MAIZE MALTING AND BREWING STUDIES

Maize Malting For Optimum Diastatic Activity and Riboflavin Development

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LIST OF CONTENTS

PREFACE

As stated in the terms of my appointment, I shall be upgraded to the status of a Research Officer after serving a one year trial period at the Institute, depending on a favourable report by the Officer-In-Charge.

On my assumption of duty on 1st September, 1975, I was advised by Mr. K.K. Eyeson, as the Head of the Chemistry, Microbiology and Nutrition Division, to undertake the biochemical aspects of a project on the "Maize Malting and Brewing Studies". This allowed Miss Mary Halm, Research Officer (Microbiology) who was the initiator of the project, to concentrate on the microbiological aspects.

Attached is a report on the project - "Maize Malting for Optimum Diastatic Activity and Riboflavin Development" - which was designed in September 1975 to cover the one year period. The project covers an investigation into the traditional process of maize malt beverage production in Ghana, analysis of traditional maize malt samples, determination of the biochemical changes during maize malting and the effect of the malting conditions, and finding the optimum parameters for maize malting to give high diastatic activity and riboflavin development in the final malt.

SUMMARY

The traditional processes of maize malt beverage production in Ghana were investigated and found to involve the general steps of steeping the maize grains for about 24 hours at 28 - 30°C and allowing germination to take place for a period of between 5 and 7 days. The resulting malt is sun-dried, milled and cooked to obtain the malt extract beverage. Although the malting procedure followed could effect considerable biochemical changes in the grains leading to the development of riboflavin and high diastatic power, analysis of the intermediate and final products showed that lack of proper attention during the germination period resulted in only a minimum degree of development of these components. The highest level of riboflavin recorded for the traditional malt was only 2.1 µg/g and the diastatic activity was 30.9°.

An investigation was also carried out into the general changes occuring during maize malting and the factors affecting the proper development of riboflavin and diastatic activity. Biochemical changes during steeping and germination were found to include the production of various hydrolytic enzymes which catalyse metabolic activities to effect changes in the proximate composition of the grains. The most profound changes during germination occured in the carbohydrates in which a progressive decrease in the starch content with a corresponding increase in the sugars was observed. There was also a considerable development of riboflavin and diastatic activity.

Summary (Contd.)

Malting temperature, moisture and period of germination were found to be the main factors affecting proper developments of riboflavin and diastatic power. Optimum development was obtained in grains soaked for 24 hours and allowed to germinate for a period of 4 - 5 days at 28 - 30°C with a constant daily sprinkling of water. Analysis of maize malt produced by this procedure showed a four-fold riboflavin development (from 1.2 to 4.8 ug/g on Dry weight Basis) and an increase of diastatic power from 12.4 to 54.7°.

1. INTRODUCTION

In the traditional societies of Ghana, as well as most African countries, use is made of the indigenous cereals available in the production of not only the main diets of the people but also cereal beverages usually served at certain traditional ceremonies such as out-doorings and funerals. The type of cereal used and the method of processing differ from place to place depending on the availability of materials and the food habits of the people.

Schwartz (1956) has described the brewing process for a traditional Bantu drink called Kaffir beer. This is prepared from ground malted and unmalted sorghum by lactic acid fermentation followed by alcoholic fermentation. In an introductory remarks in his studies on Kaffir beer Van der walt (1956) also mentioned examples such as merissa from Sudan, Bouza from Ethiopia and Pombe from East Africa. Apart from the extensive use of maize in the Southern part of Ghana for the preparation of some staple diets such as "kenkey" and "Banku" a non-alcoholic cereal beverage is also produced from maize grains.

This beverage, known as "Nmada" (in the Grater Accra Region by the Ga-Adangmes), "Ahei" (in the Central and Western Regions by the Fantis), or "Liha" (in the Volta Region by the Ewes), has been an age-old cereal drink, the method of production of which has been passed on from generation to generation.

It was found that the main processing steps employed are similar to those used on Commercial scale for the preparation of other cereal /such beverages/ as beer and malt extracts. When concentrated to some degree, the malted maize beverage has the taste and aroma like those of other malt-extracts produced from imported barley malts and which are widely consumed in the country. Although the maize malt beverage is not drunk for any other value apart from its refreshing and organoleptic properties, nevertheless, it has a very important nutritional value, as a source of vitamin B, especially riboflavin, in addition to its calorific contribution to the diet.

According to Goldberg and Thorp (1946) African cereals usually provide adequate amounts of thiamine but the riboflavin and nicotinic acid deficiencies are widespread. Whitby's nutritional survey (1968) also indicated a widespread deficiency of riboflavin in the Ghanaian diet. The nutritional significance of this beverage as a supplement is therefore aparent considering the fact that the biochemical changes that occur in the course of its production endow it with a high riboflavin content as well as other components which are of both nutritional and industrial interest.

Malting is one of the most important processing stages in the production of maize malt beverage, and the final quality of the product depends to a large extent on this process. Practically no work has so far been done on malted local cereals and their products in Ghana. The only attempt at the Food Science Department Legon (1975) provides only the fundamental guidelines on which meaningful research could be based. Literature on any detailed work to elucidate the biochemical processes that interact at the various stages of the traditional process to produce the nutritional components as well as organoleptic properties of the final product is lacking. The literature review for a fundamental appraisal of the subject under study is therefore based mainly on work done elsewhere on related aspects with similar materials.

Malting brings about some biochemical changes in cereals, and such modifications of the grain make it possible to utilize the components as good nutritional supplement or for industrial purposes. In general the malting process involves steeping the grains to revitalise them and allowing them to germinate for a period of time within which the acrospire grows to a specified length. By this time, the morphological, histological and various metabolic changes associated with germination might have occured to give the desired components in the grain.

Evidence of riboflavin production during germination of cereal grains has been reported by various workers. In 1943 Cheldelin and Lane (1943) showed that germination for 36 - 48 hours in the light resulted in considerable production of riboflavin in black-eyed peas and in lima beans. Buckholder (1943) also worked on a number of different species of seeds and found that the riboflavin levels in oats, wheat, barley and corn increased forteen, four, eight and four times respectively when they are germinated for 5 - 6 days. The findings of other workers like Klatzin et al (1949); Petit (1950); Wai et al (1947); [illegible] and Nandi and Baneijee (1950); Buckholder and M^{c}Veigh (1942); Raut and Chitre (1961); all showed similar situations in most sprouting seedlings. Gustafson (1950), [illegible], showed that the rate of biosynthesis is affected by certain physical conditions like temperature.

Other biochemical changes occuring during malting include the formation of various enzymes such as proteinases and peptidases, phosphatases, maltase and oxidases. These effect a large number of hydrolytic processes leading to the production of desirable components in the grain. The absorption of moisture during steeping sets off life processes culminating in the production of these enzymes.

One of these enzymes, the amylases, according to Jean de Clerck (1957) are mainly formed in the scutellum but small amounts occur in the endosperm and aleurone layer. Beta-amylase which attacks the amylase fraction of starch to give beta-maltose and small portions of dextrin, is known to be present in raw barley closely bound up with the albumen fraction of the grain and it is only by the activity of proteolytic enzymes during germination that causes its liberation. The other amylase, alpha-amylase, is formed during germination and hydrolyses the amylopectin portion of the starch granule to give alpha-maltose and large portion of dextrin. Novellie (1962) working on the malting conditions on the diastatic powers in Kaffircorn (Sorghum) malt found that for optimum development of diastatic power in Kaffircorn, high temperatures (25 - 30^{o}C) and high moisture content are needed during germination.

These are the changes envisaged to occur in the maize grain during malting for the production of the traditional maize malt beverage which derives its nutritional benefits from the results of these biochemical changes. Contrary to this expectation, the traditionally brewed maize malt beverage lacks the characteristic organoleptic and nutritional properties, associated with the beverage, consequently failing to attract consumer acceptability in preference to the other available refreshing beverages. These properties are obtained only through proper malting and brewing.

The aims of this study are therefore:-

(1) To investigate the various traditional methods of maize malt beverage production in Ghana, and

(2) to determine the factors that influence the development of riboflavin and diastatic activity during malting and thereby establish a maize malting procedure similar to the traditional process to produce maize malt with high levels of these components.

This will not only help to reduce cost of production and raise the nutritional content of the final product for the benefit of the traditional producer but will also standardize conditions of malting as a unique industrial opportunity for the local enterpreneur.

An outline of the method of research undertaken in persuance of the aims and objectives is as follows:

(1) Locating production areas, and investigating traditional methods of maize malt beverage production in Ghana; and analysis of intermediate and final products to assess their general quality in relation to the local conditions of production.

(2) A laboratory study of maize malting, following the traditional process, to determine the general biochemical changes occuring during malting.

(3) A study of the maize malting process under varying conditions to determine the effect of certain physical factors on the riboflavin development and diastatic activity of the final malt.

2. MATERIALS AND METHODS

MATERIALS

For all trial malting studies, a local variety of corn, which is quite small in size was used. This corn, purchased from the local markets, was acclaimed the best variety for the maize beverage production by most of the traditional brewers because of its germinating properties. It has a proximate composition as follows:- Moisture - 12.5%; Protein - 10.1%; Fat - 4.3%; Ash - 1.4%; Fibre - 1.1% and Starch 79.2%. All the values, except moisture, are on Dry weight Basis.

All reagents used for chemical analysis were "Analar" grade supplied by the British Drug Houses (BDH) Chemicals Ltd., Poole England. A size 8 inch Laboratory Hammer Mill supplied by Christy & Norris Ltd., Chelmsford was used for all milling purposes in this study.

METHODS

(a) Determination of Traditional Methods of Maize Malt Beverage Production

Working through friends, relatives, school teachers and other well known personalities in the principle towns and villages in the Southern Sectors of the Volta, Greater Accra, Central and Western Regions of Ghana, areas of production were located. To win the confidence of the producers some rapport was established in the first place through the help of people who are well known to them. Appointments were booked for discussions on the individual methods of production. It took not less than three separate visits each before the actual processes could be established. Subsequent visits were organised to follow up the process for a practical appraisal and to purchase samples of the malt and final products for analysis.

Their problems were discussed, and on the spot suggestions were made for solutions to some of them, Appendix 1 shows a questionnaire which was followed as much as possible in all the interviews.

(B) Determination of Paraneters Affecting the Quality of the Malt

A sample malting was first undertaken in the laboratory with the general traditional procedure to determine the general changes that occur during malting. This was repeated under varying conditions to determine the effect of steep temperature, duration of steeping, moisture, malting temperature, duration of germination, and drying temperature on the riboflavin development and diastatic activity of the malt as indices of vitamin biosynthesis and enzyme production respectively.

