 percent level in a practical diet fortified with known nutrients. Runnels, et al. (1953) recommended a level of 2.5 percent in commercial feeds for broilers.

Corn Distillers Grains With Solubles:

Allman and Branion (1938) were probably the first to publish work on the value of distillers grains in poultry nutrition. They reported that the addition of this product in the chick diet improved growth, feed consumption and feather development.

In a review of literature Matterson, et al. (1966) concluded that distillers grains with solubles was a satisfactory source of unidentified factor(s) for laying hens.

Steep Liquor Concentrate

Steep liquor concentrate as described by Waldroup, et al. (1970) is a blended product consisting of corn germ meal, corn bran, corn gluten meal and dried condensed fermented corn extractives.

Several research reports have indicated that some of these fractions may be sources of unknown growth factor(s) Combs, et al. (1954) demonstrated the presence of unidentified growth factors in grain fermentation solubles. Russo and Heiman (1959a; 1959b) obtained a highly significant increase in the growth rate of broilers when 5 percent corn fermentation condensed solubles was substituted for fish meal or equal amounts of corn or corn-soybean mixture.

Recently, Waldroup, et al. (1970) reported that steep liquor concentrate could be used in broiler chick diets at levels up to 15 percent, although no growth factor activity was observed.

Brewers Grains:

Some research has been reported on the value of brewers grains in feeds for poultry. According to Thornton (1962), a diet containing this product supported improved growth, early maturity and increased egg production in chickens. Kienholz (1964) also reported that its use in feeds improved reproductive performance and reduced mortality in laying hens kept in batteries. Beeson (1970) reviewing

the research on the nutritional value of brewers grains noted that it was a source of unidentified factors and that it had reduced obesity in chickens and turkey hens.

EXPERIMENTAL PROCEDURE

Introduction:

Four experiments were conducted to assess the value of waste native beer residues and brewers grains as ingredients in broiler chick starter diets. Preliminary studies included the determination of proximate analyses of these residues to assess the levels of such components as protein, fat, fibre and ash present. The results obtained are reported in Table 9a. These data were used in formulating the experimental rations.

Broiler chicks were chosen as the experimental poultry because of their ability to grow rapidly and respond quickly to dietary treatments. They were considered particularly suited for quickly screening feedstuffs of unknown nutritional value.

The trials were began on 29th June, 1971 and completed on 4th May, 1972. The data reported for each experiment cover the period from day-old through three weeks of age.

At the beginning of these investigations two commercial electric brooder batteries were assembled. Each battery consisted of four decks provided with thermostetically controlled electric heating units.

Modifications consisting of dividing each of these decks into two pens were made in order to provide eight identical pens per battery for a total of 16 pens in the two batteries. Each pen accommodated ten to thirteen chicks through three weeks of age.

Chemical grade vitamins and micro-minerals were used as required to supplement the levels of nutrients in feedstuffs indicated in tables (N.A.S., N.R.C., No. 1. 1971). Native beer residues were collected from maize and millet beers produced near Kabanyolo. In order to obtain samples of consistent quality and yet representative of those produced in villages throughout the country, a standard brewing technique was used by a reputable local brewer.

Malt Production:

The malt required for the production of these native beers was prepared from millet grains. Sufficient water was added to samples of grains to initiate germination. Full germination was encouraged before the grains were dried in the sun and ground to a coarse texture. The flour thus obtained constituted the malt.

Wort Preparation:

The media fermented to produce beer are referred to as "wort". In the production of millet beer, the wort was prepared from millet grains. Maize was the basic wort material for the production of maize beer. In either case a standard techique described below was used to prepare the wort.

Fresh grains, cleaned to remove foreign matter, was ground to a coarse consistency. Water was added and the mixture stirred to form a thick mash. This was fermented in a pot until sour to taste. The sour mash was then toasted to form a golden brown wort. The wort required for the production of millet beer was dried in the sun to a moisture content of about 15 percent, while that for maize beer was not dried prior to brewing.

Fermentation and Beer Production:

The malt and wort were mixed approximately in 1:4 ratio and transferred into a galvanized metal container. Water was added and the mixture stirred to obtain a thin slurry. It was then covered with a lid to avoid polution from dust particles or other foreign materials. Covering the container, in addition, helped to maintain warmth

produced during fermentation. No specific strain of yeast cells was added, and fermentation was accomplished by wild yeast. Millet beer was fermented for three days while maize beer took two days to produce the alcoholic beverage.

Maize beer is the juice squeezed through a woven bag from the fermented mash, while millet beer is obtained by sucking the liquid from the mash through tubes equipped with seives to exclude residues. The materials remaining after extraction constitutes the beer residues.

Recovery and Processing of Residues:

Residues were collected in plastic pails provided with tight fitting lids to minimize contamination. Water was added in amounts sufficient to bring the residue into a thick slurry preliminary to heating. In the first Experiment, these residues were cooked in an open aluminium pan to kill yeast cells and other organisms which may be detrimental when fed to poultry. Heating was considered adequate when active boiling of the slurry occurred for ten minutes.

The cooked material was dried in the sun to about 10 percent moisture, ground and stored in plastic bags until used.

Growth of yeast cells observed on these beer residues

(Table 9c) indicated that this processing technique was ineffective when yeast-free samples were required. The prolonged sun drying varying with weather condition probably encouraged growth of yeast cells subsequent to the cooking process.

Beer residues used in Experiment 2 and other subsequent investigations were heated to 160°F and maintained for ten minutes. The cooked material were dried under electric chick brooder battery heaters and carefully handled to avoid undue contamination. They were later ground and stored in plastic bags until required for mixing into the feed. Micro-biological tests carried out on samples from each bag showed that this processing technique resulted in residues being free of live yeast.

Processing of Brewers Grains:

The brewers grains used were obtained from the Nile Brewers Limited, Jinja and Uganda Brewers Limited, Port Bell. Since no fermentation occurrs in the production of brewers grains (Underkofler and Hickery, 1954) little, if any, live yeast was expected to be present in this product. Consequently, the material used in Experiment 1 was not

subjected to heat treatment. It was, however, dried in the sun to 10 percent moisture as were the beer residues and ground before mixing into the feed. Since live yeast also was found in the brewers grains used in the first experiment, heat treatment similar to that described for beer residues was employed subsequently.

Culturing Yeast Cells From Beer Residues:

The following procedure was used to determine the presence of live yeast cells in the residues.

