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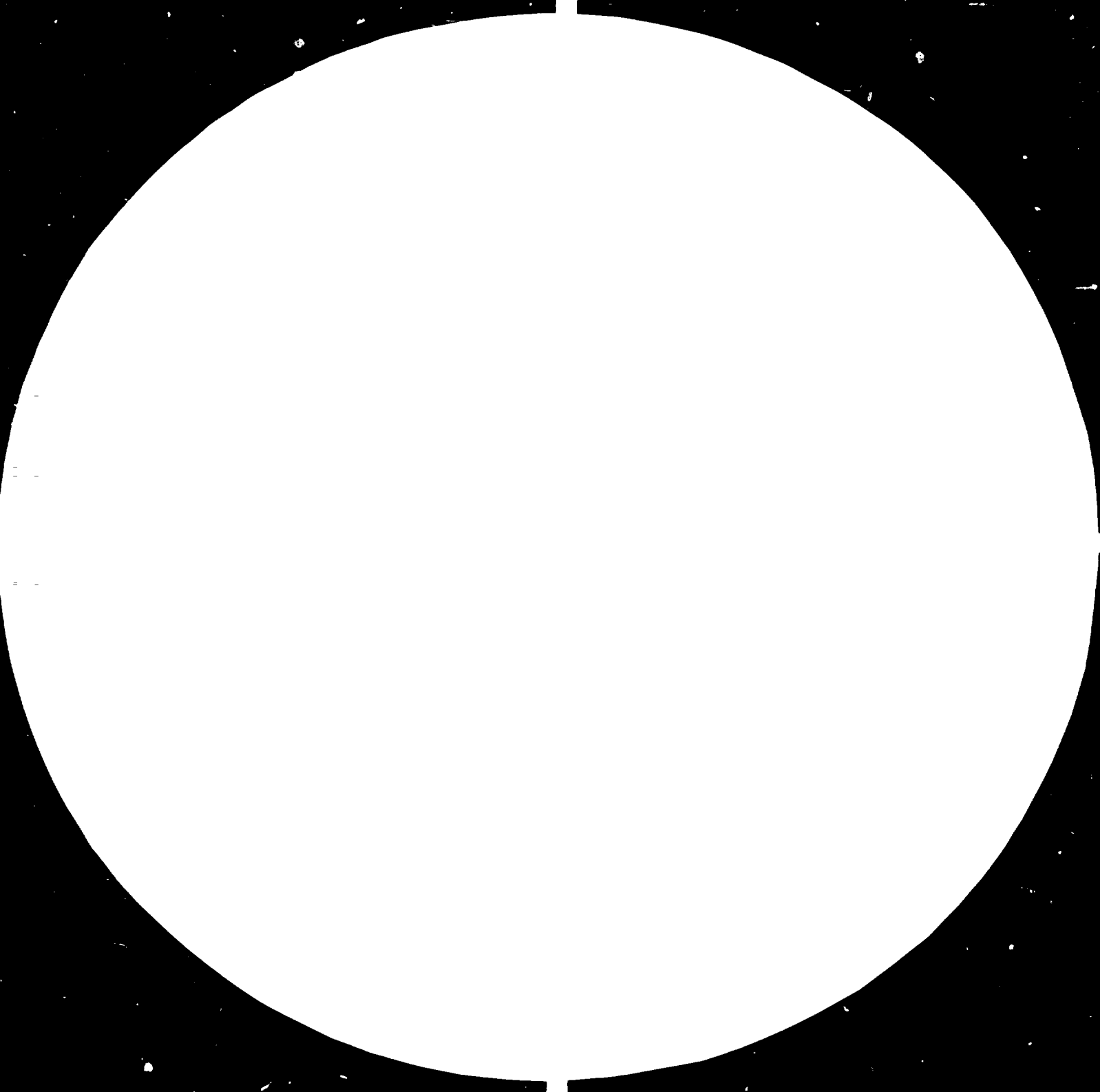
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2.8



3.2



3.6



4.0



Figure 1. Resolution test patterns used for the study. The resolution of the test patterns is indicated by the number next to the pattern.