(i) To determine the general changes occuring during malting selected maize grains were washed thoroughly and steeped in water for 24 hours at 28 - 30°C. The soaked grains were then removed and spread on a filter paper on a perforated metal plate and covered with polythene sheets to prevent excessive moisture loss. They were sprinkled with water twice daily and samples taken each day for proximate analysis as well as riboflavin and diastatic activity determinations. The results were analysed to follow the biochemical changes during malting.

(ii) The effect of duration and temperature of steeping on the subsequent development of diastatic power and riboflavin was determined by following a similare procedure as outlined above. In this case however, the sample of the maize grains was divided into three sets which were steeped at 20°C, 28°C and 37°C respectively. Samples from each set were taken after four, twelve and twenty-four hours of steeping.

These were germinated as above at 28 - 30 C for a period of time and analysed for diastatic activity and riboflavin content.

(iii) To obtain the effect of the interaction of steep - & germination temperature of maize on the quality of the final malt, samples of the grains were steeped at three different temperatures - 20°C, 28°C and 37°C for 24 hours. Each set was then divided into three and germinated at 20°C, 28°C and 37°C respectively for six days. Samples for 3rd, 4th, 5th and 6th days of germination were analysed for their diastatic power and riboflavin content.

(iv) The third parameter examined was the effect of the malting temperature. The procedure in (i) above was followed but in this case various samples of the same variety of maize were malted at temperatures ranging from 20°C to 37°C. For each temperature of malting the developments of diastatic power and riboflavin were followed in the course of germination by taking daily samples for analysis.

(v) To ascertain the effect of moisture on the quality of the final malt, three parallel maltings were carried out at low medium and high moisture levels. For the medium moisture level sample, watering after the initial 24 hours' steeping was done sparingly while the high moisture level sample had the normal twice-daily sprinkling. The low moisture level sample had no watering during germination. Steeping and germination were carried out at 28 - 30°C.

(vi) Industrial use of malted maize for the production of beverages will require artificial drying. This requirement necessitates an investigation into the effect of drying temperature on the quality of the malt. A number of samples malted by the procedure described in (i) were dried at different temperatures ranging from ordinary sun drying to oven drying between 35°C to 80°C. Each sample was then ground and analysed to obtain the effect of the drying conditions on the enzyme activity and vitamin content of the malt.

C) Preparation of Samples for Analysis

All wet samples collected for analysis were first air-dried to a moisture level below 12 per cent and milled in a size 8 inch. Laboratory Hammer Mill.

D) General Analytical Methods

The methods used for most of the determinations are given by the American Association of Cereal Chemists (AACC) (1962) and the Association of Official Agricultural Chemists (A.O.A.C)(1970). The references for these and others are given against each method.

(i) Determination of Moisture

Since most of the samples had moisture levels above 13% and the incidence of moisture loss during milling is quite significant, the modified 2 stage air oven method of moisture determination was used. This involves first drying on top of an oven to obtain initial moisture loss, milling the samples and oven drying at 105°C to obtain the final moisture loss (A.A.C.C.) (1969). The total moisture content is calculated as follows:-

$$T = A + \frac{(100 - A)B}{100}$$

where, A = % Moisture lost in air drying

B = % Moisture in air dried sample as determined by Oven drying.

and T = % total moisture.

(ii) Determination of Crude Protein

The measurement of total nitrogen was the basis for the estimation of protein content on the assumption that all the nitrogen in a sample is present in the form of protein. The greatest disadvantage here is that the method used for nitrogen content is sensitive to non-protein nitrogen containing materials such as nucleic acids, free amino acids etc. This non-protein portion, however, constitutes a small fraction of the total nitrogen. The error introduced is therefore considered insignificant.

The total nitrogen (N) was determined on about 2g sample by macro-kjeldahl method and percentage protein calculated as (N x 6.25). (A.A.C.C. 46 - 12) (1962).

(iii) Determination of Ash Content

The samples were ashed at a temperature of about 550°C in an electric muffle furnace. Silica dishes which have been ignited, cooled in a desicator and weighed were used. The residue remaining after 2 hours' incineration was determined as ash (A.A.C.C. 08-01) (1962)

(iv) Determination of Crude Fat

The Crude fat was extracted from the samples in a soxhlet extraction unit with petroleum ether (B.Pt. 40 - 60°C) for about five hours (A.A.C.C) (1962). Accurately weighed samples of about 2.0g were used.

(v) Crude Fibre Determination

An accurately weighed sample was digested under standardized conditions with petroleum spirit, boiling dilute H_2SO_4, NaOH, dilute HCl, alcohol & ether. The Crude fibre content was estimated in terms of the loss on ignition of the dried residue remaining after the digestion. (AOAC 7.053) (1970).

(vi) Total solid determination

Total solids were determined by evaporating a known volume of the liquid sample in a tared silica dish on a water bath. The weight of solids left after drying was taken as the total solids content of the sample. (AOAC 22.013) (1970)

(vii) Soluble Solids determination

The refractometer reading of the sample was taken and temperature corrections made to correspond to reading at 20°C (AOAC 22.019) (1970) The % soluble solids was calculated as % solids determined by refractometer (100-b)/100 where b = % H_2O insoluble solids.

(viii) Determination of total and reducing sugars

For the determination of total and reducing sugars, the Lane and Eynon's method as described by Pearson (1970) was carried out before and after inversion. The method involves a determination of the volume of sugar solution required to reduce completely 10ml. mixed Fehlings solution using methylene blue as the redox indicator for assessing the end point. To obtain the amount of invert sugars after inversion, the determination was carried out on a sample hydrolysed with 6.34N HCL. The total sugars was calculated as $(D_1 + S)$ where $S = 0.95 \times (D_2 - D_1)$ and D_1 & D_2 are invert sugars before and after inversion respectively.

(ix) Determination of Starch

The Lintners method of starch determination (Pearson, 1970) was used. This method involves acid dispersion of the starch followed by its polarimetric estimation. About 5g sample were hydrolysed with hydrochloric acid and the proteins present were precipitated with 5% phosphotungetic acid solution. The mixture was shaken, filtered and the optical rotation of the filtrate observed in a 200 mm tube.

The amount of starch was calculated using the formula % starch

$$= \frac{4000a}{l\ D}$$

Where a = the observed optical rotation

l = the length of the polarisation in decimeters

and D = the specific Rotary Power of the starch.

(x) Determination of Riboflavin

The fluorometric method of riboflavin estimation was used. The total riboflavin as measured in this method covers the sum total of nutritionally active flavin F.M.N. (Flavin Mono Nucleotide), FAD (Flavin Adenin Dinucleotide) and free riboflavin. Riboflavin Flouresces in light of wave length 440 to 500mm. The intensity of fluorescence is proportional to the concentration of riboflavin in dilute solutions. This is the principle behind the method of estimation. Elimination of interference from other biological materials that fluoresce similarly is accomplished by measuring the difference before and after a chemical reduction of the riboflavin by hydrosulphite. The sample is earlier incubated overnight at 38°C in Trichloroacetic acid (20% TCA) to hydrolyse all FAD to measurable FMN. The procedure given by Bessey et al (1949) was followed.

(xi) Determination of Diastatic Power in Malt Samples

The procedure for diastatic power determination as described in the Official methods of Analysis of the Association of Official Agricultural Chemists (A.O.A.C. 10.099) (1970) was used. The method involves extracting a ground sample of the malt with 0.5% NaCl solution at 20°C, digesting a starch solution with a diluted sample from the filtered infusion for a period of time and determining the reducing power of the digested sample by the ferricyanide modification. A blank determination was carried out to correct for reducing power not due to the activity of the malt amylase.

3. RESULTS AND DISCUSSIONS

THE TRADITIONAL METHODS OF MAIZE MALT BEVERAGE PRODUCTION

The use of maize in the production of cereal beverages is concentrated in the Southern part of Ghana. From the findings of the survey and other available evidence, it is only the Ga Adangme, Ewe and Fanti ethnic groups living along the coastal areas of the country which indulge in the production of the beverage. This has always been on a small scale and it is mainly the women folk who take up the trade in addition to their normal household duties as well as some other full time trade. In almost all cases the production of the beverage was inherited from a great grand mother, through the grandmother and mother.

The following paragraphs give a detailed description of the different methods used in the various areas.

The main processing steps of malting, mashing, and boiling are essential steps gone through by all producers contacted in the four regions. However, the detailed technology of each step differ from one producer to another. The difference gap becomes wider when the producers belong to separate ethnic groups.

In addition to these differences, it was observed that the group of producers belonging to the younger generation use simpler forms of the methods employed by their older counterparts. The simpler methods, incidentally, give poor quality products as far as results of sensory evaluation and consumer preference tests organised in the field are concerened. This shows that the time - consuming process used by the older producers has its own merits as regards the quality of the final product. Their process, it was learnt, is more representative of the one used by the original producers.

The various methods obtained from this survey are therefore presented such that there is one representative procedure in each particular area for:

(a) The complicated process used by the older producers.

and (b) The simpler process.

The methods are as follows:-

I. GREATER ACCRA REGION

(A) ACCRA AND SURROUNDING AREAS

METHOD (A)

Malting:

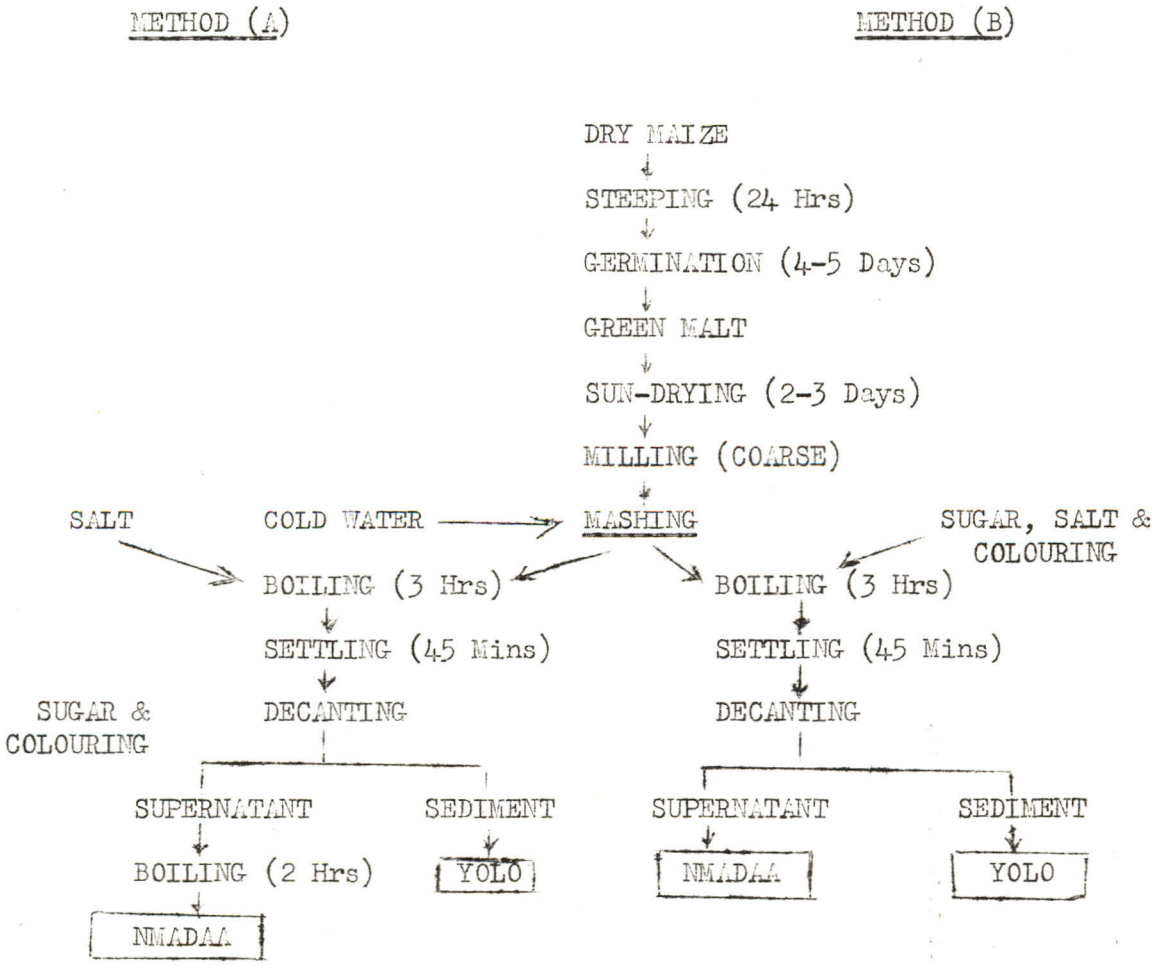
Selected washed maize grains are steeped for exactly 24 hours in good drinking water after which time they are removed and spread on a cement floor to germinate. A soaked sack is placed over the grains to prevent surface dessication. To ensure availability of moisture to the grains during germination, water is sprinkled on them each morning. This is carried out for 4-5 days. At this time the acrospire is about 6cm in length.

Germination is followed by sun-drying on alluminium roofing sheets or any similar material for 3 days after which time the malt is thoroughly dried. The dried malt is stored and used when required.

Grinding, Mashing and Boiling

The dried malted grains are milled coarsely in a disc attrition mill and the flour obtained is mixed with cold water to form a thin slurry. Salt is added and boiled for a long period of time with constant stirring. The precipitate is allowed to settle. The liquid portion is decanted and cooked again. Sugar and caramelized sugar are added as sweetening and colouring agents respectively. This product is known as Nmadaa (Ga). The precipitate is the by-product which is also cooked. It is known as Yolo (Ga). The shelf-life is normally 4 days.

FLOW DIAGRAM FOR "NMADAA" PRODUCTION IN THE ACCRA DISTRICT



METHOD (B)

Malting:

This processing step is similar to the one described in (a) above.

Grinding, Mashing and Boiling

The malt is milled and a thin slurry prepared by mixing the malt flour with cold water and the whole mash is boiled for about 3 hours with constant stirring to avoid boiling over. Caramelized sugar, salt and sugar are added. It is then allowed to settle and the supernatant decanted as Nmada, and the precipitate left as the by-product, Yolo.

Shelf life is 2 to 3 days.

(B) ADA AND SURROUNDING AREAS

METHOD (A)

Malting:

The first operation is winnowing to remove light contaminants. The selected grains are then washed and steeped for 24-36 hours depending on the hardness of the grains. They are then spread evenly on sand, watered and covered with palm branches. They are sprinkled with water 3 times daily for 3-4 days after which they are uprooted and sun-dried. Then follows a process which develops colour in the malt (a browning process). This involves storing the dried malt in basket; covering it with thick sacks and loading the whole thing with heavy stones. This set up apparently generates moist heat to accelerate browning reactions. This is carried out for 3 days and the process repeated once more for a day. The browned malted grains are then thoroughly dried and stored in basket for at least six days before use.

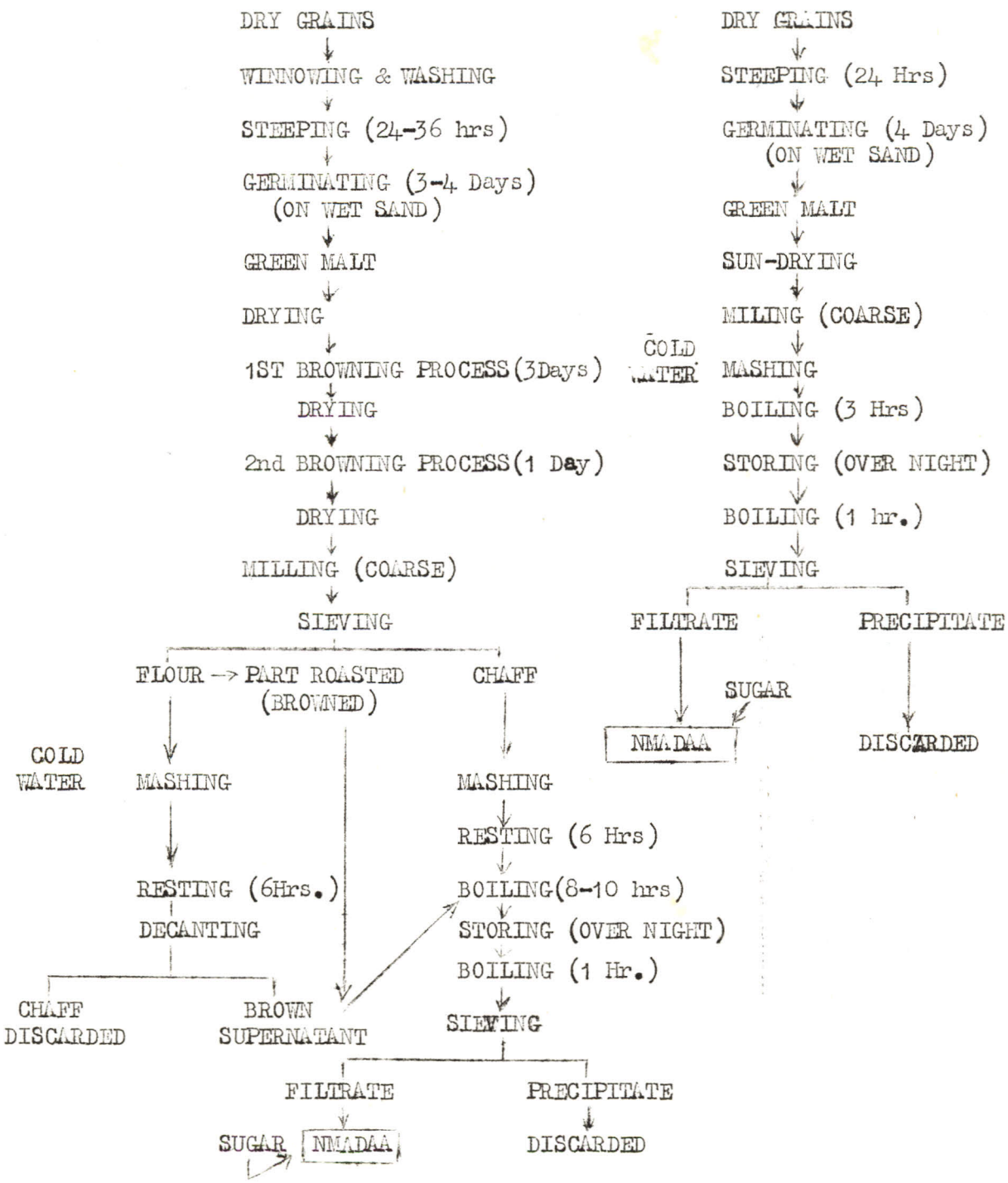
Grinding, Mashing and Boiling

A mixture of aged malt and freshly dried malt is milled coarsely and sieved. The flour and the chaff are mixed separately with cold water and kept in pots to stand for some few hours. The chaff mixture is boiled with continuous stirring while adding the flour slurry in small amounts at a time. By this time the whole mash is completely brown in colour.

Cooking is continued for 8 - 10 hours after which time the cooked mash is kept in pots till the following day when it is boiled again and sieved to remove the chaff which is discarded. The filtrate (known as Nmadaa) is normally expected to be brown otherwise a small amount of caramelized sugar or roasted flour is added to intensify the colour. Sugar is added to taste only when it is about to be consumed. No salt is added.

Shelf-life is over 10 days without sugar and 4 - 5 days with sugar.

FLOW DIAGRAM FOR THE PRODUCTION OF "NMADAA" IN THE ADA DISTRICT



METHOD (B)

This second procedure employed mainly by the younger producers in the Ada district is similar to method (a) described for the Accra district. In this case, however, there is no addition of salt and also the sieving is done after the second boiling to get rid of the chaff. The filtrate is Nmadaa. Sugar is added only when ready for drinking.

Shelf-life is 5 days without sugar and only 3-4 days when it contains sugar.

II VOLTA REGION (SOUTHERN PART)

(A) KETA AND SURROUNDING AREAS

Method (A)

Malting:

Raw grains are steeped for 24 hours after winnowing and thorough washing. The grains are spread on sand, watered and left to germinate for 4-5 days with daily watering. They are then dried thoroughly.