One gram of brewers residue was mixed with 99 ml. of sterile distilled water. Serial dilutions were made from this sample and plated into yeast-agar solid media prepared by dissolving various ingredients (Table 9b.) in distilled water. The dilutions ranged between 10^2-10^8 and the media were autoclaved at 6.8 kg. (15 pounds) pressure per 6.45 sq. cm. (1 sq. in) at 121°C for a maximum of 20 minutes. They were cooled and plated under a sterile environment.

The plates were incubated at 30°C for three days when yeast colonies, if present, were counted.

Chemical Analysis:

Residues were analysed for moisture, protein, fats,

rations. The diet for Experiment 4 was formulated to contain 22 percent protein and 3046 kilocalories Metabolizable Energy per kilogram of feed. (i.e. 138 kilocalories (ME) per percent protein per kilogram of feed). The composition of the diet is also given (Tables 4a, 4b, 4c).

The micro-nutrients were premixed in small amounts of wheat flour or sugar in quantities recommended (N.A.S, N.R.C, No. 1 1971) for proper chick nutrition before final mixing into the feed. The diets were mixed in amounts sufficient to supply feeds for only two weeks in order to ensure a constant supply of fresh feeds. The feeds were stored in plastic pails with tight fitting lids to prevent contamination throughout the experimental feeding period.

The required levels of residues being tested were added at the expense of equal amounts of maize and soybean meal. In the first and second trials, residues constituted 5 percent of the experimental diets, while in the third trial they constituted 2.5 percent. In the forth trial only maize beer residue was used in graded levels including 0, 2.5, 5 and 10 percent.

Experimental Design:

Cobbs broiler chicks obtained through Wankoko Cooperative Society Limited, Kampala, from a commercial hatchery in Cyprus were used in Experiments 1, 2 and 3. The chicks used in Experiment 4 were Cobbs broilers hatched at Entebbe Livestock Experiment Farm, Uganda. The parent stock of these birds were originally imported from England and were similar to those at the Cyprus hatchery.

Day-old chicks were randomly assigned to sixteen battery pens in a 4 x 4 Latin-square experimental design. In the first experiment each pen contained 12 birds while in subsequent trials 12-13 chicks were assigned to each pen.

The chicks were reared in electrically heated battery brooders with raised wire screen floors. Heat was adjusted to meet the comfort requirements of chicks. Feed and clean tap water were supplied ad libitum. The feed troughs were kept 1/3 full to control feed wastage. A 24-hour lighting regime was followed and ample ventilation was provided.

Dropping pans were cleaned regularly to control odours and fly infestation. In order to avoid any carry

over of diseases between batches, the room and batteries were thoroughly cleaned and rested for two weeks at the end of each experiment. Vaccination against Newcastle disease was done during the first week with the "F" strains vaccines produced at Kabete, Kenya.

Chicks were weighed in groups after they were randomly assigned to experimental pens at one day of age. Thereafter, group weights and feed consumption per pen were determined at weekly intervals through the third week. Average weight and feed conversion ratio for the groups were used for statistical evaluations.

Mortality data and any abnormal development were recorded.

Statistical Analyses:

Statistical evaluations of the data consisted of the Analysis of Variance according to the method of Snedecor (1956) using average values as described by Homeyer, et al. (1954). The multiple range test of Duncan (1955) with critical values of Harter (1960) were used to test for significant differences among treatments.

Table 1a

Composition of the Diets Used in Experiment No. 1

Ingredients:	Basal (gms/kg)	BG + Basal (gms/kg)	MzBR + Basal (gms/kg)	MBR + Basal (gms/kg)
Ground white maize	475	450	450	450
Soybean meal (36% prot.)	475	450	450	450
Residues[1]	-	50	50	50
$CaHPO_4.2H_2O$	26	26	26	26
$CaCO_3$(ground oyster shell)	13	13	13	13
NaCl	5	5	5	5
Choline chloride	2	2	2	2
DL-Methionine	4	4	4	4
Vitamin premix (in flour[2])	+	+	+	+
Mineral premix (in flour[3])	+	+	+	+

1. Residues tested:
   a) Brewers Grains (BG)
   b) Maize Beer Residues (MzBR)
   c) Millet Beer Residues (MBR)

2 = Table 1b 3 = Table 1c.

Table 1b

Composition of the Vitamin Premix
Used in Experiment No. 1

Ingredients:	Mg/Kg
Biotin	0.05
Folic Acid	0.45
Niacin	19.34
Pantothenate-Ca	7.27
Pyridoxine-HCl	1.74
Riboflavin	2.28
Thiamin HCl	0.76
Vitamin B_{12}(0.1% in flour)	8.67
Vitamin A(500,000 I.U./gm)	2.41
Vitamin D_3(400,000 I.C.U./gm)	0.50
Vitamin E(dl-alpha toc. acetate; 250 I.U./gm)	60.32
Vitamin K(94% menadione Na-bisulphite .$3H_2O$)	0.35
Butylated Hydroxytoluene (BHT) – antioxidant	34.00

Table 1c

Composition of Mineral Premix Used in Experiment No. 1

Ingredients	Mg/Kg
$MnSO_4 \cdot 5H_2O$	155.00
KI	2.00
ZnO	61.00

Table 2a

Composition of the Diets Used in Experiment No. 2

Ingredients	Basal (gms/kg)	BG + Basal (gms/kg)	MzBR + Basal (gms/kg)	MBR + Basal (gms/kg)
Ground white maize.	570	545	545	545
Soybean meal (44% prct.)	390	365	365	365
Residues[1]	-	50	50	50
$CaHPO_4.2H_2O$	21	21	21	21
$CaCO_3$ (ground oyster shell)	9.3	9.3	9.3	9.3
NaCl	5.0	5.0	5.0	5.0
Choline chloride	0.14	0.14	0.14	0.14
DL-Methionine	4.0	4.0	4.0	4.0
Vitamin premix (in flour[2])	+	+	+	+
Mineral premix (in flour[3])	+	+	+	+

1. Residues tested:
   a) Brewers Grains (BG)
   b) Maize Beer Residues (MzBR)
   c) Millet Beer Residues (MBR)

2 = Table 2b 3 = Table 2c.

