African Journal of Biotechnology Vol. 4 (5), pp. 375-380, May 2005
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2005 Academic Journals

Review

The potential for upgrading traditional fermented foods through biotechnology

O.K. Achi

Michael Okpara University of Agriculture, Umudike P.M.B 7267 Umuahia Abia State, Nigeria. E-mail: omekachi@yahoo.com.

Accepted 7 January, 2005

Fermented foods play an important socio–economic role in developing countries as well as making a major contribution to the protein requirements of natural populations. In general, traditional fermented foods are made under primitive conditions, which result in low yield and poor quality. This paper outlines the present status of some indigenous fermented foods and beverages with some information on the microbiology and biochemistry of the fermentations. Among these are ogi, a fermented cereal gruel used as a weaning food, pito and burukutu, alcoholic cereal beverages. Dawadawa from fermented oil seeds is also popular as nutritious non–meat protein foods, while serving as a condiments and flavors in soups. Traditionally, women carry out fermented food processing activities. The production is craft-based despite the dawn of science and technology. The techniques they use are labour intensive, time consuming and have low productivities, with success depending upon observation of good manufacturing practice. Factors contributing to lack of consumer appeal of indigenous manufactured foods will be also considered. In the change from craft to a technology based production system, several strategies should be adopted. These include the use of starter cultures, stabilization of spontaneous fermentations, and production of food processing enzymes. In view of the considerable range of technologies for improving traditional bioprocessing, the challenges and potential application of biotechnology in upgrading these foods will be discussed.

Key words: Traditional fermented foods, biotechnology, upgrading potentials, microbiology research assessment.

INTRODUCTION

Food fermentation is regarded as one of the oldest ways of food processing and preservation. More than anything else, man has known the use of microbes for preparation of food products for thousands of years and all over the world a wide range of fermented foods and beverages contributed significantly to the diets of many people.

In traditional fermented food preparation, microbes are used to prepare and preserve food products, adding to their nutritive value, the flavour and other qualities associated with edibility (Pederson, 1971). These processes are characterized by their limited need for energy input, allowing microbial fermentations to proceed without external heat sources.

Although fermented foods traditionally have constituted a significant proportion of our diet, Nigerians have exhibited an ambivalent attitude in terms of consumers' taste and preferences for food. The introduction of foreign high technology products especially processed ones, radically changed the Nigerian food culture into a mixed grill of both foreign and local dishes. Sold at relatively high prices, these imported items command respect from the fact that their refinement had benefited from decades of research and development in their countries of origin (Ojo, 1991). Almost in contrast, many of the local indigenous fermented foods lack this appeal. Many people prefer the imported and exotic food items because of the attractive form, long shelf life, ease of transportation and other forms of utility which consumers associate with them.

Several traditional fermentations from Asia have been upgraded to high technology production system because of the strong research tradition in fermented food technology. Their experience can be used to upgrade some Nigeria's indigenous fermented foods and beverages. Indigenous fermentation technology has been used to a limited extent in food and beverage industry. The development of appropriate technologies aimed at upgrading the quality of indigenous Nigeria foods will be indispensable for the growth and survival of the food industry. This paper focus on basic aspects of upgrading traditional fermented foods and illustrate how their development relates to sustained growth of the food and beverages industry in Nigeria.

FACTORS HAMPERING THE DEVELOPMENT OF FERMENTED FOODS

The production of fermented foods is still largely a traditional family art done in homes in a crude manner. Consequently the production has not increased substantially more than a cottage industry. Many of them are gradually acquiring label of food for the poor population or associated with low incomes (Odunfa, 1985). According to Nout (1985) amongst the various factors working against traditional fermented foods the following appear generally valid:

- Inadequate raw material grading and cleaning contributing to the presence of foreign matter (such as insects, stones) in final product.
- Crude handling and processing techniques employed.
- Lack of durability (shelf life).
- Lack of homogeneity.
- Unattractive presentation.

Inadequate presentations inhibit consumer to develop regular purchasing attitudes. Plastic containers are replacing banana leaves as a covering for food. Finally, among the factors that may be working against fermented foods is the increasing popularity of food introduced from western countries (Hesseltine, 1983). Nevertheless, demand for locally processed foods is bound to increase as the imported counterparts are expensive. The factors outlined here serves as a general guideline to some major goals in the exercise of improving the present status of fermented foods.

