OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

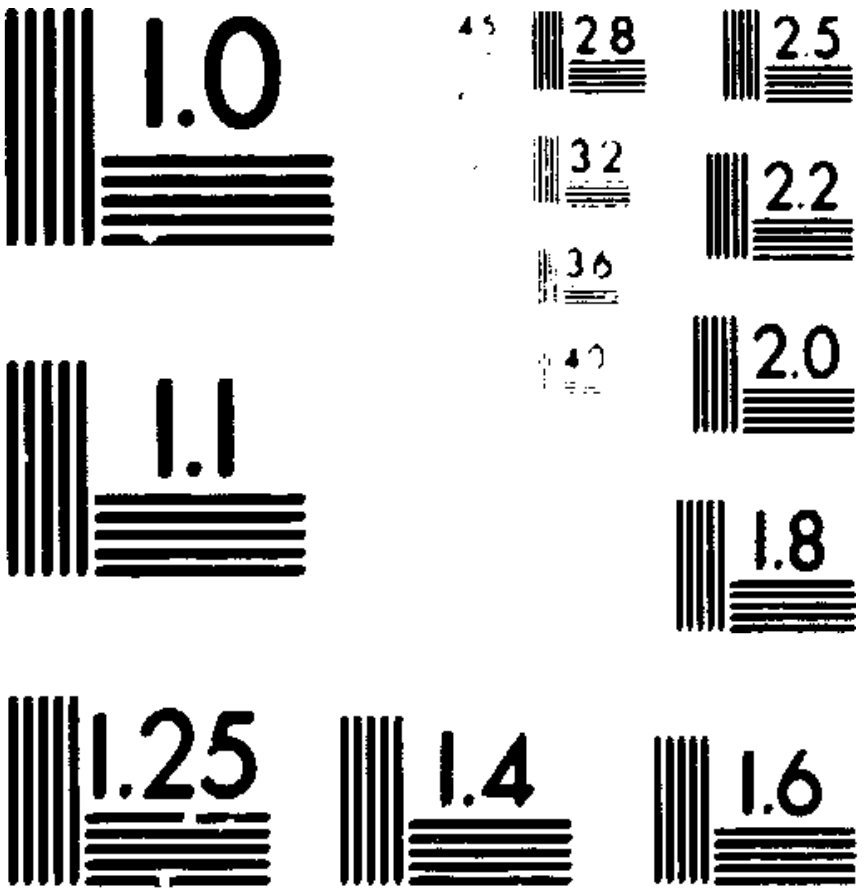
FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



1984

Some aspects of plant biotechnology of relevance to Africa.

H. G. Muller, M.Sc., Ph.D., FIFST,
Procter Department of Food Science,
Leeds University,
LEEDS LS2 9JT
UK.

14144

Lecture given at the African expert group meeting to assess implications of new technologies for the Lagos plan of action. 22-26 October 1984. Mbabane, Swaziland.

The word "Biotechnology" is very new.

The practice of biotechnology is thousands of years old.

In the west we have fermented wheat, rye and barley into bread and beer, grapejuice into wine and milk into butter, cheese and yoghurt.

In the east biotechnology has fermented soyabeans into soy sauce, natto, miso and tofu (pron. "toff"), and rice into saké.

In Africa sorghum, maize and millet have been fermented into sour beers, porridges and dumplings, palm juice into wine and cassava has been detoxicated.

Recently biotechnology has received a revolutionary impulse through gene manipulation with both positive and negative consequences for Africa.

For the past 20 years my research students and I have been concerned with the traditional cereal fermentations of tropical Africa. This work is continuing, but we have now also moved into the area of plant cell culture using fermenters.

The main object of our work in the past has been to improve the nutritional value of various fermented cereal foods of tropical Africa without increasing the cost. A small change in the process can often increase total yield or protein content or destroy toxins and anti-nutrients.

Although there are a large variety of these foods, the ones we have studied have certain characteristics in common: all are made from the

tropical cereals, maize, sorghum or millet and all are consumed as beer, boiled porridge, boiled dumpling or baked pancake.

Of the beers we have studied the Sudanese merissa and the Nigerian pito beer; of the porridges the Nigerian ogi and the Ghanaian koko; of the dumplings the Ghanaian kenkey and of the pancakes the Sudanese kissra.

Our methods of approach are always the same: first we study the traditional process in the field. Second, we reproduce the process in our laboratory in Leeds and third we try to improve the process or product.

1. Study of the traditional process

At the start of the investigation the relative importance of the product must be assessed. Is it a basic foodstuff or a relatively unimportant condiment? What are local variations of process and product and which type of product will have a maximum local appeal?