Table 2b

Composition of the Vitamin Premix
Used in Experiment No. 2

Ingredients:	Mg/Kg
Folic Acid	0.17
Niacin	3.74
Pantothenate-Ca	0.86
Ribolflavin	1.71
Vitamin B_{12}(0.1% in flour)	9.00
Vitamin D_3(400,000 I.C.U./gm)	0.50
Vitamin A(500,000 I.U./gm)	3.00
Vitamin E(dl-alpha toc. acetate; 250 I.U./gm)	40.00
Vitamin K(94% menadione Na-bisulphite .$3H_2O$)	0.24
Butylated Hydroxytoluene (BHT) — antioxidant	34.00

Table 2c

Composition of the Mineral Premix Used in Experiment No. 2

Ingredients	Mg/Kg
$MnSO_4 \cdot 5H_2O$	205.26
KI	0.46
ZnO	54.89
$FeSO_4 \cdot 7H_2O$	83.89
SeO_2	0.14

Table 3

Composition of the Diets Used in Experiment No. 3

Ingredients	Basal (gms/kg)	BG + Basal (gms/kg)	MzBR + Basal (gms/kg)	MBR + Basal (gms/kg)
Ground white maize	570	575	557	557
Soybean meal (44% prot.)	390	338	338	338
Residues[1]	-	25	25	25
$CaHPO_4.2H_2O$	21	21	21	21
$CaCO_3$(ground oyster shell)	9.3	9.3	9.3	9.3
NaCl	5	5	5	5
Choline Chloride	0.14	0.14	0.14	0.14
DL-Methionine	4	4	4	4
Vitamin premix (in flour[2])	+	+	+	+
Mineral premix (in flour)	+	+	+	+

1. Residues tested:
   a) Brewers Grains (BG) b) Millet Beer Residues (MBR)
   c) Maize Beer Residues (MzBR)
2. The vitamin and mineral premixes used in this trial was the same as those in experiment No. 2

Table 4a

Composition of the Diets Used in Experiment No. 4

Ingredients	Basal (gms/kg)	MzBR + Basal (gms/kg)	MzBR + Basal (gms/kg)	MzBR + Basal (gms/kg)
Ground white maize	535.0	522.5	510.0	485.0
Soyabean meal (39.3% prot.)	425.0	412.5	400.0	375.0
DL-Methionine	4.0	4.0	4.0	4.0
Residues[1]	-	25.0	50.0	50.0
$CaCO_3$ (ground oyster shell)	9.2	9.2	9.2	9.2
$CaHPO_4.2H_2O$	21.7	21.7	21.7	21.7
NaCl	5.0	5.0	5.0	5.0
Vitamin premix (in flour[2])	+	+	+	+
Mineral premix (in flour[3])	+	+	+	+

1. Only maize beer residues (MzBR) used.
   2 = Table 4b 3 = Table 4c.

Table 4b

Composition of the Vitamin Premix
Used in Experiment No. 4

Ingredients	Mg/Kg
Niacin	3.10
Pantothenate-Ca	7.90
Riboflavin	3.00
Vitamin A(500,000 I.U./gm)	3.00
Vitamin D_3(400,000 I.C.U./gm)	0.50
Vitamin K(94% menadione Na-bisulphite .$3H_2O$)	0.24
Vitamin B_{12}(0.1% tituration in manitol)	9.00
Butylated Hydroxytuluene (BHT) — antioxidant	34.00

Table 4c

Composition of the Mineral Premix
Used in Experiment No. 4

Ingredients	Mg/Kg
$MnSO_4.5H_2O$	177.30
KI	0.46
$FeSO_4.7H_2O$	21.90
ZnO	55.30
SeO_2	0.14

RESULTS AND DISCUSSIONS

Experiment 1

Treatment effects on body weight, feed consumption and feed utilization efficiency are shown in Tables 5a, 5b.

The data show that the weight of birds fed diets supplemented with 5 percent beer residues generally was slightly less than the weight of those fed the basal diet. The poorest growth was observed on diet containing brewers grains. The average weight of birds fed this diet was 95 percent of those on the basal diet at three weeks of age. Thornton and Mcpheron (1962) reported that brewers grains possibly contained unknown factor(s) or that the biological availability of their known nutrients are greater than the nutrients in basal diets. They observed faster growth rate on birds fed diets containing this product. Our data differed from those observations.

Residues from maize beer and millet beer also appeared to exert possibly very mild depressing effect on growth amounting to 99 and 98 percent respectively of the weight of those on the basal diet, although these results are of little if any importance.

However, when the data were subjected to

statistical analysis, the differences in growth among treatments were not significant at the 5 percent level (Table 5c).

These slightly lower growth rates were attributed possibly to the presence of live yeast cells in the residues (Table 9). It has been noted already that this fermentation was accomplished through wild yeast. There is evidence to show that certain strains of yeast might be detrimental when fed to animals (Mukiibi, 1971).

Approximately 30 percent of the birds had "pasted" vents during the first week of this experiment. However, this was observed in all groups and could not have been due to any particular treatment. It was suspected that the nonheat-treated local soybean meal used in the diet might have been a causative factor. Similar observations were once reported by Berg, et al. (1945) who found that the rations in which nonheat-treated soybean oil meal was the only source of protein caused pasting up in young chicks; especially where the dietary protein was as high as 18-24 percent. The droppings of chicks fed such a diet were reported to be of stickier consistency than those of birds fed diets containing fish meal. The droppings from our chicks in this experiment also showed sticky consistency.

The soybean meal used in this trial was obtained from locally produced expeller processed soybean cake. It contained only 36 percent protein and about 10 percent fat, while high quality soybean meal usually contains 44 or 50 percent protein and about 0.5 percent fat and is heat-treated to destroy anti-trypsin factor. The relatively high fat content of our local soybean cake indicates that the expeller pressure used during extraction was not intense and that the cake may not have received adequate heat to destroy the anti-trypsin factor present in the whole beans. No further heating of the cake is done in the local expeller process.

Feed efficiency through three weeks of age was approximately 1.7 units of feed consumed per unit live weight on the treatments as compared to 1.5 on the control. Birds fed either the beer residues or brewers grains showed slightly inferior feed conversions, but the differences were not significant at the 5 percent level (Table 5d). These modestly unfavourable results are in line with the lower growth rates occurring in this experiment.

Mortality was minimal amounting to only one percent.

Experiment 2

The slight depression in growth observed in birds fed beer residues in Experiment 1 was thought to be due possibly to the large number of live yeast cells found in the residues. Therefore, the second trial was conducted to study the response of chicks to diets again containing 5 percent residues, but having live yeast destroyed by heating the residue to 160°F for 10 minutes and drying rapidly under chick brooder heaters. In this experiment heat treated soybean meal containing approximately 44 percent protein and 0.5 percent fat was available for use.

The data presented in Tables 6a, show the average weights of chicks through three weeks of age. Table 6b. show the average feed consumption, growth and feed efficiency during the same period.

It will be noted that birds on the control diet again grew faster than those on the various treatments. The average weight on brewers grains, maize beer and millet beer residues were 91, 91 and 95 percent respectively of those on the basal diet. These differences were not significant at the 5 percent level (Table 6c), although growth decreases nearly reached significance (P=0.05)

when brewers grains or maize beer residue was added.