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ASSISTANCE TO BREWERIES
RP/URT/79/001
UNITED REPUBLIC OF TANZANIA

Prepared for the Government of the United Republic of Tanzania
by the United Nations Industrial Development Organization

Based on the work of Georg-Wilhelm Haase,
expert in brewing technology

80-38371

Explanatory notes

References to dollars (\$) are to United States dollars.

The monetary unit in the United Republic of Tanzania is the shilling (Tsh). During the period covered by the report, the value of the shilling in relation to the United States dollar was \$US 1 = Tsh 3.27

Where amounts are given in marks of the Federal Republic of Germany (DM), the following exchange rates apply:

\$US = DM 1.91

Tsh 100 = DM 23.70

References to tons are to metric tons.

The following abbreviations of organizations are used in this report:

EAIRO East African Industrial Research Organization

FAO Food and Agriculture Organization of the United Nations

MDB Marketing Development Bureau

TBL Tanzania Breweries Limited

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ABSTRACT

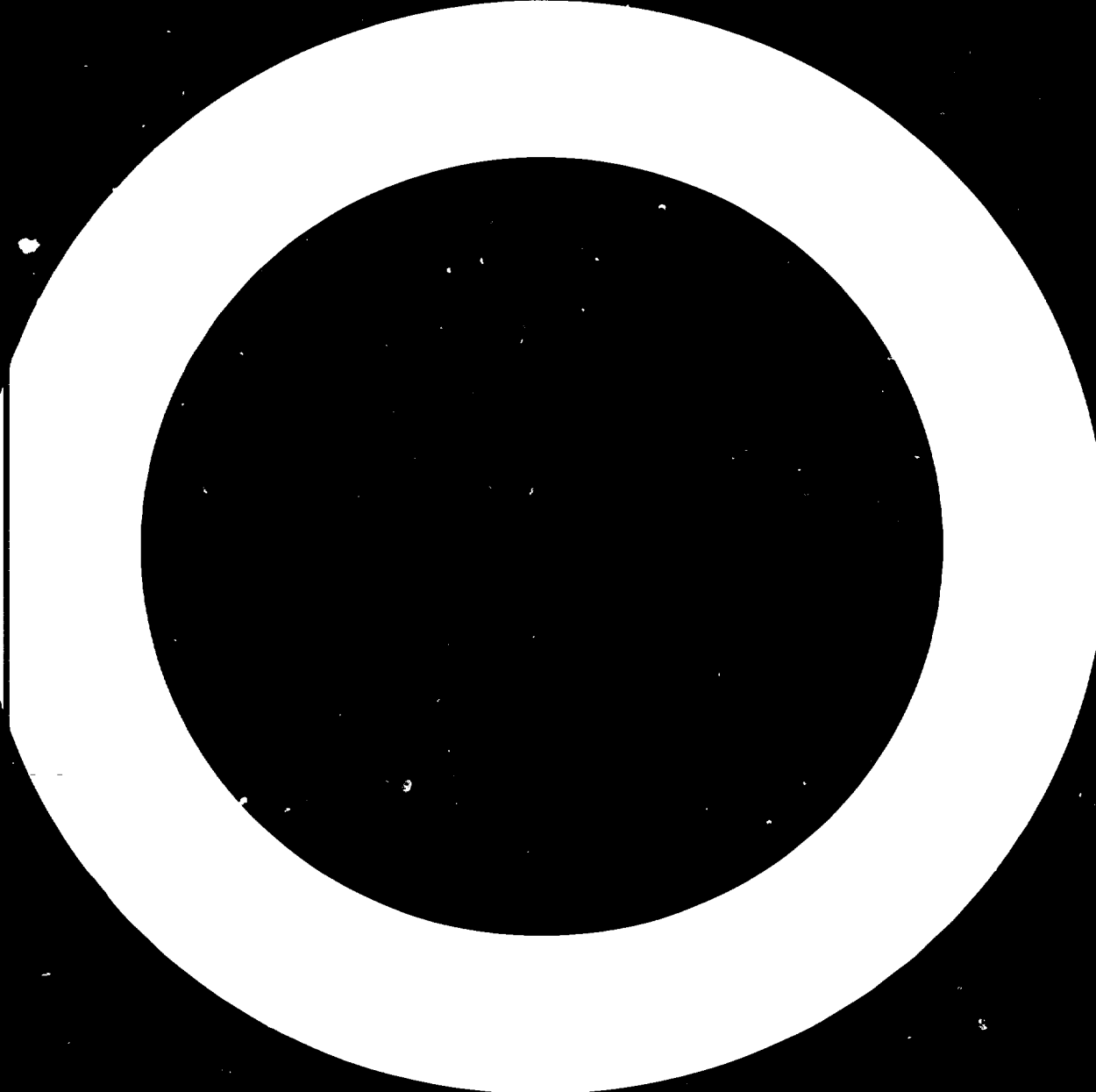
The project "Assistance to breweries" (RF/URT/79/001) was carried out for the Government of the United Republic of Tanzania by an expert of the United Nations Industrial Development Organization (UNIDO), acting as the executing agency for the United Nations Development Programme (UNDP).