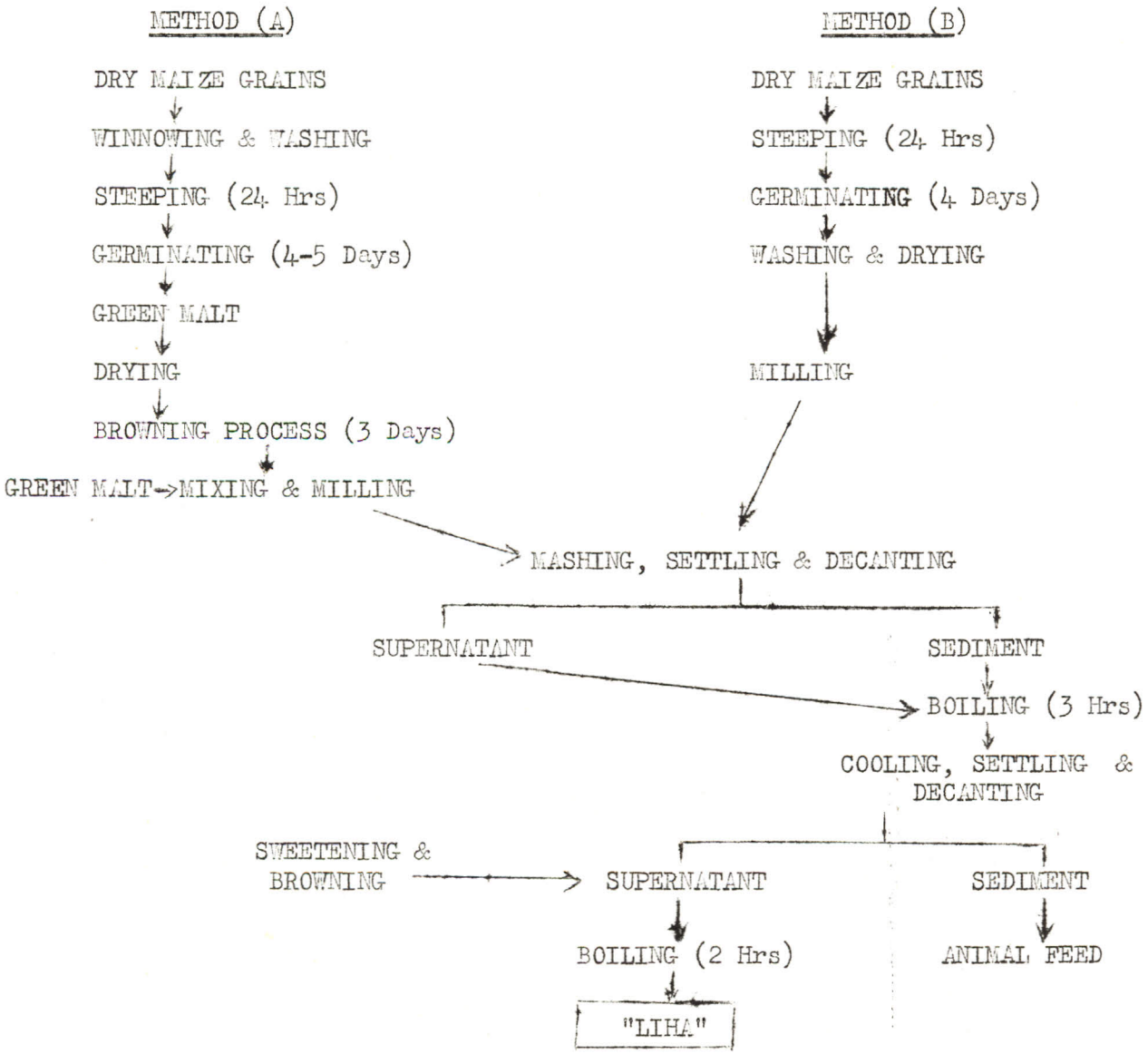
Then follows a browning process similar to what obtains in the Ada district method (a). The dried malt grains are packed in sacks and heavily loaded with stones for some days. The aged malt is then mixed with some freshly dried samples and coarsely ground in a disc attrition mill.

Mashing and Cooking

The malt flour is mashed with cold water and allowed to settle after which the supernatant is decanted off and added in small smounts at a time to the sediment while boiling. Boiling is continued for about 3 hours and the boiled mash allowed to cool. It is then decanted and the liquid portion collected and sweetened with sugar. Some caramelized sugar is also added to intensify the colour of the beverage. This is known as Liha (Ewe). The sediment is used as poultry feed. No salt is added.

Shelf-life of the beverage is 3 - 4 days.

FLOW DIAGRAM FOR THE PRODUCTION OF "LIHA" IN THE KETA AREA



Method (b)

Raw grains are steeped for 24 hours and floor malted for four days while sprinkled with water each morning. They are then dried thoroughly after washing. They are then stored and milled when required. The malt flour is mashed with cold water and allowed to settle. The mixture is then decanted and the sediment boiled and mixed with the supernatant while still boiling.

After about 3 hours' boiling, it is cooled and allowed to settle. It is again decanted and the supernatant cooked as "Liha" Sugar and caramelized sugar are added. No salt is added. The sediment is used for poultry feed.

Shelf-life of the beverage is 2 - 3 days.

(B) SOGAKOPE AND SURROUNDING AREAS

There is only one processing procedure common in this area.

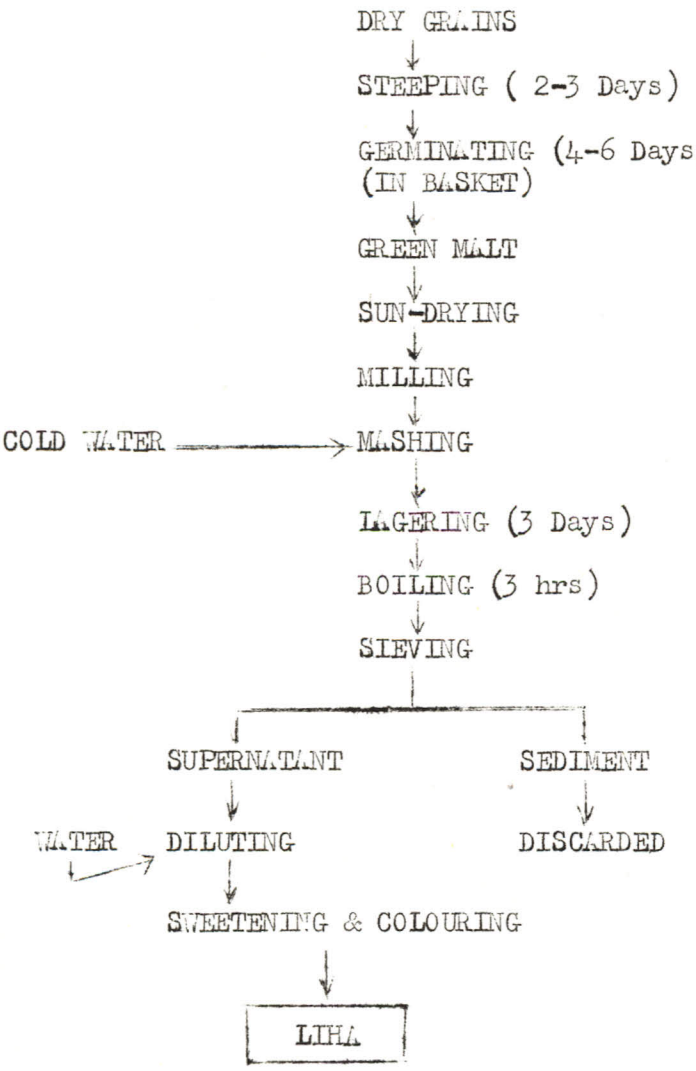
Malting:

Raw maize grains are steeped for two to three days depending on the hardness of the grains. They are then packed in baskets and sprinkled with water three times daily for four to six days after which period of time germination might have taken place. The germinated grains are thoroughly dried.

Grinding, Mashing and Boiling:

The dried malt is milled coarsely and mashed with cold water. This mash is left to rest for three days after which it is cooked for about three hours and sieved to separate the chaff from the liquid portion. This is diluted with more water, sweetened with sugar and coloured with caramelized sugar. The chaff is discarded. No salt is added.

FLOW DIAGRAM FOR THE PRODUCTION OF "LIHA" IN THE SOGAKOPE AREA



CENTRAL REGION

(A) CAPE COAST AREA

The two methods employed in this area are not very different from each other. The only difference is that one involves a two stage malting process - box (or basket) malting for 3 days followed by another 3 day period of floor malting, as against the other simpler method which involves a single stage box malting for three to four days. The subsequent processes are all quite similar.

Method

Malting:

Selected raw maize grains are steeped in water for 24 hours. The steeped grains are packed in boxes or baskets and covered with wet sacks to germinate for three to four days while sprinkled daily with water. In the other method, after this stage, they are removed and spread on polythene sheets on the floor and covered with more polythene materials for another malting period of three days.

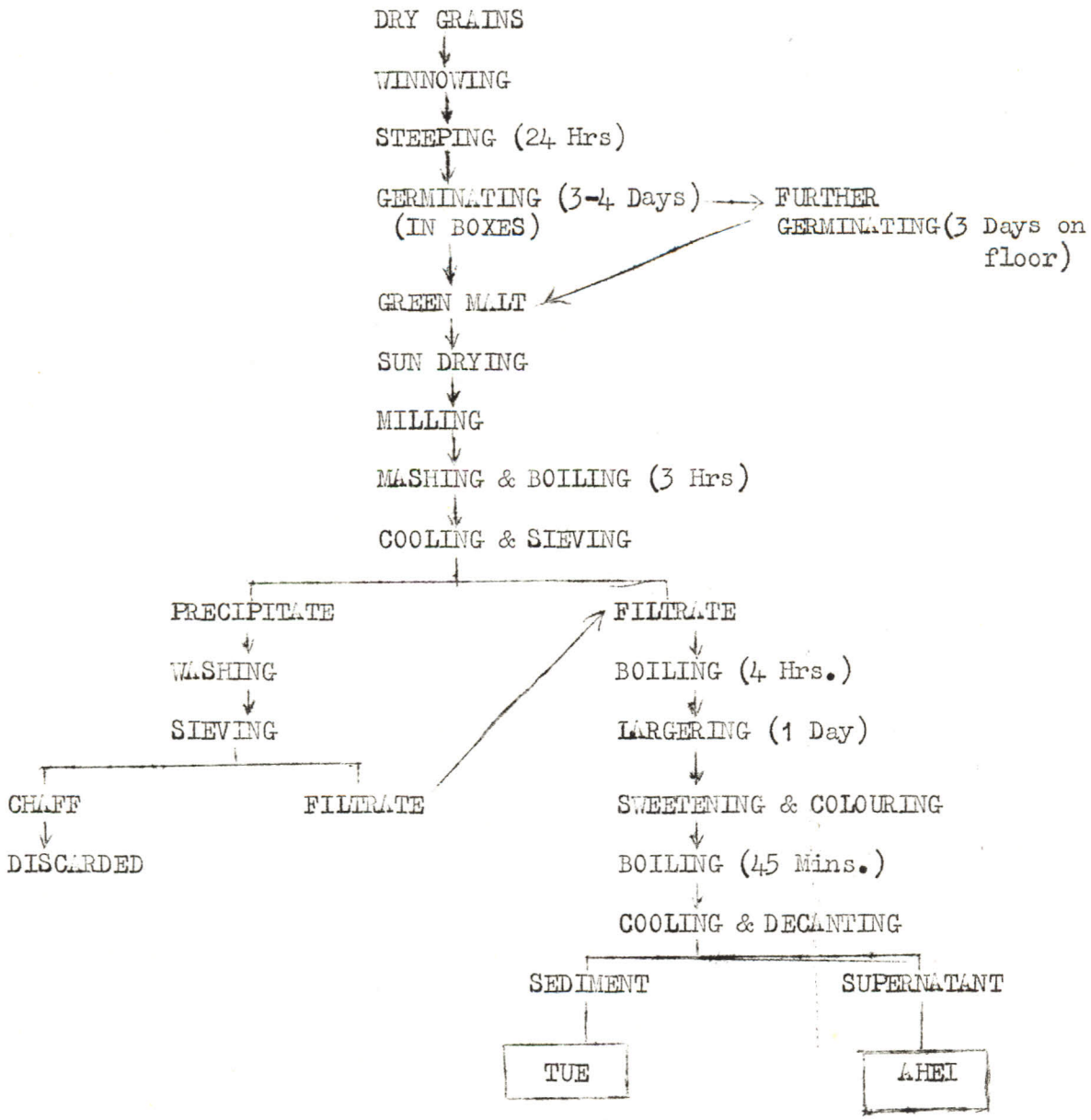
The germinated grains are then sun-dried thoroughly and stored for use.