Killing yeast cells did not improve the growth of chicks in this experiment. Therefore, the data suggest that live yeast cells had not played a significant role in growth depression, as has been suspected in the first experiment.

The incidence of "pasting up" was observed in only two percent of these birds as compared to 30 percent of the birds in the previous experiment, probably as a result of using better quality soybean meal.

The efficiency of feed utilization was similar at about 1.5 conversion ratio among all treatments except for those chicks getting maize beer residue whose feed efficiency was somewhat poorer at 1.6 units of feed per unit of live weight (Table 6b). When the data were subjected to statistical analysis, it was found that chicks fed the maize beer residue showed significantly poorer feed conversion ($P=0.05$) than those fed the control, brewers grains or millet beer residue; but no significant differences occurred between the control and brewers grains or millet beer residue (Table 6d).

Mortality was two percent which was slightly higher than those in Experiment 1, but would not be considered

excessive.

Experiment 3

Trial 3 was designed to study the response of broiler chicks to diets containing only 2.5 percent residues. It was thought that at this lower level any growth depressant that might be present possibly would be reduced and cease to play a role, thereby permitting growth responses to unidentified growth factors to occur. Morgan, et al. (1951) and Runnels, et al. (1953) obtained improved growth in broilers when fermentation residues were fed at levels as low as 2 percent.

Tables 7a and 7c summarize the performance of chicks on this trial. The data show the same trend in growth depression as in previous experiments. Birds fed residues weighed slightly less than those on the control diet, but differences among treatments were not statistically significant at the 5 percent level (Table 7b and 7d).

Comparing the data of Experiment 2 at week 3 shown in Table 6c, with those of this experiment in Table 7b, it will be noticed that decreases in growth rate among

treatments were closer to significance (P=0.05) when residues were added at 5 percent rather than at 2.5 percent level. It is suggested that the growth depressing effect might be associated with undetermined heat resisting toxin(s) produced by micro-organisms in the residues during fermentation prior to the heat treatment which was mild.

Feed efficiency for all diets was approximately 1.5 units of feed per unit of live weight (Table 7c) at three weeks of age. There were no significant differences among these data (Table 7d).

Mortality throughout the experiment amounted to only 2 percent.

Experiment 4

Data from Experiment 2 and 3 indicated that the average weight of birds at three weeks of age was inversely related to the quantity of residues added to the diets. It was thought at this point that the addition of residues at levels above five percent might cause further depression in growth of chicks.

Experiment 4 was conducted to study the response of chicks to graded levels of residue. Maize beer residue was used to represent these products in this trial,

and the levels consisted of 0, 2.5, 5 and 10 percent of the diets. Data showing the response in growth and feed conversion in chicks to these treatments are presented in Tables 8a, 8c.

The general trend in growth is shown graphically in Fig. 1. The data indicate that growth was depressed progressively with increasing amounts of residue in the diet, and when added at a level of 10 percent significant depression was observed at the 5 percent level (Table 8b) Statistical significance also essentially was reached between the low, 2.5 percent level and the 10 percent level. These observations reinforce the previous suspicion that some mild toxin(s) probably is responsible for this reduction in growth.

Feed efficiency was somewhat less favourable when the diets contained beer residue. Table 8c and Fig. 2 show that the conversion figures were progressively inferior as the levels of residue in the feed increased ($Y = 1.5+0.009X$). The differences in feed efficiency observed, however, were not significant at 5 percent level as shown in Table 8d.

Nine of the 200 birds started died during the 4 weeks period of this experiment. Approximately4 percent of

the casualties occurred on the basal diet while the rest were distributed among the other treatments. This rather high mortality was attributed to the number of weak birds that had to be included at the beginning of the trial.

Thus in all four experiments native maize beer and millet beer residues and brewers grains failed to stimulate increased growth in young chicks as expected. In fact, some depression in growth occurred, and this usually was associated with inferior feed conversion when these materials were included in the diet. Any factor(s) suspected to be present in the residues that were responsible for the depressed responses may have prevented the expression of unidentified growth factor activity.

Obviously, more research is needed to isolate the problem(s) associated with the use of these residues. These materials represent a needed feed ingredient resource in Uganda, because they contain fairly high levels of protein, about 20 percent, and are available in considerable amounts throughout the country.

Table 5a

Average Wights of Chicks Through Three Weeks of Age

Ration	Week One (gms)	% Basal	Week Two (gms)	% Basal	Week Three (gms)	% Basal
Basal	85.33	100	181.65	100	309.21	100
Basal + 5% BG	80.80	95	173.79	96	294.53	95
Basal + 5% MzBR	81.68	96	173.75	96	306.11	99
Basal + 5% MBR	82.25	96	173.60	96	304.05	98

Note: BG = Brewers Grains

MBR = Millet Beer Residue

MzBR = Maize Beer Residue

Table 5b

Average Feed Consumption, Growth and Feed Efficiency Through Three Weeks of Age

Ration	Average Feed Consumption (gms)	Average Weight: 3-Weeks (gms)	Feed/Unit Live Weight
Basal	469.38	309.21	1.52
Basal + 5% BG	511.09	294.53	1.74
Basal + 5% MzBR	520.88	306.11	1.70
Basal + 5% MBR	535.55	304.05	1.76

Note: BG = Brewers Grains

MBR = Millet Beer Residue

MzBR = Maize Beer Residue

Table 5c

The Effects of Feeding Deer Residues at 5 Percent Level on the Average Weights of Chicks at Three Weeks of Age

Multiple Range Test

	Average Weights in Grams			
Dietary Treatment	Mean($\bar{x}$)	$\bar{x}$-294.53	$\bar{x}$-304.05	$\bar{x}$-306.11
Basal	309.21	14.68	5.16	3.10
Basal + 5% MzBR	306.11	11.59	2.06	
Basal + 5% MBR	304.05	9.52		
Basal + 5% BG	294.53			

Range	$S\bar{x}$	CV	D(P=0.05)
4	6.393	3.649	23.33
3	6.393	3.587	22.93
2	6.393	3.461	22.13

Table 5d

The Effect of Adding Residues at
5 Percent Level on Feed Efficiency
Through Three Weeks of Age

Multiple Range Test

	Feed Conversion Ratio			
Dietary Treatment	Mean ($\bar{x}$)	$\bar{x}$-1.52	$\bar{x}$-1.70	$\bar{x}$-1.74
Basal + 5% MBR	1.76	0.24	0.06	0.02
Basal + 5% BG	1.74	0.22	0.03	
Basal + 5% MzBR	1.70	0.19		
Basal	1.52			