The purpose of the project was to review beer production in the United Republic of Tanzania and analyse the possibility of using sorghum as a raw material to replace imported barley or barley malt in breweries.

The mission took place in Dar es Salaam from 4 March 1979 to 9 March 1979. During this short time the expert was able to compile essential information on the brewing industry and draw up a programme for laboratory and pilot plant tests of varieties of locally grown sorghum.

The expert concludes that sorghum is a raw material well suited to brewing, either as an adjunct or as the primary source of malt. A programme of necessary investigations is outlined, but as the most important first step, the expert recommends that an adequate number of samples of red and white sorghum be sent to a European laboratory for analysis and test brews so that the most suitable varieties of sorghum can be selected, their brewing characteristics analysed, and the best proportion of sorghum to other raw materials be established.

On the satisfactory conclusion of these tests, further follow-up experiments should be made with malted sorghum.



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INTRODUCTION

The project "Assistance to breweries" (RP/URT/79/001) was carried out for the Government of the United Republic of Tanzania by an expert of the United Nations Industrial Development Organization (UNIDO) acting as the executing agency for the United Nations Development Programme (UNDP).

The purpose of the project was to review beer production in the United Republic of Tanzania and analyse the possibility of using sorghum as a raw material to replace imported barley or barley malt in breweries.

The mission took place in Dar es Salaam from 4 March 1979 to 9 March 1979.

During this time the expert had made available to him a report recently prepared by FAO/UNDP for the Marketing Development Bureau in Tanzania: "Surplus sorghum, millet and cassava disposal, and policy options to minimize future surpluses and reduce losses". This report shows the urgent necessity of expanding the utilization of locally grown cereals like sorghum and millet. It explains that sorghum and millet are already widely used for the manufacture of local alcoholic drinks in several regions of the United Republic of Tanzania, and that sorghum is also used by large breweries in a number of developing countries for the production of bottled beers. An extract from this report is given in annex I.

For the production of beer of European or American standard the essential raw material is barley malt. It can be substituted to some extent by sugar or sugar syrups, by unmalted cereals like maize, rice, barley or sorghum or by processed products of cereals or even by pure starch-flour. In any case the aim is to get as high a yield as possible of soluble matters and of fermentable sugar in the wort.