Grinding, Mashing and Boiling

The dried malt is milled after washing. The malt flour obtained is mashed with cold water to form a thin slurry and boiled for about three hours with constant stirring. The boiled mash is cooled and sieved serially. The precipitate is washed, sieved and the filtrate added to the first one.

This is boiled for several hours. It is then stored till the next day when sugar, salt and caramelized sugar are added and boiled again,

FLOW DIAGRAM FOR THE PRODUCTION OF "AHEI" IN THE CAPE COAST AREA



The beverage thus obtained is decanted to remove the supernatant which is the "Ahei" (Fanti) from the thicker by-product known as "Tue" (Fanti).

Shelf-life is 4 to 5 days.

(B) ELMINA AREA

There is only one method common in this area which is acclaimed the main Ahei production centre in the whole Central Region.

Malting:

Raw maize grains are steeped for 24 hours and spread on the floor covered with polythene materials for seven days without any watering. The rootlets are disentangled and packed in baskets and left to dry as such for about five days.

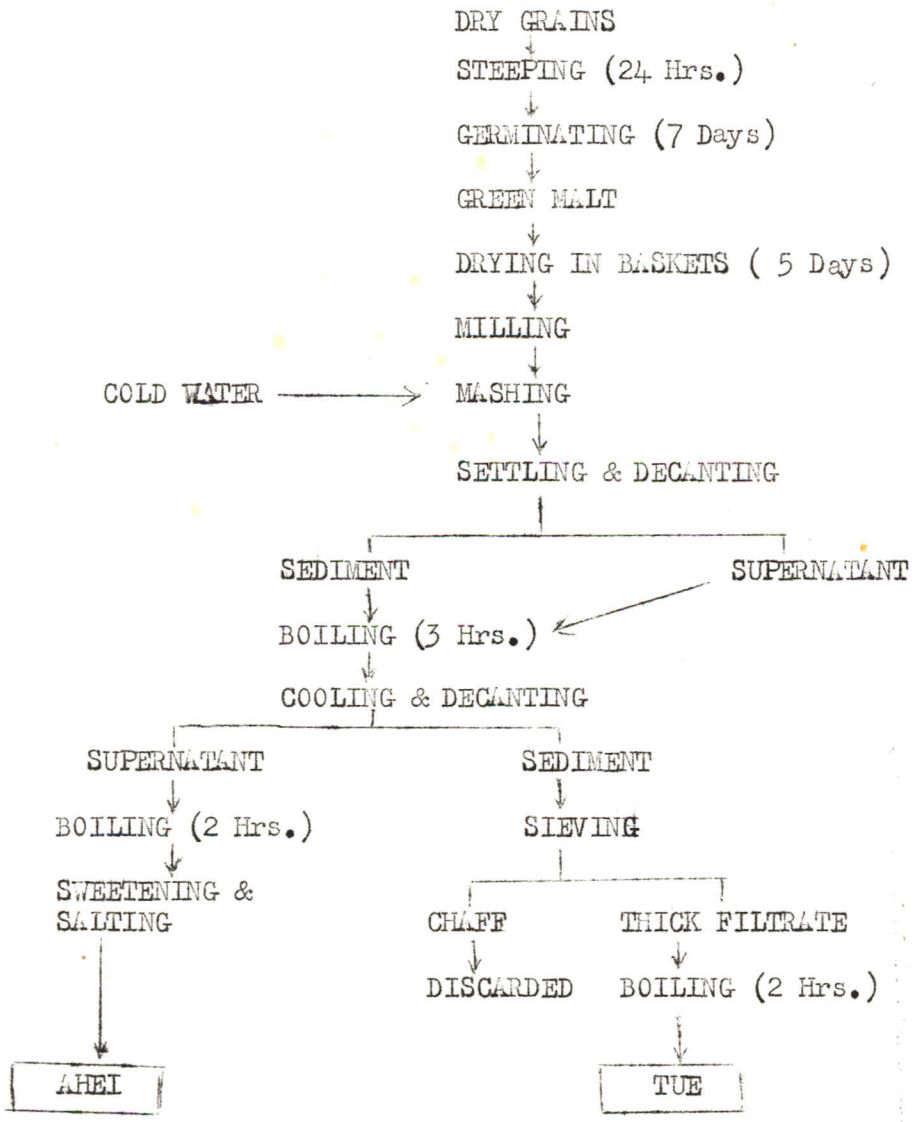
Mashing, and Boiling:

The dry malt is milled in a disc attrition mill to obtain the flour which is mashed with cold water in a large drum and allowed to settle. The supernatant is decanted and added in portions to the sediment while boiling the latter and stirring constantly. Boiling is continued for about three hours after which time the boiled mash is allowed to settle and decanted. The supernatant thus obtained is cooked as Ahei with salt and sugar added to taste.

The sediment is sieved to get rid of the chaff and the thick filtrate is cooked as "Tue" the by-product.

Shelf-life is about four days.

FLOW DIAGRAM FOR THE PRODUCTION OF "AHEI" IN THE ELMINA AREA



WESTERN REGION

(A) SEKONDI AREA

The two methods employed in this area are both quite involved and one particular procedure is not peculiar to a particular generation.

Method (a)

Malting:

Selected grains are steeped for 24 hours after winnowing. They are then spread on the floor and covered with polythene materials. After three days, they are sprinkled with water and left for germination to continue for a further period of four days. The germinated grains are packed in baskets for three days before sun-drying. After drying the malt is ready for use.

Grinding, Mashing and Boiling:

The malted grains are milled and mashed with cold water to form a thin slurry which is left to settle. The supernatant is decanted off the sediment which is boiled while adding the supernatant in small portions at a time. Boiling is continued with constant stirring for about two hours.

The boiled mash is allowed to cool after which it is sieved serially to get rid of the chaff which is washed to get maximum separation of the malt extract from the chaff. The combined filtrate is boiled again for several hours and allowed to settle overnight.

The supernatant is decanted and cooked with sugar and salt added to taste. This is the "Ahei". The sediment left after decanting is also boiled to give "Tue" which is thicker in consistency than the "Ahei"

Shelf-life of this product is about four days.

Method (b)

Malting:

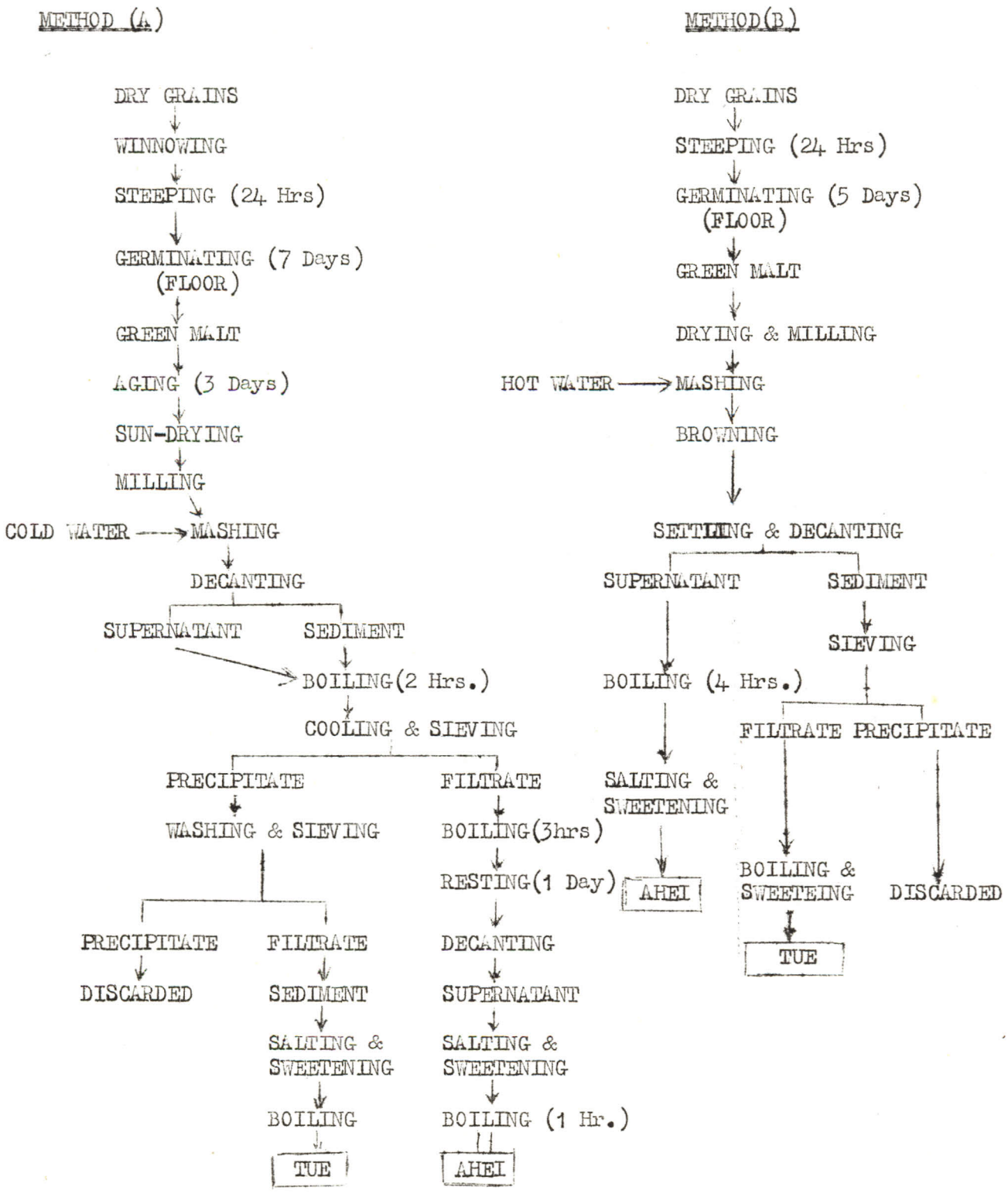
Dry maize grains are steeped for 24 hours and spread on polythene bags and covered to prevent excessive moisture loss. They are sprinkled with water daily for five days, after which period the germinated grains are sun-dried thoroughly.