Range	$S\bar{x}$	CV	D(P=0.05)
4	0.080	3.649	0.30
3	0.080	3.587	0.30
2	0.080	3.461	0.29

Table 6a

Average Weights of Chicks Through Three Weeks of Age

Ration	Week One (gms)	% Basal	Week Two (gms)	% Basal	Week Three (gms)	% Basal
Basal	118.56	100	247.60	100	366.86	100
Basal + 5% BG	110.15	92	237.06	96	333.83	91
Basal + 5% MzBR	112.40	94	230.78	93	332.56	91
Basal + 5% MBR	112.25	94	237.42	96	348.48	95

Note: BG = Brewers Grains

MBR = Millet Beer Residue

MzBR = Maize Beer Residue

Table 6b

Average Feed Consumption Growth and Feed Efficiency Through Three Weeks of Age

Ration	Average Feed Consumption (gms)	Average Weight: 3-Weeks (gms)	Feed/Unit Live Weight
Basal	553.60	366.86	1.51
Basal + 5% BG	497.08	333.83	1.49
Basal + 5% MzBR	534.42	332.56	1.61
Basal + 5% MBR	518.54	348.48	1.49

Note: BG = Brewers Grains

MBR = Millet Beer Residue

MzBR = Maize Beer Residue

Table 6c

The Effect of Adding Live Yeast-free Residues at 5 Percent Level on The Average Weight of Chick at Three Weeks of Age

Multiple Range Test

	Average Weights in Grams			
Dietary Treatment	Mean($\bar{x}$)	$\bar{x}$-332.56	$\bar{x}$-333.83	$\bar{x}$-348.48
Basal	366.86	34.31[1]	33.03[1]	18.38
Basal + 5% MBR	348.48	15.92	14.64	
Basal + 5% BG	333.83	1.28		
Basal + 5% MzBR	332.56			

Range	$\bar{S}x$	CV	D(P=0.05)
4	10.133	3.648	36.98
3	10.133	3.587	36.35
2	10.133	3.461	35.07

1. Was about to reach significance at 5 percent level.

Table 6d

The Effect of Feeding Live Yeast-free Residues at 5 Percent Level on Feed Efficiency Through Three Weeks of Age

Multiple Range Test

	Feed Conversion Ratio			
Dietary Treatment	Mean($\bar{x}$)	$\bar{x}$-1.49	$\bar{x}$-1.49	$\bar{x}$-1.51
Basal + 5% MzER	1.61	0.12*	0.12*	0.10*
Basal	1.51	0.02	0.02	
Basal + 5% BG	1.49	0.00		
Basal + 5% MBR	1.49			

Range	$S\bar{x}$	CV	D(P=0.05)
4	0.030	3.649	0.11
3	0.030	3.587	0.11
2	0.030	3.461	0.10

* Significant at 5 percent.

Table 7a

Average Weights of Chicks Through Three Weeks of Age

Ration	Week One (gms)	% Basal	Week Two (gms)	% Basal	Week Three (gms)	% Basal
Basal	97.87	100	186.65	100	331.30	100
Basal + 2.5% BG	97.38	99	180.06	96	307.41	93
Basal + 2.5% MzBR	93.27	95	181.78	97	321.31	97
Basal + 2.5% MBR	96.67	99	184.21	98	313.79	95

Note: BG = Brewers Grains

MBR = Millet Beer Residue

MzBR = Maize Beer Residue

Table 7b

The Effects of Adding Live Yeast-free Residues at 2.5 Percent on the Weight of Chicks at Three Weeks of Age

Multiple Range Test

	Average Weights in Grams			
Dietary Treatment	Mean($\bar{x}$)	$\bar{x}$-307.41	$\bar{x}$-313.79	$\bar{x}$-321.31
Basal	331.30	32.89	17.51	9.98
Basal + 2.5% MzER	321.31	13.91	7.53	
Basal + 2.5% MBR	313.79	6.38		
Basal + 2.5% BG	307.41			

Range	$S\bar{x}$	CV	D(P=0.05)
4	12.210	3.649	44.55
3	12.210	3.587	43.80
2	12.210	3.461	42.26

Table 7c

Average Feed Consumption, Growth and Feed Efficiency Through Three Weeks of Age

Ration	Average Feed Consumption (gms)	Average Weight: 3-Weeks (gms)	Feed/Unit Live Weight
Basal	497.94	331.30	1.50
Basal + 2.5% BG	459.26	307.41	1.49
Basal + 2.5% MzBR	482.94	321.31	1.50
Basal + 2.5% MBR	468.49	313.79	1.49

Note: BG = Brewers Grains

MBR = Millet Beer Residue

MzBR = Maize Beer Residue

Table 7d

The Effect of Adding Live Yeast-free Residues at 2.5 Percent on Feed Conversion Efficiency Through Three Weeks of Age

Multiple Range Test

	Feed Conversion Ratio			
Dietary Treatment	Mean($\bar{x}$)	$\bar{x}$-1.49	$\bar{x}$-1.49	$\bar{x}$-1.50
Basal	1.50	0.01	0.01	0.00
Basal + 2.5% MzBR	1.50	0.01	0.01	
Basal + 2.5% EG	1.49	0.00		
Basal + 2.5% MBR	1.49			

Range	Sx	CV	D(P=0.05)
4	0.02	3.649	0.07
3	0.02	3.587	0.07
2	0.02	3.461	0.07

Table 8a

Average Weights of Chicks Through Three Weeks of Age

Ration	Week One (gms)	% Basal	Week Two (gms)	% Basal	Week Three (gms)	% Basal
Basal	82.35	100	158.23	100	287.33	100
Basal + 2.5% Residue[1]	80.38	98	148.65	94	268.71	94
Basal + 5% Residue	76.83	94	148.39	94	242.38	84
Basal + 10% Residue	76.77	94	135.25	85	218.19	76

1. The residue used was maize beer residue.

Table 8b

The Response of Chicks to Graded Levels of Maize Beer Residues Through Three Weeks of Age

Multiple Range Test

Dietary Treatment	Average Weights in Grams			
	Mean($\bar{x}$)	$\bar{x}$-218.19	$\bar{x}$-242.38	$\bar{x}$-268.71
Basal	287.33	69.14*	44.95	18.62
Basal + 2.5% Residue	268.71	50.52[1]	26.33	
Basal + 5% Residue	242.38	24.19		
Basal + 10% Residue	218.19			

Range	Sx	Cv	D(P=0.05)
4	14.13	3.649	51.56
3	14.13	3.587	50.68
2	14.13	3.461	48.90

* Significant at the 5 percent level.