While it is often more convenient for a national industry to process imported intermediate products which are manufactured on the basis of long experience, this may involve much expense in foreign currencies. The economic situation of many countries compels or will compel them to switch over to the use of unconventional raw materials drawn from their own crops. Recent

scientific development allows us to develop technologies of a new kind using largely home-produced raw materials. Therefore the expert has based his report upon the assumption that exclusively national products or intermediates or semi-manufactured articles of home production should be used. An intermediate or semi-manufactured product is, for example, malt from sorghum, the enzymatic strength of which must match that of the barley malt. For this purpose the kinds of sorghum have to be selected which yield sorghum malts of high enzymatic strength during a malting process of optimum efficiency.

Alternatively, sorghum could be used as an adjunct rather than as the primary malt. The varying proportions in which sorghum could be so used are discussed in the report.

The question of whether to substitute imported malt by locally grown sorghum (or perhaps millet) is not only a problem for the United Republic of Tanzania. In view of the increasing consumption of beverages (mainly beer) in a number of African countries, it is already an important common problem.

I. FINDINGS

A. The present state of brewing

Tanzania Breweries Ltd (TBL) is responsible for the production of bottled beer in the United Republic of Tanzania. Two plants are operating, one in Dar es Salaam, another in Arusha. The beer production in 1978 was about 850,000 hectolitres, of which 75 per cent was produced in Dar es Salaam, 25 per cent in Arusha. The start of production of a new brewery in Mwanza is planned for 1980. With this, and with the extension of the existing plants, TBL intends to meet the increasing demand for beer.

At present, 20-27 per cent of the malt is being replaced by local sugar and raw barley. The composition of the raw material used for a brew at TBL is as follows:

	(Percentage)
Malt (imported)	65-70
White sugar (local)	15
Raw barley (local)	10
Red or white sorghum (local)	5-10

This is a careful beginning to test the applicability of the locally grown sorghum for use in beer production. But 5-10 per cent cannot influence the surplus of sorghum in the country. The target is to use quantities of sorghum which are considerably higher. In view of the current production of TBL the following factors must be taken into consideration:

- (a) The quality and taste of the product should remain stable;
- (b) There should be no change in the various phases of production;
- (c) The production costs should not be higher.

B. Cultivation of barley

It would be possible for the United Republic of Tanzania to extend its cultivation of barley so as to be able to replace some of the barley currently imported for beer production.

There is no doubt that the conditions for the cultivation of barley in the United Republic of Tanzania are suitable in certain districts. In a study concerning the establishment of a new malting plant, TBL has suggested "... to produce the quantity of barley required by the malting plant to its final capacity of 21,000 tons of malt, one has to be thinking in terms of approximately 100,000 acres of land".

The cultivation of wheat demands more or less the same conditions in climate and type of ground as the cultivation of barley. In this report, barley and wheat are competing crops.

The United Republic of Tanzania has still a rather high demand for imported wheat. It is a question of priorities whether to extend the cultivation of wheat or that of barley.

C. The use of sorghum in beer

Many papers have been published in different scientific periodicals about the use of sorghum as a raw material for fermented beverages and as a substitute for barley and barley malt. The expert was informed that a detailed study was being made about this by the East African Industrial Research Organisation (EAIRO). It would be very useful to learn about EAIRO report and to integrate their findings into the working programme proposed in this report.

In the expert's opinion it is no longer justifiable to consider sorghum as an inferior substitute for barley malt. Sorghum is a raw material well suited to the production of beverages. Its native starch can be degraded by means of enzymes to soluble matters and fermentable sugar.

However, when considering sorghum as an adjunct in brewing, it must be taken into account that there are hundreds of varieties of sorghum which are different in size, appearance, in chemical composition and structure. Some varieties contain substances which affect the taste very unpleasantly or react as enzymatic poisons. For a continuous use in the food and beverage industry, a careful selection of suitable varieties is indispensable. The permanent cultivation of the selected varieties must be guaranteed.

A first step, therefore, would be to determine which varieties of sorghum are most suitable for brewing.