Grinding, Mashing and Boiling

The dried malted grains are milled and made into a thick smooth paste which is poured into boiling water and mixed well by vigorous stirring. The resulting thin slurry is allowed to settle and cool gradually after addition of caramelized sugar. The supernatant is decanted off and boiled while removing small portions at a time into another container. Sugar and salt are added to this and cooked again. This is the "Ahei" . The sediment is sieved to remove the chaff, and the thick filtrate obtained is cooked as the by-product "Tue".

Shelf-life is three days.

FLOW DIAGRAM FOR "AHEI" PRODUCTION IN THE SEKONDI AREA



(B) TAKORADI AREA

The method used in this area is believed to have originated from Elmina. There is however, some difference between the two methods. This may probably be due to long period of separation.

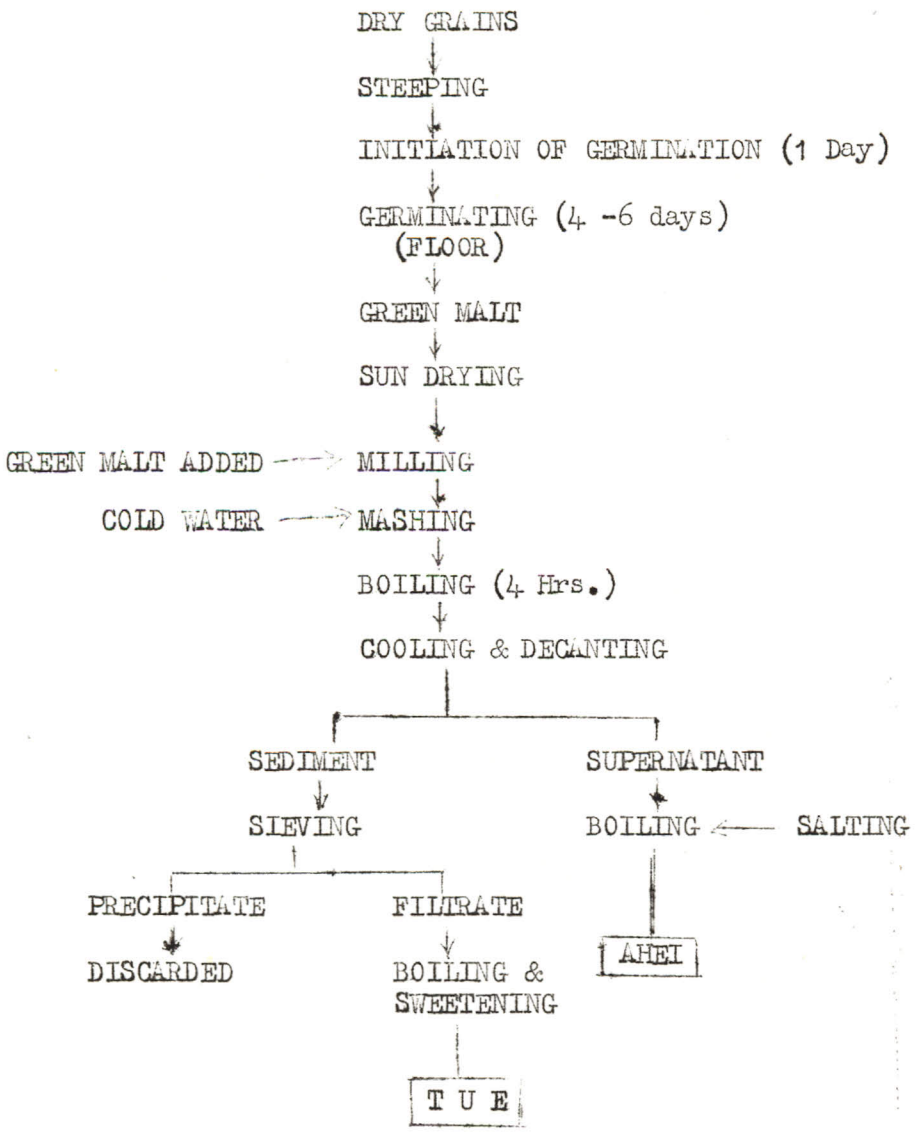
Malting:

Maize grains are steeped for 24 hours and packed in baskets with plantain leaves for one day to initiate germination. They are then floor malted for a period of four to six days. The germinated grains are sun-dried thoroughly and stored for use.

Grinding, Mashing and Cooking:

The dried malt is milled with some fresh malt. The fresh malt is believed to sweeten the whole mash. The malt flour obtained is mashed with cold water and boiled several hours with constant stirring. The boiled mash is allowed to settle and decanted. The supernatant is boiled again and salt added. This is the "Ahei". The sediment is sieved to remove the chaff and the thick filtrate is cooked as the by-product "Tue". Salt and sugar are added.

FLOW DIAGRAM FOR THE PRODUCTION OF "AHEI" IN THE TAKORADI AREA



COMPOSITION OF SAMPLES FROM TRADITIONAL BREWERS

Results of laboratory analysis of samples of the final and intermediate products from the various regions visited are shown in Table 1 and 2. The Diastatic activities of the malt samples (Table 1) range from 5.3 to 30.9 with the samples from the Greater Accra and Volta Regions having the highest diastatic activities. In general aging the malt reduces the diastatic activity considerably. For example the fresh malts from Ada had about 30° diastatic activity as against that for the corresponding aged samples which is in the neighbourhood of 20°. A decrease from 6.02 to 5.27° was also observed for the fresh and aged samples from Sekondi.

The riboflavin content ranges from 1 to 2ug/g sample. The value for raw maize (1.1 ug/g) shows that the malting process by the traditional brewers effect some increase in the riboflavin content. However, a proper malting process could have caused a higher increase.

For the other components such as protein, Fat, Ash, Crude fibre and the carbohydrates there was either increase or decrease during malting in all the samples; but the degree of increase or decrease varies from sample to sample depending on how well the process was undertaken.

TABLE I

COMPOSITION OF MAIZE MALT FROM VARIOUS TRADITIONAL BREWERS

	SAMPLES					
	1	2	3	4	5	6
Moisture	23.55	12.70	22.74	10.73	12.76	23.90
°Diastatic Activity	6.02	5.27	20.84	30.93	12.62	21.02
Riboflavin (ug/g)	2.09	1.17	1.36	1.72	1.51	1.82
Protein (%)	12.55	12.91	10.65	11.57	7.91	11.56
Fat (%)	3.33	2.91	2.92	3.47	3.11	2.50
Ash (%)	1.63	1.94	1.92	3.36	4.69	2.50
Fibre (%)	1.28	1.14	1.42	1.05	1.18	3.29
Starch (%)	56.37	50.97	57.73	61.38	51.58	62.42
Total Sugars (%)	11.55	9.34	12.36	7.89	12.15	9.46
Reducing Sugars (%)	10.32	8.83	9.16	6.81	11.69	9.20

° Apart from moisture, all values are given on Dry Weight Basis.

Sample 1 = Fresh Malt from Sekondi

" 2 = Aged Malt from Sekondi

" 3 = Fresh Malt from Keta

" 4 = Fresh Malt from Ada

" 5 = Aged Malt from Ada

" 6 = Fresh Malt from Accra.

TABLE 2

COMPOSITION OF MAIZE BEVERAGE FROM VARIOUS TRADITIONAL BREWERS

	SAMPLES				
	1	2	3	4	5
Protein (g/100ml)	0.81	1.06	0.19	0.81	0.27
Ash (g/100ml)	0.01	0.55	0.01	0.63	0.35
Total Sugars (g/100ml)	7.45	3.43	*0.45	*2.66	2.60
Reducing Sugars (g/100ml)	4.73	3.28	*0.38	*2.51	1.20
Starch (g/100ml)	3.25	3.46	0.87	1.41	1.20
Soluble Solids (g/100ml)	12.44	11.72	1.12	7.21	4.50
Total Solids (g/100ml)	14.00	12.80	3.40	9.00	5.50
Riboflavin (ug/100ml)	2.33	3.65	1.13	4.13	2.53

* No sugar added

Sample 1 = Ahei from Sekondi
" 2 = Tue from Sekondi
" 3 = Liha from Keta
" 4 = Nmada from Ada
" 5 = Nmada from Accra

Analysis of the final product shows a wide range in the various values (Table 2). The protein content ranges from 0.2 to 1.0 g/100ml ash - 0.01 to 0.6 g/100ml, Starch - 1.2 to 3.5 g/100ml and Riboflavin 1.1 to 4.1 mg/100ml. The level of each component depends on both the malting and brewing processes.

For example in the Ada district, the riboflavin content of the malt is quite low but because of the elaborate method of extraction, this vitamin is quite high in the final product. It was also observed that although no sugar was added to the product from Ada, the results of laboratory analysis and tasting gave a high sugar content (2.66 g/100 ml) which is even more than that of the Accra sample with sugar added. This finding is of a great interest to this study since it can be directly related to the high diastatic activity observed in the malt samples from this district (Table 1). Diastatic activity is a measure of the activity of the amylases which break down starch to simpler sugars.

On the whole, however, the nutrition benefits of the malting and brewing processes are not reflected in the final product due probably to the in-efficiency of the methods employed. For example to get half the recommended daily intake of riboflavin (Passmore et al, 1974) one will have to consume as much as fifteen litres of the malt beverage sample from Ada, and higher amounts of the others.

PARAMETERS AFFECTING THE QUALITY OF MAIZE MALT

(a) General Biochemical Changes during Malting

The main causative factor for the dormancy in dry seeds is the low moisture content of these seeds; and for initiation of germination, there must be an imbibition of water to hydrate the enzymes which will facilitate mobilization of reserve materials (especially the carbohydrates) for growth. The initial steeping of the dry maize grains is therefore an essential process which effects this rapid uptake of water.

Table 3 gives the observed changes in moisture level during steeping and germination at 28°C. After an initial rapid water absorption, there was a gradual increase in the moisture content throughout the germination period. On the third day, there was a sharp increase in the moisture level probably due to the appearance of the young coleoptile and coleorhiza tissues which are turgid and contain high moisture. The reduction in the moisture content on the 4th and 5th days could be due to excessive transpiration at that stage of germination.

TABLE 3

CHANGES IN MOISTURE CONTENT DURING STEEPING & GERMINATION

DAYS OF GERMINATION	% MOISTURE
0 (Dry maize)	12.46
0 (Steeped ")	34.85
1	36.33
2	41.98
3	58.46
4	58.10
5	58.15

Concerning the protein content, a slight increase was observed in the course of germination as indicated by the result in Table 4. Apart from the possibility of certain moulds on the grains fixing atmospheric nitrogen to effect the observed slight increase during germination, there is no other biochemical means of increasing the total nitrogen content of the grains. The enzymic breakdown of endospermal protein to amino acids and amides followed by protein synthesis as reported by Young et al (1960) is only bound to change the ratio of insoluble endospermal proteins to soluble nitrogenous compounds. The total nitrogen content should however remain the same; if not less as a result of small losses incurred during leaching.