1. Very close to significance (P=0.05).

Table 8c

Average Feed Consumption, Growth and Feed Efficiency Through Three Weeks of Age

Ration	Average Feed Consumption (gms)	Average Weight: 3-Weeks (gms)	Feed/Unit Live Weight
Basal	431.86	287.33	1.50
Basal + 2.5% Residue	408.71	268.71	1.52
Basal + 5% Residue	374.48	242.38	1.55
Basal + 10% Residue	346.70	218.19	1.59

Note: Maize beer residue was used.

Table 8d

The Effects of Adding Graded Levels of Maize Beer Residue on Feed Conversion Efficiency Through Three Weeks of Age

Multiple Range Test

	Feed Conversion Ratio			
Dietary Treatment	Mean($\bar{x}$)	$\bar{x}$-1.50	$\bar{x}$-1.52	$\bar{x}$-1.55
Basal + 10% Residue	1.59	0.09	0.07	0.04
Basal + 5% Residue	1.55	0.05	0.03	
Basal + 2.5% Residue	1.52	0.02		
Basal	1.50			

Range	$S\bar{x}$	CV	D(P=0.05)
4	0.039	3.649	0.14
3	0.039	3.587	0.14
2	0.039	3.461	0.13

Table 9a

Yield and Proximate Analysis of Beer Residues (Air Dry)

Sample Description	% Yield	% DM	% CP	% Fat	% Fibre	% Ash
Millet Beer Residue (MBR)	15.4	88.5	16.1	5.5	6.8	7.3
Maize Beer Residue (MzBR)	12.6	90.5	21.4	3.6	6.5	7.0
Brewers Grains[2] (BG)	-	92.3	21.3	6.5	16.3	4.2

1. Percent Yield = $\frac{\text{Weight of Residue}}{\text{Weight of Grains Used}} \times 100$

2. Percent yield for BG was not calculated due to lack of information regarding the amount of original grains used.

Table 9b

Medium For the Culture of Yeast

Ingredients	Gms/Litre
$(NH_4)_2SO_4$	2.9
$Na_2HPO_4.12H_2O$	2.3
Glucose	55.6
Agar	15.0

Table 9c

Growth of Yeast Cells on Beer Residues

Boiled (MBR)	10^{-5}	1.3×10^{7}
	10^{-6}	1.2×10^{6}
Unboiled (mBR)	10^{-4}	1.4×10^{6}
	10^{-5}	1.7×10^{6}
Boiled (MzBR)	10^{-4}	6.5×10^{6}
	10^{-5}	3.4×10^{6}
Unboiled (MzBR)	10^{-4}	1.5×10^{6}
	10^{-5}	1.8×10^{7}
Boiled (BG)	10^{-4}	1.2×10^{5}
	10^{-5}	1.5×10^{5}
Unboiled (BG)	10^{-4}	1.5×10^{4}
	10^{-5}	1.7×10^{6}