D. The use of technical enzymes

If large quantities of sorghum are used as an adjunct in brewing, it would be necessary to use technical enzymes which fully replace the biochemical task of a malt.

In addition to their enzymatic strength, malts have another quality which is essential for the technology of beverage production; they mediate the aroma. The latter is obtained during the malting process when kilning dry. Technical enzymes, however, do not have any aroma.

It would be possible for the United Republic of Tanzania to produce its own technical enzymes. However, the production of technical enzymes must be on a sufficiently large scale if it is to be economically viable. The expert believes that the right conditions are not present in the United Republic of Tanzania for the time being. Investment in and operation of such plants is expensive, and there is no reasonable relation to the range of application in the United Republic of Tanzania. Nevertheless, if technical enzymes are used together with sorghum, even if the enzymes have to be imported, it would result in a net saving of foreign exchange, as shown below.

The following amounts of powdered technical enzymes (which have been fully proven in sorghum processing) are required per ton of sorghum:

0.6 kg of type A (at \$25.25 per kg)	\$ 15.15
2.0 kg of type B (at \$9.98 per kg)	19.96
Total cost per ton of sorghum:	<u>35.11</u>

At present the annual requirement for malt is around 12,000 tons (see annex II), which is equivalent to 70% of the total raw material used.

The malt is imported at a cost of \$252 per ton (f.o.b. European harbour

Therefore with the present proportion of raw materials the cost in foreign exchange is:

- 30 per cent local raw materials
- 70 per cent (12,000 tons) imported malt

	<u>\$</u>
Whereas if enzymes are used the cost would be:	3 024 000
30 per cent (5,200 tons) imported malt	<u>1 310 400</u>
70 per cent (12,000 tons) sorghum as local raw materials	-
31,200 kg of enzymes (at \$35.11 per kg for 12,000 kg of sorghum)	422 760
	<u>1 733 160</u>

Thus if technical enzymes are used with 70 per cent sorghum, the total saving in foreign exchange will be \$1,290,340

If savings of foreign exchange are considered more important than the reduction of the sorghum surplus, it would be possible also to replace part of the sorghum by sugar, thus reducing the amount of enzymes required.

The following composition of raw materials could be used:

	<u>Cost of imports (\$)</u>
Imported malt (30%)	1 310 400
Local sorghum (50%)	-
Local sugar (20%)	-
Imported enzymes	<u>300 700</u>
Total	1 611 100

This would mean an additional saving of foreign exchange of \$ 122,060 .

Ultimately the United Republic of Tanzania should aim at producing its own malt from sorghum, and from other cereals.

The raw materials for the production of beer could then be composed exclusively of local materials as follows:

	<u>Percentage</u>
Malted barley	30
Malted sorghum	40
Raw sorghum	30

The enzymes are available in the malted cereals so that technical enzymes need not be imported, and there is no cost in foreign exchange.

II. RECOMMENDATIONS

1. Recommended investigations

To be able to give a clear statement about the applicability of locally grown sorghum for the use in TBL production it is necessary:

(a) To investigate the main varieties of sorghum grown and cultivated in the United Republic of Tanzania;

(b) To carry out a programme of different test brews in micro-and/or macro-pilot plants;

(c) To carry out a programme of different test maltings in a pilot plant to find out which Tanzanian sorghum varieties are most suitable for malting;

(d) As a control, to compare the results with the malting and brewing characteristics of varieties of sorghum from countries with similar climates and types of soil, in case it might prove worth while to replace existing varieties in the United Republic of Tanzania;

2. Recommended first steps

The findings of the researches must be prepared step by step into a technology which is practicable in big factories.

As it may not be considered practicable to carry out all of the above programmes at first, it is recommended that the initial steps should be:

(a) To investigate the possibility of increased use of raw sorghum (white and/or red) instead of other adjuncts;

(b) To find out the highest percentage of substitution of malt by sorghum without changing the existing parameters.