There are several ways of obtaining this information. Often my African research student is acquainted with the process on arrival in Leeds and this knowledge may be strengthened by a field trip home after the first year of his postgraduate course. Occasionally my visit to Africa can be arranged. Finally, past students are of considerable help. Many of these now hold senior positions in their country and are only too willing to help their future colleagues.

Our studies on kenkey can serve as an example. Kenkey is the staple food of the Ghanaian. It is a fermented dumpling which is wrapped in leaves and boiled. Fig. 1 shows a diagram of the preparation of Ga kenkey and Fig. 2 gives a list of some of the varieties.

Next samples were analysed chemically. There was a considerable variation in weight, flour extraction and salt content. Flavour was also

KENKEY

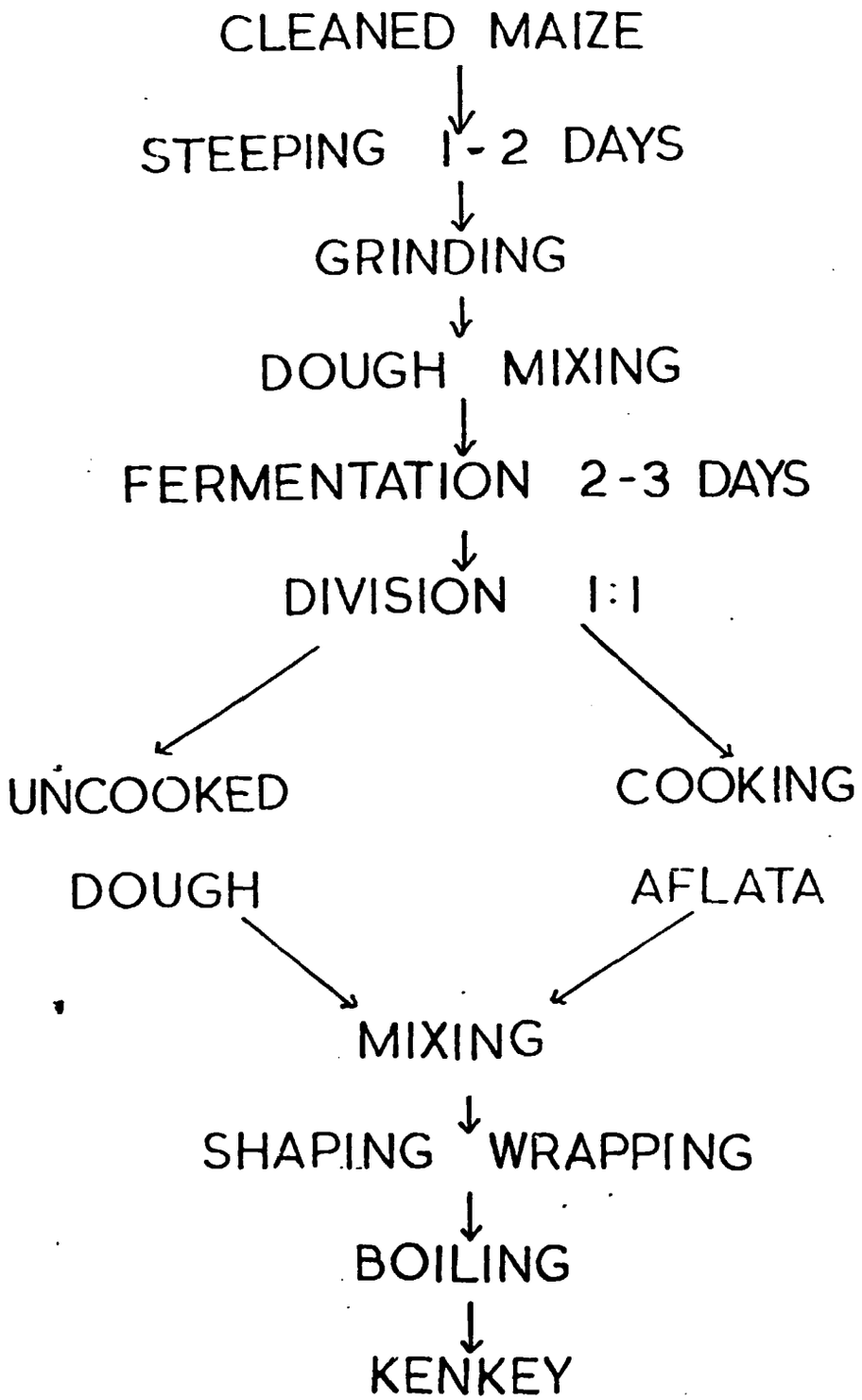


Figure 1

GHANAIAN KENKEY

Type	Town	Wrapping	Wt. (g)
Kukui	Kpandu	Zea	270
Abor	Winneba	Musa	430
Dokon Pa	Winneba	Sterculia	565
okon Pa	Yanoransa	Sterculia	515
shanti	Osino	Marantochloa	335
sihu	Cape Coast	Musa	425
aw	Amosiama	Musa	540
	Accra	Zea	320

Figure 2

different, depending int. al. on the different types of leaf wrapping.