Note: MBR = Millet Beer Residue

MzBR = Maize Beer Residue

BG = Brewers Grains

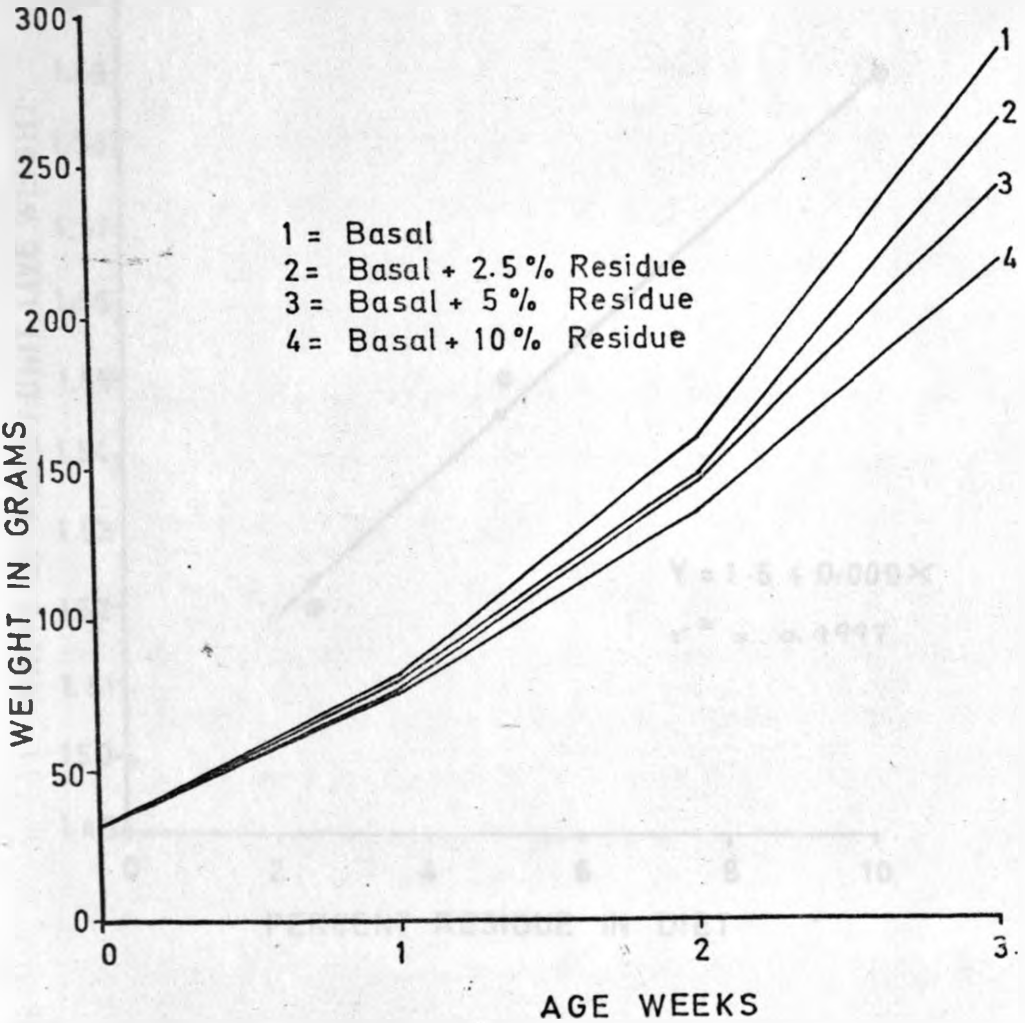

Fig. 1 Growth responses of chicks to graded levels of maize beer residue

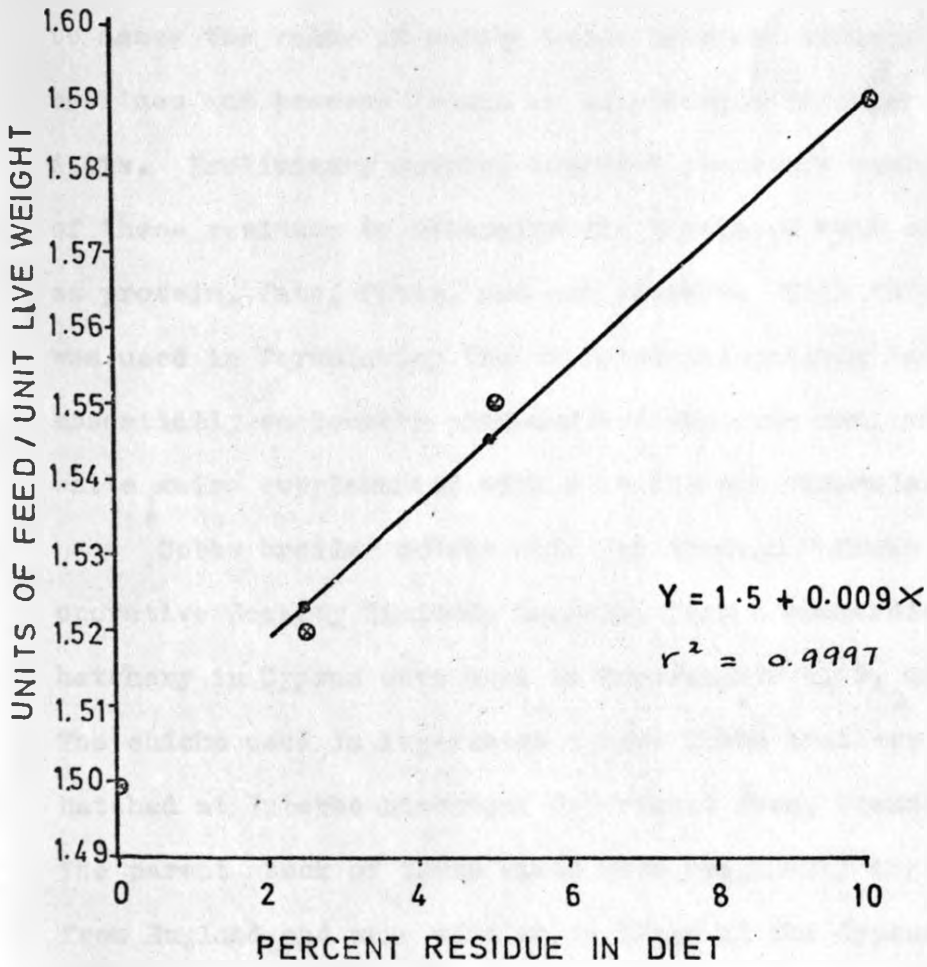

Fig. 2

The effect of graded levels of maize beer residue on feed conversion efficiency through three weeks of age.

SUMMARY

A series of four feeding trials were conducted to asses the value of native maize beer and millet beer residues and brewers grains as supplements in chick diets. Preliminary studies involved proximate analyses of these residues to determine the levels of such components as protein, fats, fibre, and ash present. This information was used in formulating the experimental rations based essentially on locally produced soybean cake meal and ground white maize supplemented with vitamins and minerals.

Cobbs broiler chicks obtained through Wankoko Co-operative Society Limited, Kampala, from a commercial hatchery in Cyprus were used in Experiments 1, 2, and 3. The chicks used in Experiment 4 were Cobbs broilers hatched at Entebbe Livestock Experiment Farm, Uganda. The parent stock of these birds were originally imported from England and were similar to those at the Cyprus hatchery.

Day-old chicks were assigned randomly to sixteen pens in a 4 x 4 Latin-square experimental design. The chicks were reared in electrically heated battery brooders

with raised wire screen floors. Group weights of birds were taken after they were assigned to experimental pens at one day of age. Thereafter, group weights and feed consumption per pen were determined at weekly intervals through the third week and converted to average weights and feed conversions. Mortality data and any abnormal developments were recorded.

It was found that the growth rate of chicks fed diets supplemented with 2.5 and 5 percent residues were generally slightly depressed, although the observed differences in weights were not statistically significant ($P=0.05$). Feeding yeast-free residues had no favourable influence on growth and feed efficiency as compared to diets in which residues contained live yeast cells.

When graded levels of residues from 0, 2.5, 5 and 10 percent of the diet were fed, growth progressively decreased slightly with increasing amount of residues in the diet. A significant ($P=0.05$) decrease in growth rate was observed when residue was added at 10 percent level.

Feed conversion efficiency was somewhat less favourable when residues were added to the diets. In all

trials birds on the control diets required approximately 1.5 units of feed to produce a unit live weight at three weeks of age while those on treatments required about 1.6 units.

Mortality rate varied from 1 to 2 percent, and in one special instance it was about 4.5 percent. This is considered to be within the range of tolerance under good poultry management conditions.

The nature of the suspected growth depressant(s) in the residues is unknown. However, it is suggested that the depressing effects may have been due to undetermined toxin(s) produced by micro-organisms associated with wild yeasts in the material during fermentation.

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APPENDIX

Appendix 1.

Moisture Determination:

A clean crucible was dried in the oven at 100°C for 24 hours and weighed accurately on a chemical balance.

One gram of beer residue was weighed into the crucible. Then, the crucible containing the residue was placed into the oven, again heated to 100°C. After 24 hours they were allowed to cool to room temperature in a desiccator before the final weight was taken. Duplicate samples were taken for each residue.

Calculation:

Wt. of Moisture = Wt. of Original Sample - Wt. of Dried Sample.

$$\text{Percent Moisture} = \frac{\text{Wt. of Moisture}}{\text{Wt. of Original Sample}} \times 100$$

Appendix 2.

Determination of Crude Protein (Nitrogen):

Nitrogen was determined by the Micro-Kjeldahl method as outlined below.

Digestion:

One tenth (0.1) of a gram of residues was accurately weighed and transferred quantitatively into a clean 30 ml. Kjeldahl flask. Approximately 1 gram of a catalyst mixture consisting of 160 grams Na_2SO_4, 10 grams $CuSO_4$ and 3 grams selenium powder, was added and the mixture moistened with distilled water. Finally, 3.5 ml. of concentrated H_2SO_4 (Analar) was decanted into the flask.

The flask was then placed on the digestion heater. Gentle heat was applied until the mixture became clear. Then the mixture was heated strongly for 30 minutes to complete the digestion phase.