To carry out these investigations, the following working schedule is recommended:

1. Sorghum analyses;
2. Test brews;
3. Test brews with enzymes in 2 to 3 variations of the proportions of raw materials.

Annexes III and IV give full details of the testing procedures to be used. Annex V details the cost of these first steps.

3. Where the tests should be carried out

It is not advisable to burden a factory which is running at 100 per cent capacity with the implementation of basic investigations. The particular production charges are too large, the risk of test failure is linked with losses of material and money. All investigations, the analyses of the raw material and the tests in pilot plants should be carried out by an institute which specializes in this field. Qualified institutes exist in nearly every European country. An institute in the Federal Republic of Germany with more than a 100 years experience in the field of malting and brewing has already been contacted, and it has been confirmed that it can carry out the proposed test programme.

4. Samples to be tested

To get reproducible results it is useful to get samples which represent the main varieties of red and white sorghum and of millet grown in the different areas.

The report prepared for the Marketing Development Bureau (see introduction) gives a map of the United Republic of Tanzania showing the major areas where sorghum and millet are produced. It would be reasonable to select the test samples from areas not far from the present and future locations of the breweries.

It will be a matter for the local authorities to decide the number of samples to analyse (annex III). To get a really representative picture the author recommends that at least five samples be analysed.

The results of micro test brews are comparable with the results of industrial production. The raw materials have to be identical with those in the brewery (annex IV).

5. Follow-up activities

As soon as the tests described above are completed, it should be possible to determine the best composition of raw materials for TBL, using a proportion of sorghum as adjunct and imported technical enzymes.

At the same time, experiments with malted sorghum must be made with a view to producing sorghum malt in the United Republic of Tanzania.

In this correction, the next steps should be to:

(a) Investigate the possibility of using malted sorghum together with malted barley and raw sorghum, and to find out the most favourable composition given that the greatest possible use of sorghum is desirable;

(b) Investigate if sorghum can be malted with the same malt house equipment as barley.

Until these investigations have been carried out, and a positive result obtained about the production and use of sorghum malt, it seems prudent to delay any decision about the construction of a malting plant.

6. The use of sorghum in chibucu

During his stay in the United Republic of Tanzania the author visited a chibucu brewery near Dar es Salaam. Chibucu, a kind of beer, is distributed in plastic containers, mainly to local bars and for household consumption in Dar es Salaam.

Chibucu is manufactured from the following raw materials: yellow maize (partly imported), a small quantity of barley malt (2 per cent, imported), industrial enzymes (imported), and lactic acid (imported).

The expert is convinced that large amounts of sorghum or millet can be used for the production of chibucu or similar beverages, providing that, with the assistance of the Government, chibucu production can be converted to the use of these locally grown cereals only and that a medium-term plan can be developed to establish chibucu factories, all using the same raw materials and operating the same production scheme, in areas with sufficient density of population.

Investigations into the local production of malt would also be of value to the chibucu brewery.

Annex I

EXTRACT FROM THE FAO/UNDP REPORT: "SURPLUS SORGHUM, MILLET AND
CASSAVA DISPOSAL, AND POLICY OPTIONS TO MINIMIZE FUTURE
SURPLUSES AND REDUCE LOSSES"

"Sorghum and millets are widely used for the manufacture of local alcoholic drinks in several regions of Tanzania. Sorghum is also used by large breweries for the production of bottled beers in a number of developing countries. It is estimated that large breweries in South Africa produce around 1,000 million litres of sorghum beer annually.

"Millets are also capable of being used to produce beers comparable to sorghum based beers but the small size of millet grains gives rise to technical problems in large scale modern malting plants and thus has limited their use to-date.

"There are two large-scale breweries in Tanzania:

Tanzania Breweries, producing the ordinary bottled beers distributed throughout Tanzania and

Darbrew Ltd, producing the Chilbuku beer distributed in plastic containers mainly to local bars and for household consumption in Dar es Salaam.