Sometimes a traditional process can be very complicated as is shown by the Sudanese kissra (Fig. 3). This can be consumed as a porridge, as very thin pancakes or as the alcoholic beverage merissa. The latter is fermented longer. Having thus assessed importance, variability and method of the traditional process an attempt can be made to reproduce the process in the laboratory.

2. Reproduction of the traditional process in the laboratory.

Let me give you as an example Ogi and Koko (Fig.4).

Ogi is a sour porridge fermented as a suspension and is the most important weaning food in Nigeria. It is basically sour starch. Koko is the Ghanaian equivalent, but an important difference is that it is fermented as a dough, not as a suspension. Both are made from local maize, sorghum or millet.

Our first problem was that we did not have the correct fermentative organisms and produced a rather evil smelling brew. So we flew in a sample of ogi from Lagos, threw it into the sink and soaked our glassware in it. We have had no problem since.

However we know a great deal more today than we did 20 years ago. We know now that during ogi fermentation the microbial flora changes. There are, of course, variations but basically the original grain contains species of Aspergillus, Penicillium,Bacillus, Lactobacillus and Streptococcus. On steeping Lactobacillus plantarum and Streptococcus lactis multiply. During fermentation Streptococcus lactis and Candida spp. occur.

Banigo used cultures of L. plantarum, S. lactis and Zygosaccharomyces rouxii.

We use Saccharomyces cerevisiae, Zygosaccharomyces rouxii, Lactobacillus plantarum and Streptococcus lactis. In our view it is highly desirable that all wild fermentations should be replaced by starter cultures.