Blank Titration:

Ten millilitres of distilled water plus a drop of phenolphthalein was measured into the Markham distillation apparatus. A small amount of 40 percent NaOH also was added.

Ten millilitres of 2 percent boric acid solution plus two drops of mixed indicator (3 parts 0.1 percent Bromocresal Green and 2 parts 0.1 percent Methyl Red, both dissolved in ethyl alcohol) were then measured into a receiving flask which was placed under the condenser so that the liquid covers the condenser tip.

Steam was introduced into the Markham apparatus and distillation was continued until the receiving flask was about 2/3 full. The solution thus obtained was titrated against a standard 0.02N HCl and the volume of acid used was recorded as the blank titre.

DISTILLATION:

When digestion was completed, the flask was cooled for about five minutes to avoid crystallization of the digest and the contents transferred into 50 ml. flask with fresh distilled water and made up to volume.

Ten millilitres of the prepared solution was pipetted into a steamed Markham apparatus and about 10 ml. of 40 percent solution of NaOH (w/v) were added. Distillation was carried out and the evolved ammonia was absorbed into a flask containing 10-12 ml. 2 percent boric acid (w/v) to which 2 to 3 drops of mixed indicator (3 parts 0.1 percent Bromocreasal Green and 2 parts 0.1 percent Methyl Red, both dissolved in ethyl alcohol) was added.

When the flask was 2/3 full, the absorbed ammonia was titrated against a standard 0.02N HCl and the volume of acid used was recorded. Duplicate titrations were done for each sample. The net titre used in the final calculations

was obtained by subtracting the blank titre from the volume of acid used to neutralize the ammonium salt.

Calculation of Percent N in Sample:

Note:

1 litre of 1N HCl ≡ 14 gm N

1 millilitre of 1N HCl ≡ 14 mg N

1 millilitre 0.02N HCl ≡ 14 x 0.02 mg N

≡ 0.28 mg N

Percent N in Sample:

$$= \frac{\text{0.28 mg N x Net Titre x 50 ml. (Total Vol. Solution)}}{\text{Wt. of Original Sample (mg) x 10 ml. (Vol. Titrated)}} \times 100$$

Percent C.P. in Sample = Percent N in Sample x 6.25

Appendix 3.

Determination of Crude Fat:

Two grams of residue was weighed into the extraction thimble. A clean flask was dried in the oven at 95°C and cooled in a desiccator to obtain a constant weight of the flask.

About 50 ml. of ether was measured into the flask and the thimble containing the sample was placed in the Soxhlet

apparatus. Extraction was done overnight. The beaker containing the extract was dried in the oven ($95^{\circ}C$) for 30 minutes and allowed to cool in a dessicator to room temperature before final weighing.

Calculation:

Wt. of C.F. = Wt. of Flask + Dried Extract - Wt. of Flask.

$$\text{Percent CF} = \frac{\text{Wt. of C.F.}}{\text{Wt. of Sample}} \times 100$$

Appendix 4

Crude Fibre Determination:

The fibre content of beer residues was determined by the Winde Method.

Three grams of sample was weighed in a thimble and placed in a Soxhlet apparatus. The fat was extracted overnight using Petroleum Spirit ($40^{\circ}C$ - $60^{\circ}C$). The dried residues from this extraction process was transferred quantitatively into a conical flask.

Two hundred millilitres of boiling 1.25 percent H_2SO_4 (w/v) was decanted into the flask containing the residue. A finger condenser through which cold water was permitted

to flow constantly was fitted on to the flask. The flask was then heated strongly to effect boiling of the contents within one minute after the addition of H_2SO_4. Heating was continued for 30 minutes.

The cold finger condenser was rinsed with distilled water and the contents of the flask was transferred onto a linen cloth on a Buchner funnel. The fibre was filtered under vaccum and washed several times with boiling distilled water.

The residue was transferred back into the conical flask. Then, 200 ml. of boiling 1.25 percent NaOH (w/v) was added and the cold finger condenser fitted to the flask. Heating again was done for 30 minutes. Filtration and washing were carried out under a vaccum with the Buchner funnel. The fibre was initially washed with 1 percent HCl (w/v) and then rewashed with hot distilled water to remove all the HCl.

Final washing was done with 10 ml. ethyl alcohol and 10 ml. diethyl either before the fibre was dried at 100°C on a previously weighed ashless filtre paper. The fibre and filter paper were weighed and transferred to an ignited crucible of known weight. Ashing was done in a furnance at 600°C and the crucible with the greyish-white

residue was cooled in a desiccator and reweighed.

The percentage crude fibre was determined using the following formulae:

Wt. of Fibre = (Wt. of Crucible + Wt. of Filter Paper + Wt. of Dried Fibre) - (Wt. of Crucible + Wt. of Filter Paper + Ash)

$$\text{Percent C.F.} = \frac{\text{Wt. of Fibre}}{\text{Wt. of original sample}} \times 100 \times 0.98^{*}$$

* A correction factor of 0.98 was applied to allow for the effect of altitude on the boiling point of reagents.

Appendix 5

Determination of Ash:

Two grams of sample were weighed into a procelain crucible of known weight and placed in a muffle furnace previously heated to 600°C. Heating was continued at this temperature for two hours. The crucible containing the ash was then cooled in a desiccator before the final weight was taken. The percent ash was calculated by the folowing equation:

Percent Ash:

$$= \frac{(\text{Wt. of Crucible + Ash}) - \text{Wt. of Crucible}}{\text{Wt. of Original Sample}} \times 100$$

BIOGRAPHICAL SKETCH

The author was born on March, 15th 1941 at Bobi Paidongo, West Acholi District of Uganda. He was educated at Gulu Catholic Mission up to Secondary II. In 1958 he joined St. Aloysious College, Nyapea from where he graduated with the Cambridge School Cetificate (Grade I) in 1961. He was admitted to Senior V at Mbale Senior Secondary School in 1962 but resigned in 1963 to take up a course in Agriculture at Bukalasa Agricultural College. In December 1965, he graduated with a College Diploma in Agriculture and was appointed an Assistant Agricultural Officer with the Ministry of Agriculture, Forestry and Cooperatives. He worked as an Assistant Lecturer in Animal Science at Bukalasa College and was also in charge of practical training for students.

In March, 1966 he received a second Diploma in Agriculture from the University of East Africa; and late that year joined West Virginia University, United States of America, under the Agency for International Development Program for a B.Sc. degree course in Agriculture. He returned in December 1967 and was appointed Agricultural Officer. He worked as a Lecturer in Animal Science at Arapai Agricultural College and was appointed Head of Department in March 1970. In October that year, he was admitted to the M.Sc. Program at Makerere University, Kampala.