TABLE 4

CHANGES IN THE CRUDE PROTEIN CONTENT DURING GERMINATION

DAYS OF GERMINATION	% CRUDE PROTEIN (D.M.B.)
0 (Raw Grains)	10.05
0 (Steeped ")	11.01
1	10.99
2	11.74
3	12.83
4	13.23
5	13.81

Table 5 shows a gradual decrease in the fat content during the germination period (From 4.3% to 2.98%). This is not unexpected since the fats are known to be broken down during germination by the action of lipases. These enzymes, according to the metabolic process, attack the bonds between the fatty acids and glycerol. glycerol liberated is phosphorylated to glycerol phosphate by the action of the enzyme glycerokinase and later to pyruvic acid which enters the Krebs cycle for energy. The fatty acids find their fate in a beta-oxidation where they are peroxidatively decarboxylated. These reactions eventually end up in energy production through a series of metabolic processes. The observed decrease in the fat content during germination confirmed the observations by other workers such as Toole et al (1956), Malhorta (1934), Dure (1960) and Ingle et al (1964).

TABLE 5

CHANGES IN THE FAT CONTENT DURING GERMINATION

DAYS OF GERMINATION	% FAT (DMB)
0(Raw)	4.31
0(Steeped)	4.24
1	3.74
2	3.52
3	3.30
4	3.00
5	2.98

The fibre content was found to reduce slightly during the first day of germination and then there was an increase throughout the 5 day germination period (Table 6). This initial decrease may be due to the action of the enzyme cellulase which degrades cellulose through oligosaccharides to cellubiose and finally to glucose units. Also, the action of the enzyme cytase in the hydrolysis of the hemicellulose to simple sugars such as xylase, arabinose, galactose and mannose, contributed to the decrease. Cellulose and hemicellulose are the two main fractions of the cell wall constituents. In the course of germination, however, there is a rapid synthesis of these cell wall constituents from sugars. Most hexose sugars are known to undergo a direct conversion to cellulose. Eventually, the rate of anabolism overcome the catabolic action of the enzymes; and hence the increase in the crude fibre content of the germinating grains.

TABLE 6

CHANGES IN THE CRUDE FIBRE CONTENT DURING GERMINATION

DAYS OF GERMINATION	% CRUDE FIBRE(DMB)
0 (Dry Grains)	1.47
0(Steeped ")	1.46
1	1.43
2	1.47
3	1.66
4	1.89
5	2.20

The slight decreases during steeping might be due to exudation of some minerals from the grains into the steep water. At this stage, there was no active growth and the cells might not have any need for absorption of extra minerals.

As shown in Table 7 below, there was a slight increase (from 1.39% to 1.85%) in the ash content of the maize during germination. Since certain minerals are essential to the germination process for the synthesis of cell components and the activation of some enzyme systems, there could be an active absorption of these minerals from the water sprinkled on the germination grains.

TABLE 7

CHANGES IN THE ASH CONTENT DURING GERMINATION

DAYS OF GERMINATION	% ASH DMB
0,(Dry Grains)	1.39
0 (Steeped ")	1.28
1	1.54
2	1.63
3	1.75
4	1.84
5	1.85

The most profound changes observed during the germination period occured in the carbohydrates. Table 8 and 9 below indicate a progressive decrease in the starch content with a corresponding increase in the sugars. These changes are also linked up with the increasing diastatic activity observed in the germinating grains (Table 10).

TABLE 8

CHANGES IN THE STARCH CONTENT DURING GERMINATION

DAYS OF GERMINATION	% STARCH (DMB)
0 (Dry Grains)	79.16
0 (Steeped ")	78.67
1	77.42
2	76.70
3	68.29
4	60.19
5	54.25

Starch is normally broken down by two hydrolytic enzymes - alpha amylase and beta amylase - to simple sugars.

TABLE 9

CHANGES IN THE TOTAL AND REDUCING SUGARS CONTENT DURING GERMINATION

DAYS OF GERMINATION	% TOTAL SUGARS (DMB)	% REDUCING SUGARS (DMB)
0 (Dry Grains)	1.01	0.18
0 (Steeped ")	1.00	0.20
1	1.50	1.01
2	7.30	1.30
3	7.11	4.94
4	15.41	12.38
5	18.82	16.22

It is these enzymes which are responsible for the increasing diastatic activity observed in the malt. Alpha-amylase attacks the alpha-1, 4 linkages of the starch polymers at random but has no effect on terminal linkages and those within three glucose units of alpha 1, 6 linkages. Beta-amylase on the other hand, removes successive maltose units from the non-reducing end of an alpha - 1, 4 linked chain of either amylose or amylopectin - the two components of starch. In 1960 Dure reported that only beta-amylase is present in the dry seed, and that alpha-amylase originates exclusively in the scutellum, the organ between the embryo and the endosperm, and is secreted into the endosperm during germination so that, in the course germination, these enzymes are made available in the endosperm to effect the breakdown of starch to monosaccharides and maltose.

TABLE 10

CHANGES IN THE DIASTATIC ACTIVITY DURING GERMINATION

DAYS OF GERMINATION	°Diastatic ACTIVITY (DMB)
0 (Dry Grains)	2.62
0 (Steeped ")	2.60
1	3.61
2	12.90
3	33.25
4	45.81
5	46.20

A closer look at table 8, 9 and 19 reveals that drastic changes in diastatic activity, starch content and the total sugars occured around the 3rd and 4th days of germination. This property of the malting process is of a great importance to both the industrial and traditional uses of the maize malt. In cases where sugar is required in the form of sucrose, this process provides glucose which is used by a complex biochemical mechanism in the production of sucrose. Glucose is phosphorylated to glucose-6-phosphate and part to glucose-1-phosphate. The latter is converted to uridine diphosphate glucose (UDPG) in the presence of Uridine triophosphate (UTP). Sucrose is formed by condensation of the UDPG and frutose-6-phosphate.

The final component examined for changes during germination was riboflavin. As shown in Table 11, there was an increase in the riboflavin content of the maize during malting. At the fifth day of malting the level was found to be as much as four times the original content (from 1.21 ug/g to 4.93 ug/g). The increase started right from the steeping stage and continued gradually till the third and fourth days when there was a sharp rise. There was then a slow development between the fourth and fifth days of germination.

TABLE 11

CHANGES IN THE RIBOFLAVIN CONTENT DURING GERMINATION OF MAIZE

DAYS OF GERMINATION	RIBOFLAVIN CONTENT ug/g (DMB)
0 (Dry grains)	1.21
0 (Steeped ")	1.40
1	1.98
2	2.60
3	3.01
4	4.49
5	4.93

As stated in the introduction, Buckholder (1943) found fourfold increase in the riboflavin content of corn after 5 to 6 days germination period. This earlier finding has been confirmed by the results of this study.

(b) Duration and Temperature of Steeping

The results for the determination of the effect of duration and temperature of steeping on the subsequent development of riboflavin and diastatic activity are shown in Table 12 below. As clearly indicated, the initial steeping conditions have very little affect on the development of riboflavin; and diastatic activity.

EFFECT OF DURATION AND TEMPERATURE OF STEEPING ON THE DIASTATIC POWER AND RIBOFLAVIN DEVELOPMENT

TIME OF STEEPING (HRS.)	STEEP TEMPERATURE (°C)	°DIASTATIC POWER AFTER GERMINATION AT 28-30°C FOR			RIBOFLAVIN CONTENT ug/g AFTER GERMINATION FOR		
		3 Days	4 Days	5Days	3Days	4 Days	5days
4	20	32.57	44.96	46.00	2.85	4.00	4.80
	28	33.00	45.39	46.18	2.84	3.97	4.71
	37	31.80	42.00	45.00	2.58	4.00	4.78
12	20	32.68	45.63	46.16	2.88	4.23	4.96
	28	33.85	46.00	46.48	2.78	4.46	4.88
	37	31.82	42.08	45.32	2.60	4.53	4.69
	20	33.05	45.61	46.03	2.87	4.45	4.86
	28	33.87	46.10	46.52	2.90	4.47	4.88
	37	32.00	42.71	45.16	2.67	4.51	4.91

Low temperatures and short steeping periods only retarded the rate of development of these components a little, but the final malt contained almost the same level and activity for all cases. This observation can be explained in part by the fact that, the small sample used for the laboratory investigation did not take long to attain the malting temperature of 28-30°C when removed from a steep temperature of 20°C or 37°C. Also, the method of malting employed provided a liberal amount of water during germination, and this could make up for the low moisture attained during short steeping periods. The various biochemical transformations are therefore not retarded to any great extent.

(C) Interaction of Steep and germination temperature of Maize

This determination was carried out to find out the over-riding factor for a good malt as far as steep and germination temperatures are concerned. From Table 13, it can be seen that the steep temperature does not affect the enzyme and riboflavin developments significantly. It is rather the germination temperature which actually matters. A warm steep temperature only accelerates the development of the components a little in the course of germination at a cold temperature.

TABLE 13

EFFECT OF THE INTERACTION OF STEEP - AND GERMINATION TEMPERATURE OF MAIZE ON THE DEVELOPMENT OF RIBOFLAVIN AND DIASTATIC ACTIVITY

STEEP TEMPERATURE (°C)	GERMINATION TEMPERATURE (°C)	°DIASTATIC POWER AFTER GERMINATION FOR			RIBOFLAVIN CONTENT (ug/g GERMINATION FOR		
		3DAYS	4DAYS	5DAYS	3DAYS	4DAYS	5DAYS
20	20	16.91	18.41	18.32	2.27	3.52	3.58
28	20	17.20	18.97	19.55	2.85	3.61	3.90
37	20	18.00	20.16	20.89	2.54	4.00	4.10
20	28	33.05	45.61	46.03	2.75	4.40	4.92
28	28	33.25	45.80	46.20	3.10	4.53	4.90
37	28	32.80	42.71	45.62	2.58	4.51	4.89
20	37	15.82	17.00	15.27	1.43	1.57	2.20
28	37	15.70	16.82	14.88	1.33	1.48	2.00
37	37	14.10	16.57	15.10	1.40	1.46	1.85

However, a cold steep (20°C) does not have any clear-cut effect on the development of the malt component when germinated at a higher temperature.

(d) Malting Temperature

For the three different malting temperatures used to determine the effect of temperature on the various biochemical transformations during malting, a temperature of between 28 - 30°C was found to be the best. This is clearly indicated by the results in Table 14 below.

