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Safety of Small –Scale Food Fermentations in Developing Countries

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Abstract

Fermented foods are animal or plant tissues subjected to the action of microorganisms or enzymes to give desirable biochemical changes and significant modification of food quality. Small-scale traditional fermented foods are common in developing countries especially in Africa. Examples include “Ogi” (fermented maize, sorghum or millet); “Kenkey” (fermented sorghummaize, sorghum or millet); “Banku” (fermented maize or mixture of maize and cassava); “Kunuzaki” (fermented millet) and “Injera” (fermented sorgum flour). Fermentation enhances the nutrient content of foods through biosynthesis of vitamins, essential amino acids and proteins, by improving the protein and fibre digestibility, by enhancing micronutrient bioavailability and by degrading antinutritional factors. Small –scale fermentation processes enhance food safety by reducing toxic compounds such as aflatoxins and cyanogens and producing antimicrobial factors such as lactic acid, bacteriocins, carbondioxide, hydrogen peroxide and ethanol. For example, *Lactobacillus* isolates from “ogi” are able to produce bacteriocin which is active against common food –borne pathogens including Salmonella which might contaminate the fermented food. Bacteriocin has also been known to improve the shelf life of ‘jellied’ “ogi”, extending it by 10 days. The Hazard Analysis Critical Control Point (HACCP) system, which has made it possible to assure the microbiological safety of “ soy-ogi” and also produce “soy-ogi” of good consistent organoleptic quality has been implemented by Federal Institute of Industrial Research, Oshodi (FIRO), Nigeria. The safety of fermented in developing countries can be improved upon greatly by using quality raw materials, using unique starter cultures that have the ability to detoxify, maintaining proper hygienic standards in the processing environment and using proper packaging.

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1.0 **Introduction.**

1.1 **Fermented foods**

Animal or plant tissues subjected to the action of microorganisms or enzymes to give desirable biochemical changes and significant modification of food quality are referred to as fermented foods (Campbell- Platt, 1994). Traditional fermentation of foods according to Steinkraus, 1995 serves several functions;

1. Enrichment of the diet through development of a diversity of flavours, aromas, and textures in food substrates.
2. Preservation of substantial amounts of food through lactic, alcoholic, acetic acid and alkaline fermentations.
3. Enrichment of food substrates biologically with protein, essential amino acids, essential fatty acids and vitamins.
4. Detoxification during food fermentation processing.
5. A decrease in cooking times and food requirements.

1.2 **Importance and Benefits of Fermented Foods**

Fermented foods contribute to about one-third of the diet worldwide (Campbell- Platt, 1994). Fermentation causes changes in food quality indices including texture, flavour, appearance, nutrition and safety. The benefits of fermentation may include improvement in palatability and acceptability by developing improved flavours and textures; Preservation through formation of acidulants, alcohol and antibacterial compounds; enrichment of nutritive content by microbial synthesis of essential nutrients and improving digestibility of protein and carbohydrates; removal of antinutrients, natural toxicants and mycotoxins and decreased cooking times. (Steinkraus, 1995; Nout, 1994;).

Other advantages of traditional fermentations are that they are labour- intensive, integrated into village life, familiar, utilize locally produced raw materials, inexpensive, have barter potential and the subtle variations resulting, add interest and tradition to local consumers. Small- scale food fermentation provides a form of employment for some people especially those that have unique local know- how (Wood, 1994).

Since fermentation of foods in the developing countries for example in Nigeria, is majorly carried out on small- scale level by many local processors using traditional

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techniques, this papers seeks to look out examples of small –scale fermented foods, how safe are small-scale fermented foods and improving the safety of small scale fermented foods in developing countries.

2.0 Small Scale fermented foods in African countries

Small scale fermented foods are traditional fermented foods that are produced using traditional techniques. They are common food products and condiments in African countries. Some of them are cereal based i.e they are fermented from cereals others are fermented from tubers and stems. Some are also fermented from cow milk .For example, 'ogi', 'kenkey', 'injera', 'pito', and 'kunu-zaki' are fermented from cereals. 'Gari' , 'lafun' and 'fufu' are fermented from cassava. 'Wara-kisi' is fermented from cow milk while 'iru' is fermented from locust beans.