INDUSTRIALIZATION OF INDIGENOUS FERMENTED FOODS

Fermented food products can be grouped into four categories according to the main substrates or raw materials used in the processing:

- Fermented starchy foods e.g. garri.
- Fermented cereals e.g. ogi.
- Alcoholic beverages e.g. pito, burukutu, obiolor.
- Fermented legumes and oil seeds e.g. dawadawa, iru, ogiri, okpiye.
- Fermented animals proteins e.g. nono and yoghurt.

Significant contributions have been made in research to understand the microbiology and biochemistry of the fermentation, in order to enhance their nutritional and overall food value (Eka, 1980; Okafor, 1977, 1983; Odunfa, 1985; Achi, 1990, 1992). Quite a number of agro-food processing enterprises have invested in the development of a commercial production technology. Cadbury Nigeria PLC now markets the traditional fermented seeds of *Parkia* under the trade name of Dadawa.

Dadawa is used in much the same ways maggi cubes are used in the western world as a nutritious flavoring additive along with cereal grains in sauces and may serve as meat substitute. Dawadawa (iru) is prepared from the seeds of African locust bean, *Parkia biglobosa*, a tree legume found in the savannah regions of Africa, Southeast Asia and tropical South America. The processing is a natural uninoculated solid-substrate fermentation of the boiled and dehulled cotyledons (Eka, 1980; Campbell-Platt, 1980; Odunfa 1985). Only bacteria are found associated with the fermenting beans. The genera of bacteria are *Bacillus* and *Staphylococcus* (Odunfa, 1981). The bean mass after fermentation is sun–dried and moulded into round balls or flattened cakes. Due to the high protein content, it has great potential as a key protein source and basic ingredient for food supplement.

Dawadawa fermentation is very similar to that of okpiye prepared from the seeds of *Prosopis africana* (Achi, 1992), ogiri prepared from melon seeds (*Citrullus vvulgaria*) snd caster oil bean (*Ricinus communis*) (jideani and Okeke, 1991). Although the organisms involved in the fermentation of these foods and several others have been identified this have had marginal effect as far as the industrial or commercial production is concerned.

Ogi is an example of traditional fermented food, which has been upgraded to a semi – industrial scale. Traditional and industrialized methods for manufacturing ogi are compared in Figures 1 and 2. The principal microorganisms involved in the fermentation are believed to be *Lactobacillus plantanrum, Candida Krusei* and *Debaromyes hansenii* (Odunfa and Adeleye, 1984). Attempts have been made to modify the processing of ogi to enhance its nutritional qualities. A further improvement is the manufacture of soy-ogi by the Federal Institute of industrial Research, Oshodi (FIIRO). Addition of soy improves the protein content and the nutritive value very much. Tempe is a traditional Indonesian fermented food made from soybeans in

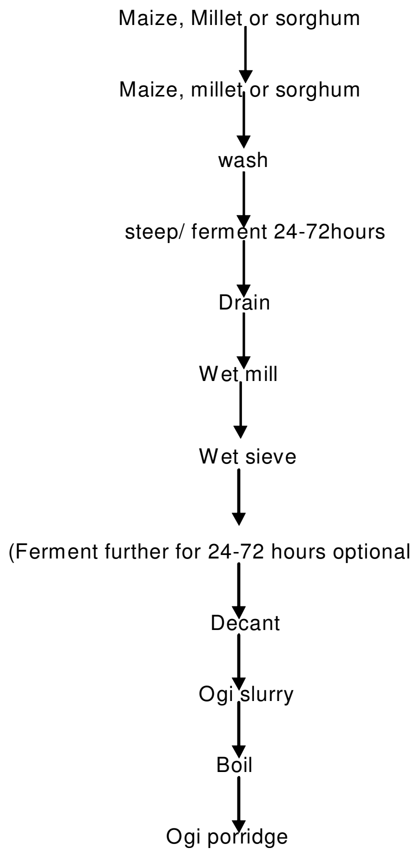

Figure 1. Traditional Nigeria Ogi manufacture (Banigo et al., 1974).