KISSRA

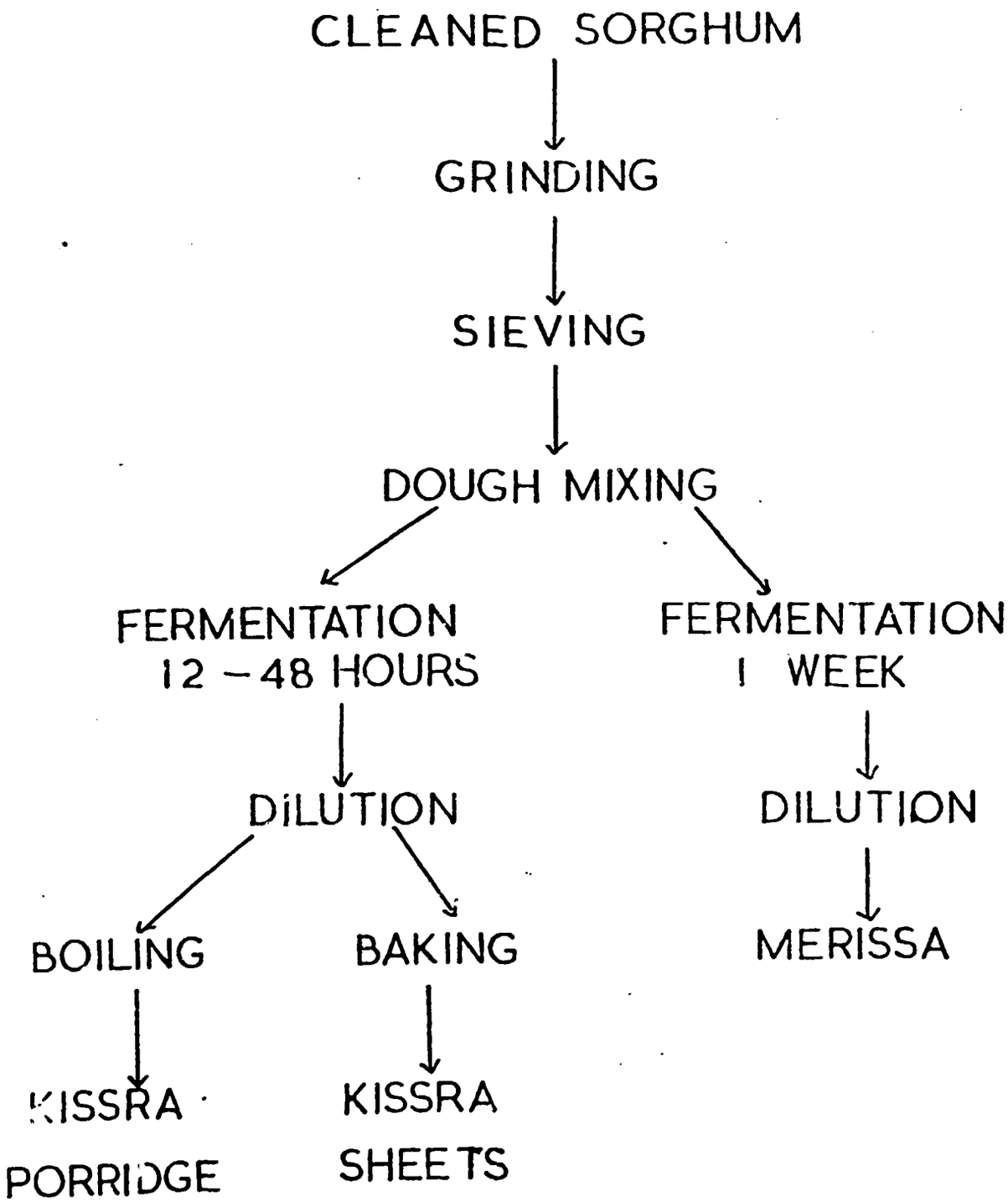


Figure 3

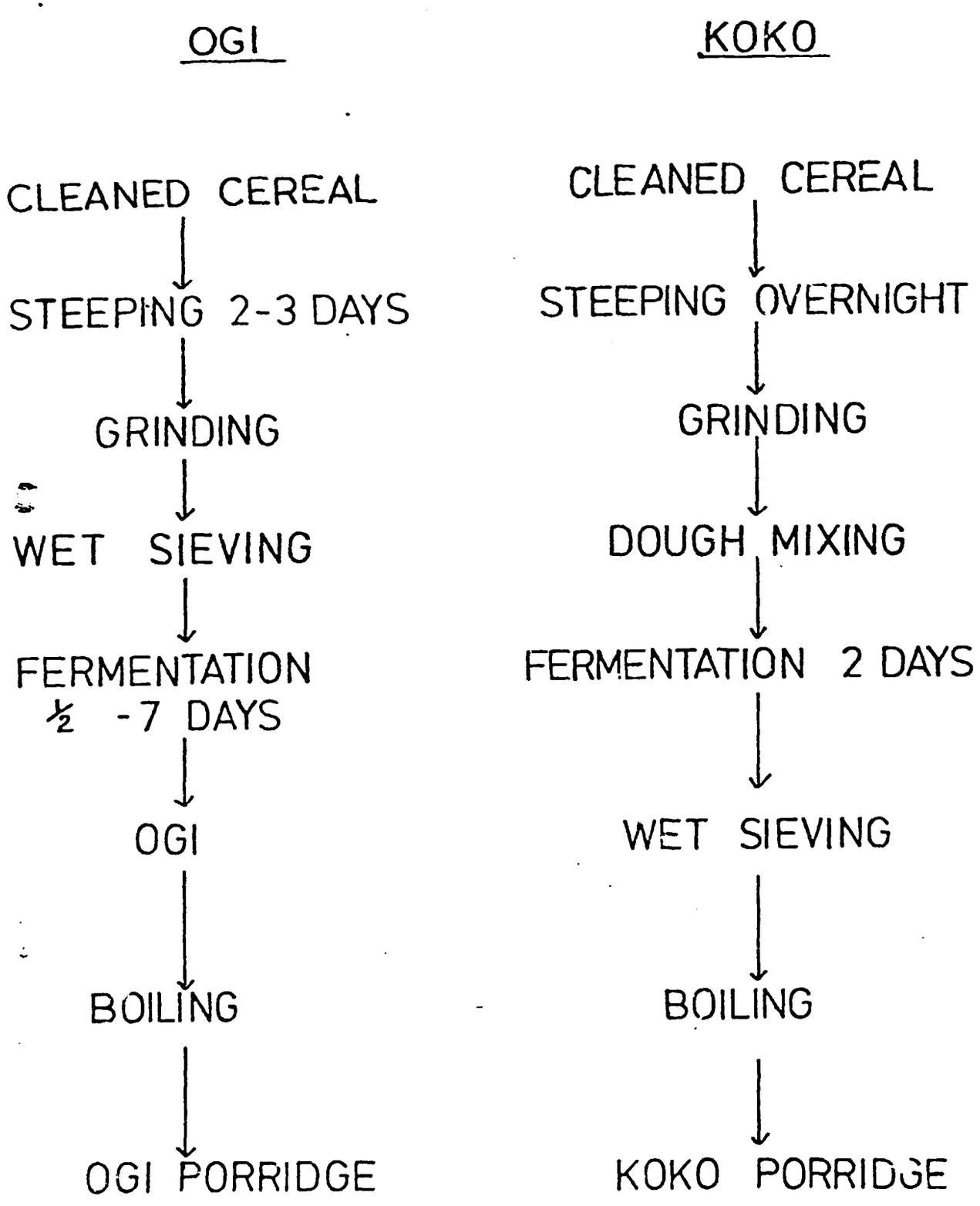

OGI
CLEANED CEREAL
STEEPING 2-3 DAYS
GRINDING
WET SIEVING
FERMENTATION
½ -7 DAYS
OGI
BOILING
OGI PORRIDGE
KOKO
CLEANED CEREAL
STEEPING OVERNIGHT
GRINDING
DOUGH MIXING
FERMENTATION 2 DAYS
WET SIEVING
BOILING
KOKO PORRIDGE

Figure 4

All our fermentations are evaluated by taste panels of West African students attending the University. Both conventional hedonic and difference tests are used.

The rate of fermentation is controlled by a check on acid production. pH determinations are not suitable because of the buffering effect of the system. Several methods were tried and eventually a sodium hydroxide titration against the supernatant of an ogi centrifugate was effective.

The final criterion of reproducibility is the total solids content or the protein balance, whichever is more convenient (Fig. 5).

Ogi is not acceptable to European tastes because of the high levels of acetic and butyric acids (Fig. 6). Nevertheless we were able to modify the product to European taste by mixing roller dried wheat flour with dehydrated buttermilk and yoghurt (Fig. 7). Are there other African products which can be made acceptable in the West?

3. Improvement of process or product.

We have found, for example, that fermentation as a dough is better than fermentation as a slurry since water soluble nutrients are saved in the dough process. Particularly the limiting amino acid lysine is lost in ogi manufacture. Fine milling causes less nutritional loss than coarse milling as less overtails are discarded. Finally, protein content can be increased by fermentation by 0.5 - 2.0 %, even without additional N-source.

The fate of several antinutrients and toxins have been studied in this laboratory and three should serve as examples: tannin, phytic acid and aflatoxin.

Tannins in sorghum are in many ways undesirable. They combine with protein and decrease the protein efficiency ratio (P.E.R). Our studies with pito beer have shown that root growth as well as α and β amylase activity

TOTAL SOLIDS IN OGI (% D.B.)