We will consider the preparation of some cereal based small- scale fermented foods in Africa.

'Ogi

'Ogi' is a porridge prepared from fermented miaze , sorghum or millet in West Africa. It is a staple of that region, and serves as a weaning food for infants. The traditional preparation of 'ogi' (fig 1) involves soaking of corn kernels in water for 1 – 3 days followed by wet milling and sieving to remove bran, hulls and germ (Akinrele, *et al*, 1970; Odunfa, 1985). The pomace is retained on the sieve and later discarded as animal feed while the filtrate is fermented (for 2- 3 days) to yield 'ogi', which is sour, white starchy sediment. Ogi is often marketed as a wet cake wrapped in leaves or transparent polythelene bags. It is diluted to a solids content of 8 to 10 % and boiled into pap, or cooked and turned into s stiff gel called 'agidi' or 'eko' prior to consumption.

Maize (or millet and sorghum)

↓

Soak for 2 to 3 days (primary fermentation)

↓

Wet mill

↓

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Sieve and discard pomace
↓
Ferment filtrate and allow to sediment
(Secondary fermentation)
↓
For 1 – 3 days
↓
'OGI'

Fig 1: Flow diagram for the preparation of 'ogi'.(Akinrele *et al*, 1970 ; Odunfa, 1985)

Banku

Banku is a popular staple consumed in Ghana. It is prepared from maize and/ or from a mixture of maize and cassava (Owusu- Ansah *et al*, 1980). Preparation for banku is summarized in fig 2. The preparation of banku involves steeping the raw material (maize or a mixture of maize and cassava) in water for 24hrs followed by wet milling and fermentation for 3 days. The dough is then mixed with water at a ratio of 4 parts dough to 2 parts water; or 4 parts dough to 1 part cassava and 2 parts water. Continuous stirring and kneading of the fermented dough is required to attain an appropriate consistency during subsequent cooking.

Corn
↓
Clean
↓
Steep for 24hours
↓
Wet mill
↓
Ferment for 3 days
↓
Dough formation
↓
Stir and knead

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↓

Cook

↓

'BANKU' **(**Fig 2: Flow diagram for the preparation of 'Banku'.)

Kunu-Zaki

This is a millet – based non-alcoholic fermented beverage widely consumed in the Northern parts of Nigeria. This beverage is however becoming more widely consumed in Southern Nigeria, owing to its refreshing qualities. Adeyemi and Umar (1994), described the traditional process for the manufacture of kunu-zaki. This process involves the steeping of millet grains, wet milling with spices (ginger, cloves, pepper), wet sieving and partial gelatinization of the slurry, followed by the addition of sugar and bottling (figure 3). The fermentation which occurs briefly during steeping of the grains in water over a 8- 48 hour period is known to involve mainly lactic acid bacteria and yeasts.

Dehulled millet grains

↓

Clean

↓

Steep

↓

Wet mill with addition of spices

↓

Wet –sieve

↓

Allow to settle

↓

Decant supernatant and retain slurry

↓

Slurry in cold water + slurry in boiling water

↓

Add sweetener and mix

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↓

Bottle

↓

KUNU-ZAKI

Fig 3: Flow chart for the traditional process of kunuzaki

Kenkey

This is a fermented maize dough which is popularly consumed in Ghana. During the production of kenkey, the dough is divided into two parts; one part, the ‘aflata’ is cooked into a thick porridge, while the other uncooked part is later mixed with the ‘aflata’. The resulting mixture is moulded into balls and wrapped in dried miaze husk or plaintan leaves, after which it is steamed. It is interesting to note that kenkey varieties vary widely throughout Ghana. In northern Ghana, sorghum is sometimes used instead of maize for preparation of the dough.