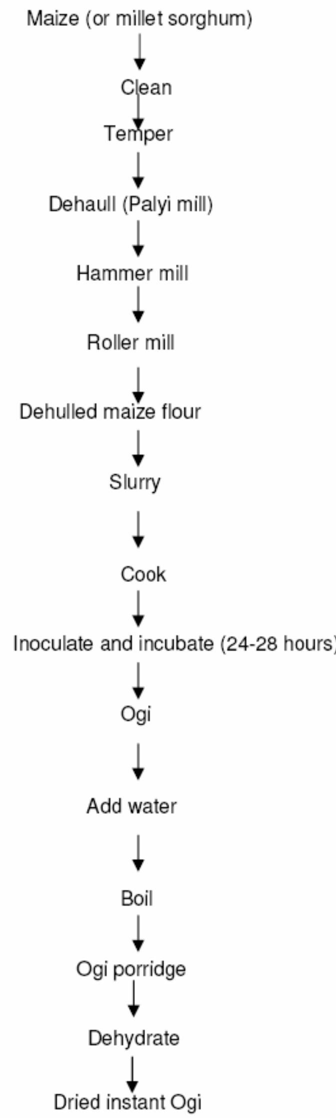

Figure 2. Improved Nigeria Ogi Manufacturer (Banigo et al 1974).

which fungi, particularly *Rhizopus* spp., play an essential role. Fresh Tempe of good quality is a compact and sliceable mass of cooked particles of raw material covered, penetrated and held together by dense non-sporulated mycelium of *Rhizopus spp.* (Nout and Rombouts, 1990). In Indonesia about 76, 000 tons of soybeans are used annually in the fermentation (Shutleff and Aoyagi, 1983) of tempe. It is estimated that 128, 000 workers are employed in the tempe industry. The tempe awareness has been extended to the United States where about 16 companies are engaged in its production. There are interesting prospects for industrial production of Nigeria fermented foods by harnessing the high technology input of the tempe process and upgrading the protein content of our predominantly starchy foods.

Burukutu and Pito are popular alcoholic beverages in the northern parts of Nigeria. They are brewed from sorghum, maize and/or millet. Both fermentations are similar except that adjuncts are added during mashing for the production of burukutu whereas they are not added in the production of pito (Faparusi et al, 1973: Ekundays 1969). Traditional burukutu and pito preparation is a batch process carried out on a small scale 2 or 3 times a week. The stages in their preparation are malting, mashing, fermentation and Maturation (Figure 3). Sorghum grains are stepped in water overnight. The grains are then drained of water and spread on banana leaves and allowed to germinate. The grains are watered on alternate days and turned over at intervals. Germination lasts for four to five days. The malted grains are sun dried before grinding.

During burkutu production, adjuncts in the form of garri (a farinaceous starchy powder produced from cassava, *Manihot esculenta*, is mixed with a mixture of the ground malt and water in a ratio of 1:2:6, gari:malt:water. The resulting mixture is left to ferment for 2 days. It is then boiled for four hours, cooked, and left to mature for two days (Faparusi, 1970: Faparusi et al., 1973). The sorghum malt contains mainly yeasts and moulds. In the fermenting mixture, the organisms isolated are yeasts, mainly *Saccharomyces cerevisiae* and *S. chavelieri* and the bacteria *Leuconostoc mesenteroides* and *Lactobacillus* spp. During the 48 hour fermentation period, the pH falls from 6.4 to about 3.7. During

Grain maize and sorghum
↓
Soak for two days
↓
Malt (germinate) for 5 days
↓
Grind (or sun- dried and hold until used)
↓
Adjusts(gari) added to burukutu production no adjuncts in pito
↓
Mix mash with cold water
↓
Boil mash for 6 to 12 hours
↓
Filter through a fine mash
↓
Cool filter
↓
Ferment overnight (mixed natural inoculum)
↓
Boil for 12 hours
↓
ool concentrate and add starter (sediment from previous brew)
↓
Ferment for 12 to 24 hours
↓
Pito

Figure3. Flow sheet for the traditional production of pito and burukutu South African sorghum (red varieties).

maturation, the dominant microorganisms are *Acetobacter* spp. and *Candida* spp. resulting in further souring of the beverage. The premium burukutu is a cloudy liquid with a vinegar taste and odor. An example of how a traditional fermented food can be modified for industrial production is the work on the South African sorghum beer. It is an alcoholic effervescent pinkish-brown beverage with a sour flavor, an opaque appearance and the consistency of a thin gruel. The preparation of the South African sorghum beer follows a similar pattern to that of burukutu or pito fermentation. In the traditional process, the malt is produced by soaking sorghum grains in water for 8- 24 hours draining and then allowing the grain to sprout for 5- 7 days. The malt is sun-dried and ground into a fine powder. The main steps in the brewing are mashing, souring, boiling, conversion, straining alcoholic fermentation (Hesseltine and Wang, 1979). The ground malt is made into thin slurry, boiled and cooked. A small amount of uncooked malt is added and left for one day during which it undergoes natural lactic fermentation. Lactobacillus is chiefly responsible. The mash is boiled and left for alcoholic fermentation to take place. More ground malt is added and after the fermentation on the fifth day, it is strained and is then ready to drink. The factory process is less complicated (Figure 4) and it still incorporated the lactic and alcoholic fermentation steps, but the top fermenting yeast *Saccharomyces cerevisiae* is inoculated.