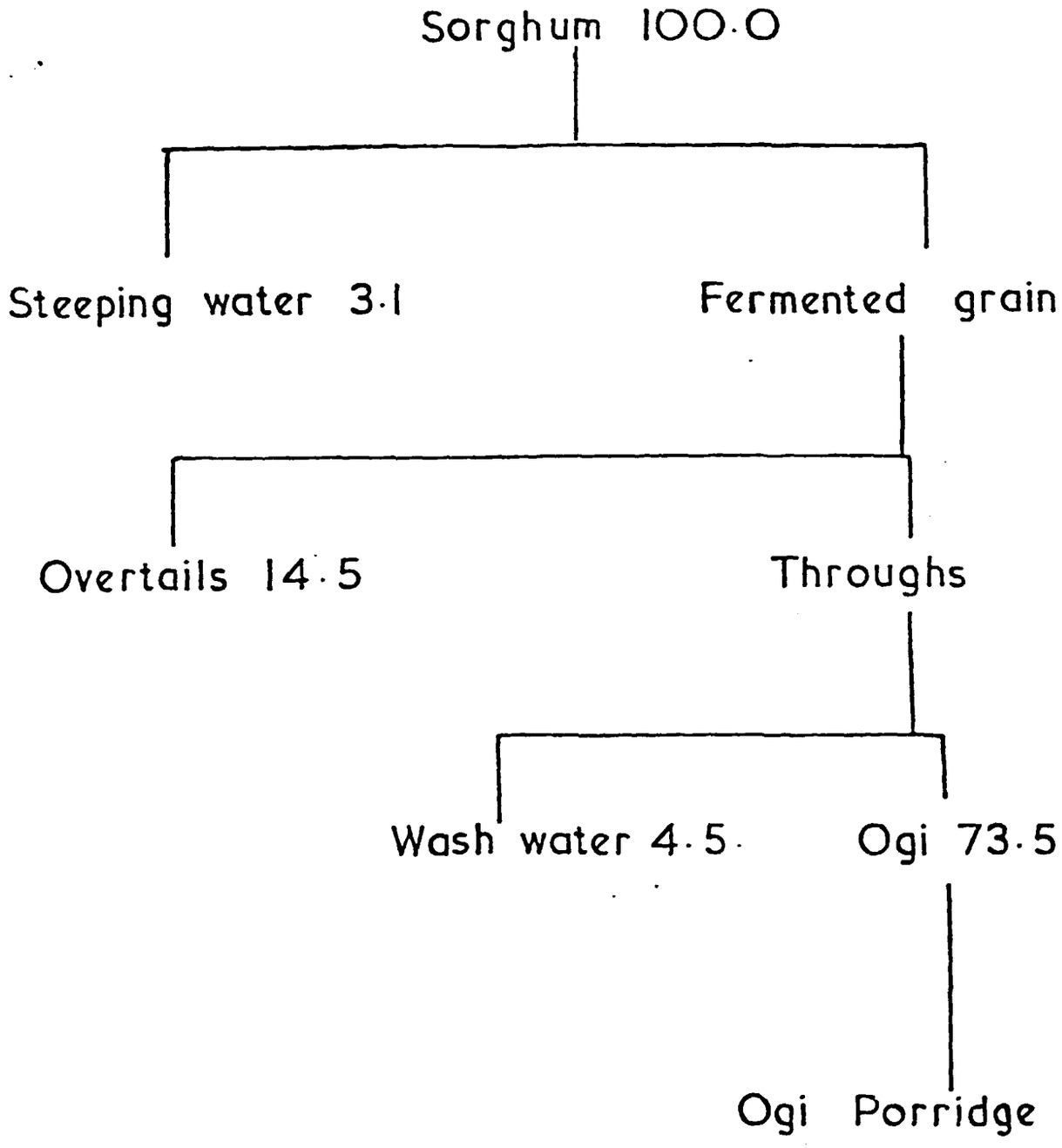


Figure 5.

ACIDS IN OGI (%)

Ogi type	Lactic	Acetic	Butyric
Maize	1.06	0.18	0.01
Sorghum	1.18	0.21	0.04
Millet	5.53	0.21	0.02

Figure 6.

are suppressed. These facts are important in brewing practice. At present one of my research students is studying the effect of sorghum tannins on proteases and amylases.

Tannins however give the necessary bitterness in sorghum beers which are achieved by the addition of hops in European brews.

It is also an important fact that high tannin seeds are avoided by the weaver bird which may occur in vast numbers in Africa and devastate the harvest. It is possible to remove tannins before use by various methods. For instance alkali dehulling has reduced tannins by 90%. We have therefore suggested that instead of sowing low tannin varieties for human food, high tannin varieties should be grown and detoxicated before use.

A brief word about the role of phytic acid in kenkey. Phytic acid is contained in wheat and maize. It binds Ca, Fe and Zn and makes them unavailable in human nutrition. In wheat fermentation, phytic acid is destroyed by the enzyme phytase but in maize phytase is not active unless the maize has germinated.

Fig. 7 shows the balance of phytic acid in kenkey production and it is clear that it can be greatly reduced by incorporating germinated maize into the kenkey dough.