Maize

↓

Clean

↓

Steep

↓

Mill

↓

Dough preparation

↓

Ferment for 72hours

↓

Cooked dough Raw dough

↓

Mix (aflatasation)

↓

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Mould into balls

↓

Wrap with maize husks

↓

Boil for about 3hrs

↓

KENKEY

Fig 4: Flow chart for the traditional preparation of 'kenkey'

Injera

Injera is the most popular baked product in Ethiopia. It is fermented sorghum bread with a very sour taste (Stewart and Getachew, 1962) and is the undisputed national bread of Ethiopia. The baked product is referred to by different names depending on the locality of production in Ethiopia. It is referred to as 'bidena' in Oromigua, 'taeta' in Giragigua, and 'solo' in Walaytigna. According to a report by Gebrekidan and Gebrettiwat (1982) over 8% of total sorghum production in Ethiopia is used for 'injera production'. The sorghum grains are dehulled manually or mechanically and milled to flour which is subsequently used in the preparation of injera (fig 5)

Sorghum flour

↓

Mix with water, 4:1 w/v

↓

Knead to form dough

↓

Mix with starter (fermented yellowish liquid saved from previously fermented dough)

↓

Knead

↓

Add water

↓

Ferment for 48hr

↓

Add water and allow to stand for 1hr

↓

Bake on hot greased clay griddle metal till holes begin to form on top

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↓
INJERA

Fig 5: Flow diagram for the preparation of injera.

3.0 **How safe are small-scale fermented foods .**

To an extent, small-scale fermented foods in Africa are safe for consumption. Small- scale fermentation processes enhance food safety by reducing toxic compounds such as aflatoxins and cyanogens and producing antimicrobial factors such as lactic acid, bacteriocins, carbondioxide, hydrogen peroxide and ethanol. For example, Lactobacillus isolates from 'ogi' are able to produce bacteriocins which are active against common food borne pathogens including salmonella which contaminate the fermented food. This bacteriocin also improved the shelf life of 'jellied ogi' extending it by 10 days (Olasupo *et al*, 1997B)

The products formed after fermentation of foods for example lactic acid and bacteriocin by microorganisms in the fermenting substrates make them to be safe for consumption. *Lactobacillus plantarum, Lactobacillus fermentum* and *Saccharomyces cerevisiae* which are probiotics were the microorganisms isolated from maize 'ogi'. Some other microorganisms like *Clostridium bifermentans, Corynebaterium sp, Staphylococcus aureus, Aspergillus niger, penecillium sp* and *Rhizopus stolinifer* were isolated during the first day of steeping but they were no longer isolated after 48 and 72 hours of steeping (Ijabadeniyi, 2004)

Ijabadeniyi, 2006(unpublished) looked at the microbiological safety of local fermented foods sold within Akure metropolis, Nigeria. Twenty (20) samples of some local fermented foods each among which were lafun, ogiri , gari and kunuzaki were bought from sellers and they were screened for the presence of bacteria, moulds and yeasts. The result of the screening is shown in Table 1. The fact that Pathogenic bacteria like *Salmonella, Clostridium, Shigella* etc were not isolated from the local fermented foods confirms that small- scale fermented foods are safe for consumption to an extent since *Aspergillus flavus* which can produce aflatoxins were isolated from some of the local fermented foods.

The antagonistic activities of 'ogi' on some pathogenic microorganisms have been investigated by Ijabadeniyi and Omoya, 2005 (unpublished). The bacteria and fungi used

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in the investigation were *Escherichia coli, Salmonella typhi, Staphylococcus aureus, Clostridium perfringens, Bacillus cereus, Aspergillus niger and Candida albicans. The 'ogi'* samples effectively inhibited the growth of bacteria with zones of inhibition ranging from 2mm to 7mm but *Aspergillus niger* and *Candida albicans* were resistant to 'ogi'. The result showed that maize 'ogi' especially was able to inhibit the growth of the tested pathogenic bacteria. This might be the reason why 'ogi' water (called 'omidun' in western Nigeria) is used to prepare concoction for the treatment of typhoid fever. Also some old people drink 'ogi' water regularly because they believe it is medicinal.

Olasupo *et al*, 1995 have also isolated *Lactobacillus* isolates from selected African fermented foods. These isolates were found to be bactericidal to many pathogenic bacteria.

4.0 Improving the safety of small scale fermented foods in African Countries

The safety of fermented foods in developing countries of Africa can be improved upon greatly by using quality raw materials, using unique starter cultures that have the ability to detoxify, maintaining proper hygienic standards in the processing environment and using proper packaging.