Packaging is an essential process in the industrial production of the South Africa sorghum beer. As now sold in South Africa, it is packaged in milk cartons, which are filled and sealed just as milk would be (Hesseltine and Wang, 1979). Because the product is drunk in an active state of fermentation, however, each carton is left with an opening, large enough to allow $_{CO2}$ to escape but small enough so that the corn fragments will scale the hole if the carton is turned on its side (Hesseltine, 1983).

DEVELOPMENT OF FERMENTED FOOD AND BEVERAGES IN NIGERIA

The industrial development of indigenous fermented foods and beverages can be divided into four areas; Raw material development, starter development, process development, finished product development.

Raw material development

Raw materials can be tested in order to find the more suitable variety, strain, and its availability for using as substrates. For example, it is now generally accepted that a sorghum cultivars with low tannin content give a better quality European-type beer.

Starter development

All of the indigenous fermented foods are originally fermented by natural microorganisms which has been transferred from generation to generation. Isolation, selection, preservation or collection and starter making of a high efficient microbial strain for use as an inoculums has to be passed before industrialized large-scale production (Okafor, 1981, 1990; Daengsubha and Suwana-adth, 1985). Lactic acid bacteria and yeasts are probably the most important groups of organisms in fermented food, grape-wine yeast or ‘tempeh rhizopus’ will make the fermentation process more promising.

Undoubtedly, one of the improvements in the future will be the used of starter cultures that have been genetically engineered. The development of such strain with better and stable genetic properties is a challenge to microbiologists. These may offer nutritional benefits in the form of increased protein production as well as compatibility to multistrain fermentations carried out under non- sterile conditions (Nout, 1985).

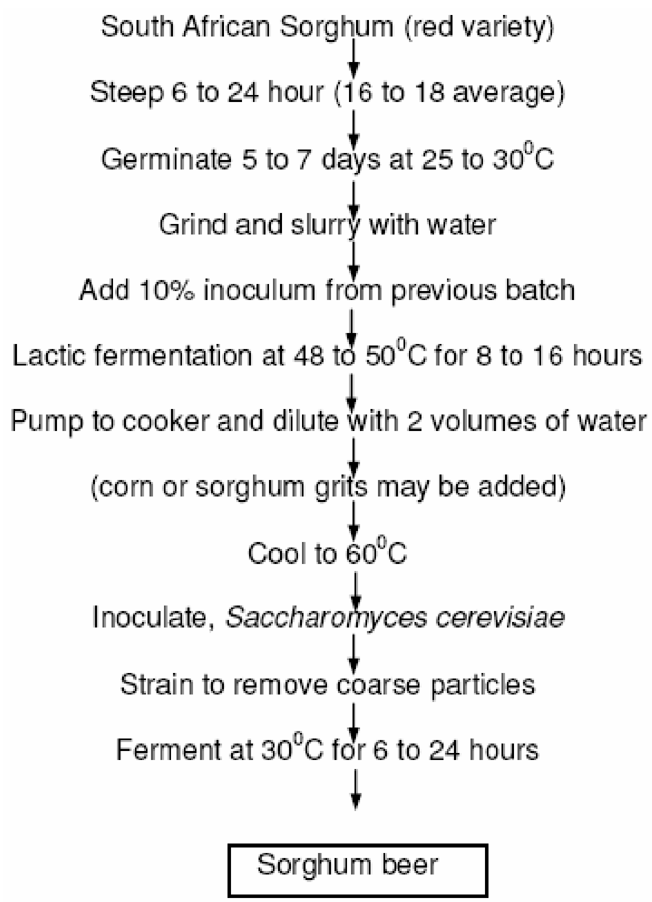

Figure 4. Flow sheet for factory production of South African sorghum beer.

Starter culture medium

The development and commercialization of a bulk starter medium, a product that may significantly improve the growth of starter culture for fermentation processes is a prerequisite for improving indigenous fermentation technologies. Since relatively high numbers of bacterial or yeast cells are needed to inoculate the large quantities of the medium in large industrial processes, an interim step can be used in which relative small numbers of the required organisms are added to the bulk starter medium. Thus the starter culture is added to the bulk starter medium to produce the bulk starter, which is added to the fermenting medium in the vats. This concept previously developed for cheese manufacture is also applicable for the preparation of starter culture for other fermentation processes.