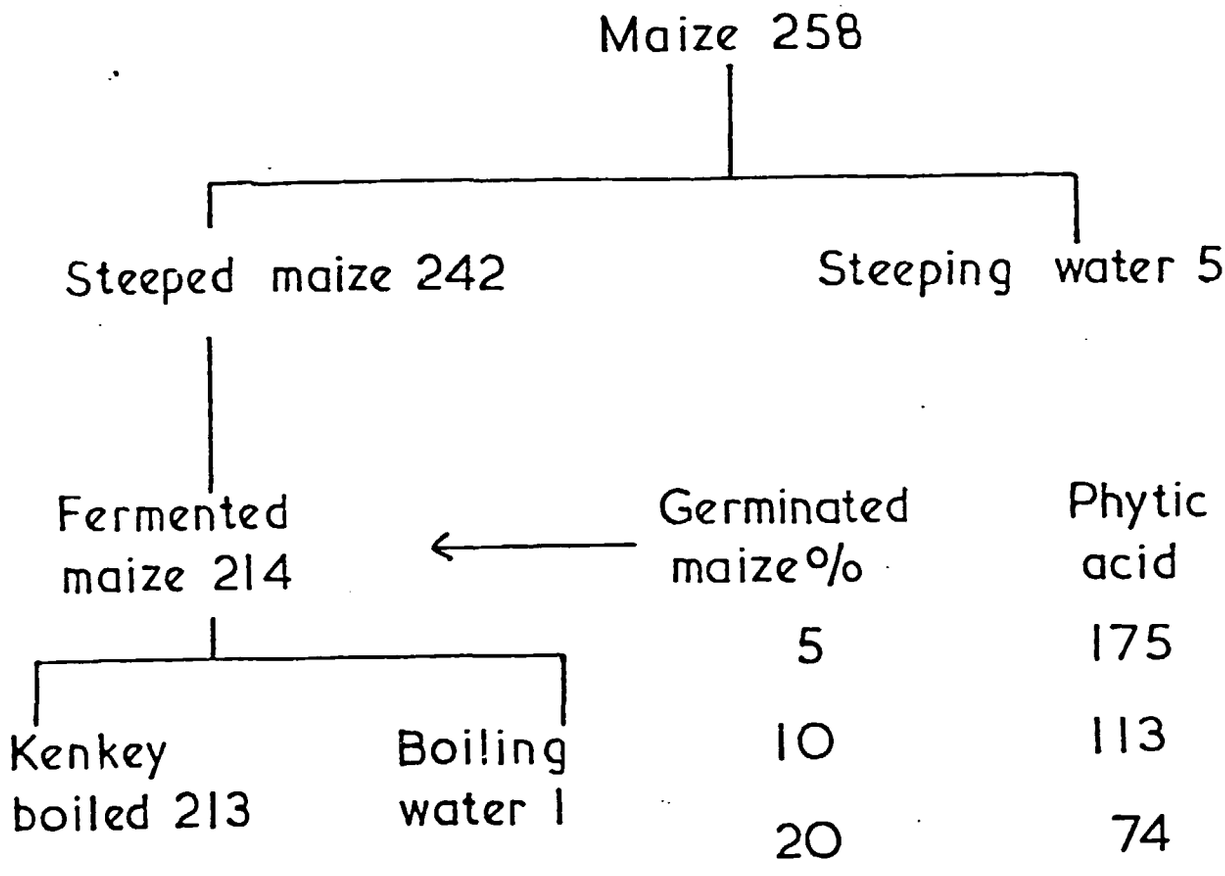
Finally let me deal with aflatoxins. These are antibiotics which act on higher animals such as fish, birds and mammals including man. They are produced by Aspergillus flavus and A. parasiticus.

Fig. 8 shows a culture of A. flavus.

Aflatoxins are particularly common in the wet tropics and are both very toxic and carcinogenic. It is thought that they are the cause of the high incidence of liver cancer in, for example, Nigeria.

In the UK the maximum legal limit is 30 µg/kg, in the US 20 µg/kg and in Japan zero.

PHYTIC ACID IN KENKEY (mg./100g.D.B)



Germinated maize%	Phytic acid
5	175
10	113
20	74

Figure 7.

We have found 200-250 µg/kg in cereals from Nigeria while some Nigerian workers have reported

350 µg/kg in cereals

400-800 µg/kg in dried fish

and 600-1100 µg/kg in groundnuts

Nwokolo and Okonkwa Trans. Roy. Soc. Trop. Med. Hyg., 72, 329-332, 1978

No wonder there is liver cancer in Nigeria!

Fig. 9 shows the fate of aflatoxin B_1 during ogi preparation. It is apparent that the original level of 200 µg/kg is reduced to 58 µg/kg in the ogi porridge.

We have been able to produce a method of grain treatment which reduces the level of B_1 from 100 µg/kg to about 5 µg/kg and B_2 to trace amounts only. This method is at present being patented.

There are in fact several methods of removing aflatoxin, none of them perfect. Ciegler et al.(1966) screened 1000 micro -organisms and found that Flavobacterium aurantiacum completely removed aflatoxin from a liquid medium. This process is also patented.

Of course there would be little need to remove aflatoxin from African food if agricultural practices were to be improved.

Before I deal with the disadvantages of Biotechnology for Africa, let us briefly summarise the advantages.

Wild fermentation can be replaced by pure culture.

The protein content of carbohydrate foods like cereals, yam, cassava etc., can be increased using a suitable micro organism and N-source. Antinutrients can be removed and toxins destroyed, and cellulose can be converted by e.g. Neurospora.

What are the disadvantages?