Using quality raw materials

The quality and safety of small-scale fermented foods may be improved by choosing raw materials other than those traditionally used for their production. For example in my master's research project, Quality protein maize (from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria) was used to produce 'ogi'.

Using starter cultures

Microorganisms responsible for effecting important changes in the food during fermentation should be selected and subjected to genetic improvement geared toward maximizing desirable quality attributes in the food and the limiting any undesirable attributes. Using appropriate starter cultures is advantageous due to the competitive role of microorganisms and their metabolites in preventing growth and metabolism of unwanted microorganisms.

A strong starter may reduce fermentation time, minimize dry matter losses, avaoid contamination with pathogenic and toxigenic bacteria and molds, and minimize the risk

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of incidental microflora causing off flavour (Nout, 1994). According to Nout (1994) optimization of starter cultures may be achieved by both conventional selection and mutation, or by recombinant – DNA techniques to result in increased levels of safety.

Maintaining proper hygiene standard and packaging

During preparation of fermented foods, maintaining proper hygiene standards in the processing environment should be a priority. The raw materials to be used must be fresh. For example, mouldy cereals must not be used for preparation of fermented cereal i.e ogi and kunu-zaki. Also, during steeping as in the production of 'ogi', the water for steeping must clean and not be contaminated. The local processors must wash their hands with detergent before commencing the preparation. The equipment to be used for the preparation must also be thoroughly washed and cleansed. After preparation of fermented foods, it is necessary for them to be properly packaged for future consumption or marketing.

Application of Hazard Analysis Critical Control Point (HACCP)

In the food industry generally, approaches based on Good Manufacturing Practice (GMP) are being largely replaced by application of the Hazard Analysis Critical Control Point (HACCP) concept. It is an improvement on traditional practices by introducing a more systematic, rule based approach for applying our knowledge of food microbiology to the microbiological quality. The same concept can also be adopted with physical and chemical factors affecting food safety (Adams and Moss, 1999). And since small- scale fermented foods are integral part of global food supply, it will not be out of place for Hazard Analysis Critical Control Point (HACCP) concept to be used in the assurance and improvement of safety of small-scale fermented foods in developing countries.

Federal Institute of Industrial Research, Oshodi (FIRO), Nigeria has implemented a Hazard Analysis Critical Control Point (HACCP) concept for the production of soy-ogi at the institute's pilot plant as part of an EU- STD3 funded project on 'capability' building for research and development in quality assurance and fermentation technology for traditional African fermented foods'. The HACCP system has made it possible to assure the microbiological safety of the product and also produce 'soy-ogi' of good consistent organoleptic quality. The same HACCP quality system has been developed and implemented for ‘kenkey’ and ‘soumbala’. (WAITRO, 2000).

In conclusion, since small –scale food fermentation will likely remain an important part of global food supply although many of them may evolve into fermentation involving the use of starter cultures, enzyme additives and controlled environmental conditions, research should be directed towards identifying novel techniques (i.e irradiation and nanotechnology) for improving the safety of small- scale fermented foods in African countries.

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Table 1: Microorganisms associated with some local fermented foods sold within Akure metroplolis

Fermented food	Bacteria Isolated	Moulds Isolated	Yeasts Isolated
Lafun (fermented yam flour)	*Streptococcus* sp, *Pseudomonas* sp, *Lactobacillus* sp.	*Articulospora inflate, Aspergillus niger, Aspergillus ripens, Aspergillus flavus, Lemonniera aquatica*	None
Ogiri (fermented melon seed)	*Pediococcus* sp, *Streptococcus* sp, *Lactobacillus* sp	*Rhizopus* sp, *Aspergillus* sp	None
Gari (fermented cassava)	*Pseudomonas, Corynebacterium and Lactobacillus*	*Thallospora aspera, Passalora bacilligera, Varicosporium sp and Scolecotrium graminis*	None
Kunu-zaki	*Lactobacillus sp*	*Aspergillus flavus, Penecillium sp, Geotrichum candidum*	*Saccharomyces cerevisiae*