TABLE 14

EFFECT OF MALTING TEMPERATURE ON THE DEVELOPMENT OF DIASTATIC POWER AND RIBOFLAVIN IN MAIZE

DAYS OF GERMINATION	°DIASTATIC POWER AT A TEMPERATURE OF			RIBOFLAVIN CONTENT (ug/g) (DMB) AT A TEMPERATURE OF		
	20°C	28°C	37°C	20°C	28°C	37°C
0(Dry grains)	2.62	2.62	2.62	1.20	1.20	1.20
0(Steeped ")	2.53	2.60	2.61	1.58	1.44	1.43
1	3.53	3.64	2.93	1.88	2.00	1.57
2	9.74	12.93	10.85	2.27	2.53	1.49
3	16.91	33.81	13.80	2.77	3.51	1.47
4	18.41	45.76	14.79	3.07	4.78	1.52
5	18.32	46.23	17.90	3.65	4.86	2.00
6	19.00	42.81	14.00	3.92	4.33	2.02

In the case of riboflavin development, however, malting 20°C was found to be not very different from the results obtained at 28°C. The production of riboflavin was only retarded a little. During the investigation, it was observed that germination started very early in the samples malted at 37°C. However, the young embryo could not stand the high temperature and consequently, most of them withered after only 36 hours' malting.

This could have a profound effect on the overall development of the malt components. At 20°C, there was only a retardation in the rate of germination and embryo development. Although the development was slow, there was no termination of growth. With longer germination, therefore, the degree of development in the 20°C samples could catch up with that in 28°C when the latter reaches its optimum.

This brings out the question of duration of germination. From all previous results, as well as those in Table 14, rapid development of both diastatic activity and riboflavin was observed in the first four days (especially between the third and the fourth days). After this there was a very slow rate of development. In some cases, there was a decrease in the degree of enzyme activity as well as riboflavin content after the fifth day of malting. These observations show that maize malting requires a germination period of not less than four days. Five days germination may be undertaken but six days is unnecessary.

(e) Moisture during Malting

Absorption of water by germinating maize grains has been observed in the previous determinations carried out. But to ascertain the actual effect of moisture restriction on the general development of the malt, a series of parallel maltings was undertaken and the results shown in Table 15 below. Restriction of water to the germinating grains was found to cause a reduction in the production of enzymes and vitamins.

TABLE 15

EFFECT OF MOISTURE ON THE DEVELOPMENT OF DIASTATIC POWER AND RIBOFLAVIN IN GERMINATING MAIZE

DAYS OF GERMINATION	MOISTURE CONTENT %			°DIASTATIC POWER (D.M.B.)			RIBOFLAVIN CONTENT (ug/g) (D.M.B)		
	LOW	MEDIUM	HIGH	LOW LEVEL MOIS-TURE	MEDIUM LEVEL MOIS-TURE	HIGH LEVEL MOIS-TURE	LOW LEVEL MOIS-TURE	MEDIUM LEVEL MOIS-TURE	HIGH LEVEL MOIS-TURE
0(Dry Maize)	12.45	12.45	12.45	2.62	2.62	2.62	1.20	1.20	1.20
0(Steeped ")	34.80	34.80	34.80	2.61	2.61	2.61	1.47	1.47	1.47
1	33.42	35.73	36.80	3.00	3.34	3.68	2.00	2.28	2.30
2	30.18	38.94	42.00	2.84	4.67	13.12	2.00	2.52	2.61
3	27.65	46.34	58.55	2.81	18.82	34.66	1.51	2.84	3.68
4	20.82	50.12	58.61	2.68	33.87	45.80	1.50	3.08	4.75
5	18.13	54.66	58.45	2.68	40.63	46.00	1.51	3.60	4.78
6	16.77	58.63	58.00	2.66	45.76	43.83	1.50	4.84	4.27

With the high level moisture sample there was the usual increase of over 40 °diastatic power over a five-day germination period. The riboflavin development for this sample increased four-fold. However, the rate of development in the medium level moisture sample reduced considerably while the low level moisture sample had an initial slight increases on the first day of germination followed by a gradual decrease in the developed components throughout the germination period. A constant drying was observed in this sample which was only steeped for 24 hours and left to malt without any further watering. The findings show that for maximum nutritional and enzyme developments there must be an adequate supply of water throughout the period of malting.

(f) Drying Temperature for Maize Malt

An investigation into the effect of drying temperature on the quality of the maize malt is of little or no benefit to the traditional brewer who uses sun-drying. However, a large scale use of malted maize for the production of beverages will require the introduction of artificial drying techniques. The results presented in Table 16 show the highest drying temperature at which the malt components are adversely affected to any appreciable degree.

TABLE 16

EFFECT OF DRYING TEMPERATURE ON THE DIASTATIC POWER AND RIBOFLAVIN CONTENT OF MAIZE MALT

MALT SAMPLE NO.	DRYING TEMPERATURE (°C)	°DIASTATIC POWER (D.M.B.)		RIBOFLAVIN CONTENT (ug/g) D.M.B.)	
		* CONTROL	TEST	* CONTROL	TEST
1	35.0	43.5	43.6	4.3	4.3
2	40.0	45.0	44.2	4.8	4.7
3	50.0	45.8	41.6	4.5	4.5
4	60.0	46.2	43.4	4.8	4.6
5	70.0	45.6	20.1	4.6	4.3
6	80.0	46.7	18.9	4.5	4.2

* Sun-dried samples were used as controls for each drying temperature.

Malt samples dried for 20 hours at temperatures ranging from 35 to 60°C only cause negligible destruction to their diastatic activities. A drastic reduction in diastatic power was observed in samples dried at 70°C and above. For industrial purposes a drying temperature of between 50°C and 60°C is therefore recommended as being the optimum temperature to preserve most enzyme activities in the malt. The riboflavin content was virtually not affected by the drying temperatures used in this study. Riboflavin is known to be thermo-stable, and temperatures of up to 80°C are perhaps too low to effect any appreciable destruction of the vitamin.

The recommended temperature range for artificial drying (50 - 60°C) is therefore good enough to maintain the riboflavin, level in the final malt.

4. CONCLUSIONS AND RECOMMENDATIONS

From the results of (a) the investigations into the Ghanaian traditional methods of maize malt beverage production, (b) the laboratory analysis of the intermediate and final products, (c) the biochemical changes during maize malting under conditions similar to those of the traditional process, and (d) the determination of the various parameters affecting the developments of diastatic activity and riboflavin, the following can be stated as the main findings of this study.

(1) Malting as undertaken by the traditional producers is an essential step in the maize malt beverage production as it effects all the biochemical transformations in the grain necessary to impart both the typical nutritional and organoleptic properties to the beverage.

(2) However the traditional brewers do not derive the maximum benefits of the malting process because of lack of proper attention during the germination period. Only up to about two-fold increase in riboflavin and low diastatic activities are achieved through their malting process.

(3) Various factors were found to affect the enzyme and nutritional developments in the malt. Temperature, moisture, and duration of malting have a profound effect on the quality of the final malt. As far as these factors are concerned, however, steeping conditions do not affect the subsequent changes in the grain as much as the conditions of germination. With temperature, the germination temperature is the over-riding factor, and with moisture, short steeping periods do not affect the proper development provided there is adequate provision of water during malting.

(4) Steeping at 28 - 30°C for between 12 and 24 hours, followed by germination at the same temperature for 4 to 5 days with twice daily sprinkling of water was found to cause high diastatic activity and riboflavin development in the malt. Maize malt thus produced has a four-fold increase in the riboflavin content and as high as 46° diastatic power.

(5) Lower (20°C) or higher (37°C) steeping and germination temperatures adversely affect the changes in the grain. Longer period of malting also reduces the developed components.

(6) For artificial drying, oven drying at temperatures up to 60°C do not affect the enzyme activity of the malt. Higher temperatures cause drastic reduction in the diastatic power but do not reduce the riboflavin level to a similar extent.

In the light of the above findings, it is therefore recommended that for both traditional and large scale use of maize for the production of maize malt beverages, the following malting procedure should be strictly followed to obtain maximum desirable properties of the malt.

After winnowing and washing, the maize grains are steeped in good drinking water for about 24 hours at 28 - 30°C. The Steeped grains are then removed and spread on sacks or such similar materials which will not retain much water, covered with polythene materials to prevent excessive moisture loss through evaporation. The malting grains are sprinkled with water twice daily for 4 - 5 days after which time the rootlets are disentangled and the malt thoroughly dried in the sun. Where artificial drying is required, the drying temperature should not exceed 60°C.

5. DEVELOPMENT AND PROSPECTS

Maize malt produced by the above recommended procedure has a very high diastatic activity as well as riboflavin content. These are also indications of general enzyme and nutritional developments. With this high level of enzyme activity and nutritional content, the malt can be used by the traditional brewers to obtain a better quality maize malt beverage. It is also an ideal malt for the local enterpreneur who wishes to indulge in the production of a bottled maize malt beverage with properties similar to the barley malt extract.

For the small-scale traditional brewer, such a malt is ideal to cause sweetening of the mash and thus saves any extra cost of adding sweetening agents to the beverage. With the increase in organoleptic and nutritional properties the beverage produced with this malt can compare favourably with other more expensive cereal malt extracts produced with imported raw materials.

The procedure for the high quality maize malt production as shown by the findings of this study does not involve any expensive technology and will not therefore pose any problem to the traditional brewer. There is however, the need for another investigation into the mashing and boiling processes of the maize malt beverage production using the high quality maize malt. A standard procedure for mashing and boiling for a desirable enzyme activity is necessary to utilize the developed components of the malt to maximum advantage. Such an investigation will also find a mashing process for maximum extraction.

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APPENDIX 1

QUESTIONNAIRE FOR THE FIELD SURVEY ON THE TRADITIONAL METHODS OF MALTED MAIZE BEVERAGE PRODUCTION IN GHANA

1. Region.....Town or Village.....Area.....

2. Name of Producer .....Age.....Educational Background.....

3. Origin of Trade (Inherited or Acquired).....

4. Years in Trade.....

5. Part-time or Full-time.....

6. Method of Production:-

   (a) Preparation of Raw grains.....

   (b) Steeping: Temperature.....Duration.....

   (c) Malting:

      (i) Method (Floor or Basket).....

      (ii) Duration of Malting.....

      (iii) Treatments during malting.....

      (iv) Drying (sun-drying or otherwise).....

      (v) Aging process.....

   (d) Malt Storage .....

   (e) Malt Milling (Fine or Coarse).....

   (f) Mashing and Boiling:

      (i) Mashing method (cold or hot).....

      (ii) Resting Period .....

      (iii) Treatment of Mash.....

      (iv) Duration of Boiling.....

      (v) Other treatments.....

(g) Additives .....

7. By-products and their use .....

8. Any modifications and why .....

9. Shelf-life of Product/s .....

10. Problems .....

11. Other Producers in the Area .....

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