British scientists have been amongst the leaders in gene-manipulation and biotechnology but British Industry has been very slow to exploit the advantages. Amongst the reasons are lack of money, the strength of the agricultural lobby, the conservatism of British industry, and restrictive

Aflatoxin B_1 in Ogi (ug/kg)

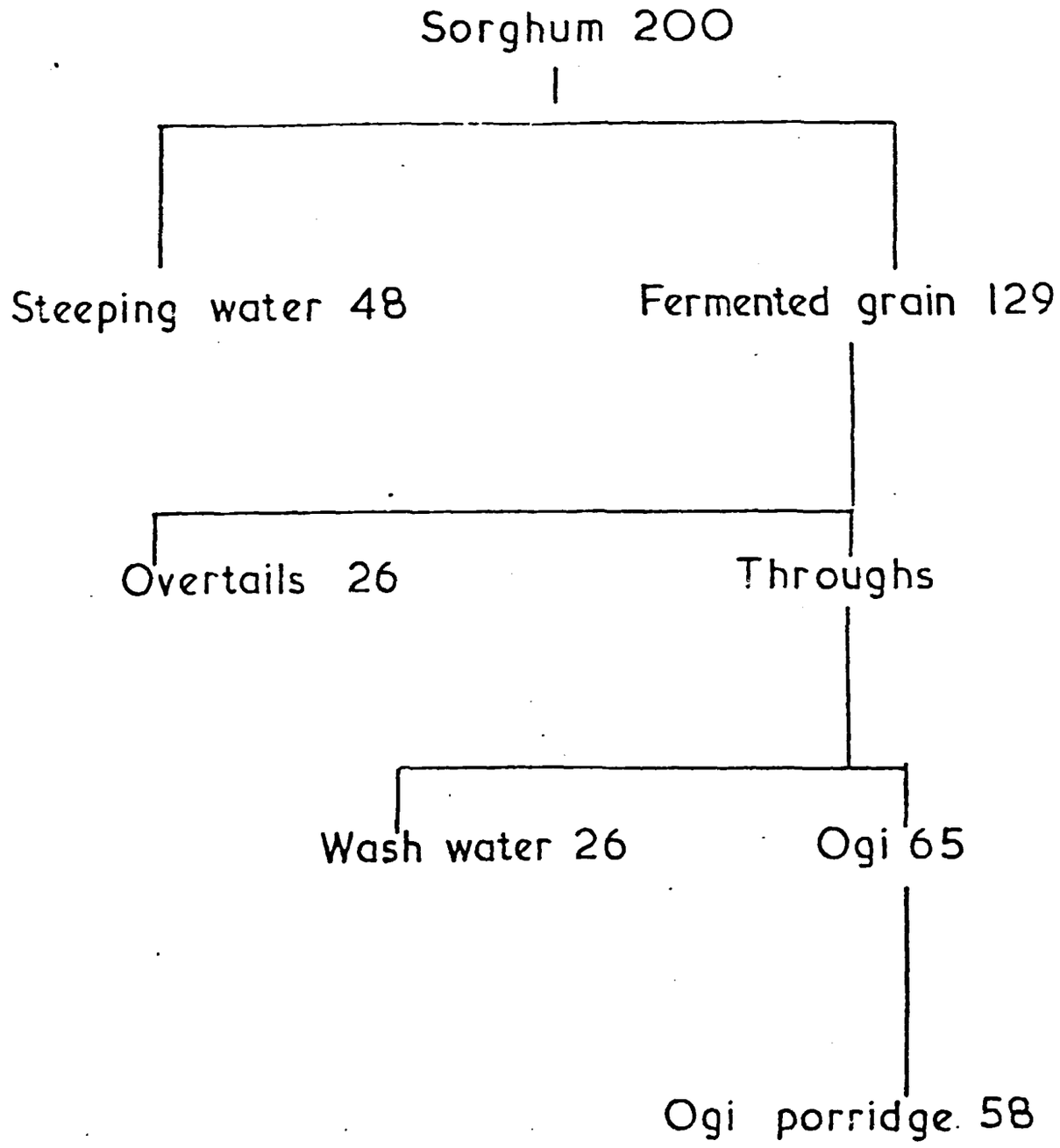


Figure 9

health legislation. Some of these factors would not operate in Africa.

Last year we began growing plant cells in fermenters. Of course, we are not the only ones in the UK. Amongst the most interesting plants are those which yield high priced products and many of these come from tropical Africa.

Wild basil, Buchu, Capsicum, Dill, Eucalyptus, Guava, Lemon grass and mint are used for flavour, Avocado for sugars, cedarwood for sesquiterpenes, cinchoma for quinine, Tonka beans for lactones and Pyrethrum for insecticice.

If we can provide a relatively cheap and consistent product for the British food industry, that would be more acceptable than a variable and expensive imported product.

That, I think is a [redacted] problem for Africe. In my view it is not solved by running expensive fermenters in Africa but by making use of African labour, sunshine and warmth and improving African agriculture and husbandry.

Note: Figures 7 and 8 are not attached to this written text.