"Tanzania Breweries and its parent Ministry (Industry) are presently exploring the possible use of sorghum and millets for beer production and UNIDO has been approached for technical information. UNIDO has responded positively and has proposed that a specialist consultant come to Tanzania to assist in the further examination of the feasibility of beer production from sorghum and millets. Although enquiries are still at an early stage, Tanzania Breweries considers that:

(a) the use of millets is unlikely because of the small size of their grains and

(b) some sorghum could be used as an adjunct rather than as the primary malt but its use should probably have to be kept to a maximum of 40 per cent if the present character of the beer product is to be retained. At present production levels, this would imply a use of up to 4,000 tons of sorghum annually."

Annex II

FORECASTS OF BEER PRODUCTION AND BARLEY AND MALT REQUIREMENTS

Item	1979	1980	1981	1982
Projected beer production (hectolitre)	913 330	1 293 320	1 486 660	1 648 330
Corresponding barley malt requirement (ton)	11 250	15 720	17 950	20 470
Corresponding barley requirement (ton)	14 075	19 650	22 440	25 590
Amount of malt required per unit of beer (kg/hl)	12.33	12.15	12.07	12.42

Annex III

ANALYSIS OF UNMalted CEREALS

The following analyses should be performed on each sample of unmalted cereal:

Moisture content

Protein content

Extract content

Fat content

Tannin

Anthocyanogen

Germinating capacity

The total cost of these analyses for each sample would be DM 313.

Annex IV

EXPERIMENTAL ARRANGEMENTS FOR THE MICRO-TEST BREWS

1. Based on the results of the cereal analyses (see annex III), the two most suitable samples should be selected (if possible: one red and one white sorghum).
2. It is recommended to vary the raw materials composition for the test brews as follows:
 - (a) 30 % barley malt + 20 % red sorghum;
 - (b) 30 % barley malt + 20 % white sorghum;
 - (c) 70 % barley malt + 30 % red sorghum;
 - (d) 70 % barley malt + 30 % white sorghum;
 - (e) 60 % barley malt + 40 % red sorghum;
 - (f) 60 % barley malt + 40 % white sorghum;
 - (g) As a zero-test the actual raw materials composition of TBL current production should be used:
 - 70 % barley malt + 15 % white sugar
 - + 10 % raw barley + 5 % red sorghum.
3. The following analyses have to be performed for each test brew:
 - (a) Wort analyses:
 - Extract content
 - Viscosity
 - Colour
 - pH
 - Total protein
 - Coagulable nitrogen
 - Odour and taste
 - (b) Beer analyses:
 - Original gravity
 - Apparent extract
 - Real extract
 - Alcohol content

pH
Colour
Anthocyanogen
Tannin
Saccharification
Total protein
MgSO₄, precipitable
Coagulable nitrogen
Attenuation degree
Viscosity
Head retention
Bitter substances
Taste test

4. The following amounts of sorghum are needed per test brew:

<u>Proportion of sorghum (%)</u>	<u>Amount (g)</u>
20	400
30	600
40	300

That is, each particular sample should be about 2.5 kg.

5. The total expenses for each test brew are DM 1,500.
6. Use only jute bags or similar materials (never plastics) for packaging cereal samples. Otherwise, the germinating capacity will be affected.
7. To reduce expense, test brews (c) and (d) (under 2 above) could be omitted.

Annex V

ESTIMATED COST OF THE TESTS

Compilation of the estimated expenses for the first step:

	<u>DM</u>
Analyses of no less than five samples (see annex III) at DM 313	1 590
Five micro-test brews at DM 1,500 (see annex IV)	7 500
Two journeys of the expert from Munich to institutes in the FRG where the tests would be carried out, three days each, to supervise the micro-test brews and to participate in the taste tests and in the discussion of the results	600
Approximate total	<u>9 700</u>