Microbial processes development represents therefore an ideal example for basic scientific research with an applied goal. The knowledge gained in such process development can be translated into microbial process technology, which in turn can be classified as high, intermediate, and low- or village-type technology.

Development of fermentation processes

In the change from a craft to a technology based production system, there is the need to apply some materials and equipment for better quality control and faster production. In the industrial scale operations, a quantitative approach is desirable to enable the optimum design of fermentative containers, incubation room and their heating, cooling and insulator capacities. A cooperative research network designed to upgrade the technology for large-scale industrial production of fermented foods is therefore needed.

REFERENCES

Achi Ok (1990). Microbiology of " Obiolor " a Nigerian fermented non –alcoholic beverages. J. Appl. Bacterial. 69: 321–325.

Achi OK (1992). Microorganisms associated with natural fermentation of prosopis African a seeds for production of "okpiye". J. Plant foods hum. Nutr. 42:297-304.

Compbell Platt G (1980). African locust bean (Parkia species) and its west African fermented food product " dawadawa ". Ecol. Food Nutr. 9: 123- 132.

Daengsubha W, Suwana-adth M (1985). Development of Indigenous Fermented Foods in Thailand and other South East Asian Developing Countries: IFS/ UNU. Foods in Thailand and other South East Asian Development of indigenous fermented foods and food technology in Africa. Doula Cameroun, Oct. 1985.

Eka OU (1980). Effect of fermentation on the nutrient status of locust beans. Food Chem. 303- 308.

Ekundayo JA (1969). The production of "pito; a Nigeria fermented beverage. J. Food Technol. 4: 217- 225.

Faparusi SI (1970). Sugar changes during production of " Burukutu" beer. Z Allg Microbiol.13: 563-568.

Faparusi, SI, Olofinboba, MO, Ekwundayo, JA (1973). The Microbiology of burukutu beer Z. Allg Mikrobiologie. 13: 563-568.

Hesseltine CW (1983).The future of fermented foods. Nutr. Rev.14: 293-301.

Hesseltine CW, Wang HL (1979). Fermented foods. Chem. Ind. Lond. 12: 393-399.

Jideani IAO, Okeke CR (1991). Comparative study of microorangnisms and sensory attributes of condiments from the fermentation of different seeds. Plant food Hum. Nutr. 41: 27-34.

Nout MJR (1985). Upgrading traditional biotechnological processes. IFS/ UNU workshop on development of indigenous fermented foods and food Technology in Africa. Douala, Cameroun, Oct. 1985.

Nout MJR, Rombouts (1990). Recent developments in Tempe Research. J. Appl. Bacterial 69: 609-633.

Odunfa SA (1981). Microorganisms association with fermentation of African Locust Bean during preparation. J. Plant Foods 25: 245-250.

Odunfa SA (1985). African Fermented Foods In: Microbiology of fermented foods. Vol. 2. Ed: BJB Wood pp. 155-191. Elsevier Appl. Sci. Publ. Lond.

Odunfa SA (1987). Africa Fermented Foods. From Arts to Science. J. Food Agric. 1: 179-183.

Odunfa SA, Adeleye S (1985). Microbiological changes during the traditional production of Ogi- baba, a West African fermented sorghum gruel. J. Cereal Sci. 3: 173-180.

*Ojo MO (1991). The role of Agro- Industries in Promoting Food Culture in Nigeria CBN Econ. Fin. Rev. 29: 306-314.

Okafor N (1991). Microorganisms associated with cassava fermentation for garri production. J. Appl. Bacteriol 42: 279-284.

Okafor N (1981). A scheme for the improvement of fermented foods of Africa South of the Sahara in global impacts of Applied Microbiology (SO Emejuaiwe, O Ogunibi, SO Sanni) pp. 61-69. Academic press. Lond.

Okafor N (1983). Processing of Nigerian Indigneous fermented foods – A chance for innovation. Nig. Food J. 1: 32-37.
Okafor N (1990). Traditional alcohol beverages of Tropical Africa, Strategies for scale-up. Process (Biochem Intl. 25:213-220.
Shurtleff W, Aoyagi A (1983).The soyfood and industry and market Directory and Databook pp. 1- 112. The Soy food center Lafayette California
Steinkraus KH (1985). Potential of African fermented foods IFS/UNU workshop on Development of indigenous fermented foods and food technology in Africa. Duala, Cameroun. Oct. 1985.