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The role of microorganisms in the production of some indigenous fermented foods in Nigeria

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Abstract

Indigenous fermented foods are products of the activities of microorganisms which include such foods like *fufu, gari, ogi, ogiri, iru*, and *ugba*. The fermentation of the substrates such as corn and cassava was a resultant of different biochemical processes and lactic acid fermentation to yield products like organic acids, aldehydes, alcohols and ketones. Different groups of microorganisms play significant roles in the fermentation of these locally fermented food products, thus enhancing their organoleptic and preservative properties while improving their nutritional quality. Some of the species of the microorganisms include *Lactobacillus*, *Lactococcus*, *Streptococcus*, *Saccharomyces*, *Corynebacterium* and *Leuconostoc*. This paper review on some locally fermented foods and the significant roles different microorganisms played in the fermentation, preservation and improvement on the nutritional and organoleptic qualities of the fermented foods under review. Factors that influenced the activities of the microorganisms' such as water activity; pH, oxygen availability, and temperature during the production were also discussed.

Keywords: Fermentation, microorganisms, fermented foods, indigenous.

Introduction

Fermentation is one of the oldest and most widespread methods of food processing and preservation. Most importantly since thousands of years ago, man has put microbes into use for preparation of food products, fermented foods and beverages (Achi, 2005). Every locality has some traditional type of fermented products which involved the activities of Lactobacilli and yeasts alone or in combination with other microorganisms (Maiangwa *et al.,* 2013).

Food is one of the basic necessities of life for which traditionally fermented food is an indispensible part of these necessities (Okaka and Okaka, 2001). Different parts of Nigeria have a locally fermented food peculiar to them because of their ethno-cultural and religious background. This has made it difficult to have one traditional food (Adebayo *et al.*, 2010). Locally fermented food is a form of food processing where microorganisms (e.g. lactic acid bacteria) are utilized for food production through the process of fermentation (Chelule *et al.*, 2010). The fermentation processes of these foods constitute a vital body of indigenous knowledge used for food preservation. They are acquired by observation and experience, and passed from one generation to another (Aworh, 2008). The fermentation process is on a small scale and is within the household which is generally characterized by the use of non-sterile equipment, natural inoculums, sensory fluctuations, and unattractive packaging which results in unpredictable quality of the end products (Olarenwaju *et al.*, 2009).

Fermented foods from cassava

Fufu

Fufu is prepared by peeling fresh cassava tubers, washing and soaking it in water (Aworh, 2008). Thereafter, they are cut into chunks of different sizes and soaked in earthen pots and drums for 3-5days to undergo fermentation. The pH value is reduced during this period of lactic acid fermentation while the tubers are softened. This facilitates the reduction of cyanogenic compounds in the tubers (Uyoh *et al*., 2009).

When the cassava tubers are steeped into water, the retting processes sets in. *Bacillus* sp plays a major role by breaking down the pectin in the cell walls of the cassava root (Adesulu and Awojobi, 2014). This was as a result of the production of pectinase. After the pectinase activity, the lactic acid bacterium (LAB) acts by the production of flavour (Bamforth, 2005). The soft tubers are then sieved and allowed to sediment and dewatered with press.

Gari

A fresh cassava tuber is peeled to remove the brownish thin outer covering. The inner whitish portion is then grated in a machine and placed in cloth bags for 18 – 48 hours to allow it to undergo fermentation (Kobawila *et al.*, 2005). The mash is dewatered by placing heavy objects on the cloth bags. The mash is sieved through a coarse sieve and heated in iron pot while stirring.

During the first stage (48hours), the bacterium *Corynebacterium manihot* played a significant role in the fermentation (IKediobi and Onyike, 1982). It breaks down the starch to organic acids including lactic acid. This brings about a drop in the pH value which encouraged the rapid breakdown of linamarin and this ushers in the second stage where there is subsequent proliferation of the fungus *Geotrichum candidum* which produces the favouring ketones, aldehydes and other compounds (Lei *et al.*, 1999; Ayoade, 1999). *Lactobacillus* sp, *Leuconostoc* sp and the yeast *Candida* sp are also present in the fermenting mash and they produce linamarse which breaks down the linamarin and remove the cyanide in the *gari* (Oyewole and Isah, 2012).

Fermented food from corn

Ogi

This is a Nigerian sour gruel made from maize. Corn is steeped in water for about two days, wet-milled and sieved with a mesh to remove the fibrous tissue in the maize. The starchy sediment is allowed to settle and the water is decanted. It is prepared by boiling it to form a thick gruel. Initially, the fungi *Cephalosporium* and *Fusarium* which were acquired from the field were involved in the fermentation of *ogi* within the first 24 hours (Obire and Amadi, 2015). They were soon replaced by lactic acid bacteria (*Lactobacillus plantarum* and *Lactobacillus mesenteroides)* and yeast (*Saccharomyces cerevisiae*, *Rhodotorula* spp and *Candida mycoderma*). These microbes are predominant during the wet milling of the corn. The activities of lactic acid bacteria and occasionally that of yeasts and acetic acid bacteria are responsible for flavour production in the *ogi* (Oyewole and Isah, 2013). Gas chromatographic analyses confirmed the presence of these acids in their quantitative order: acetic, butyric, pentanoic, isohexanoic and isobutyric acids (Banigo *et al*., 1974).

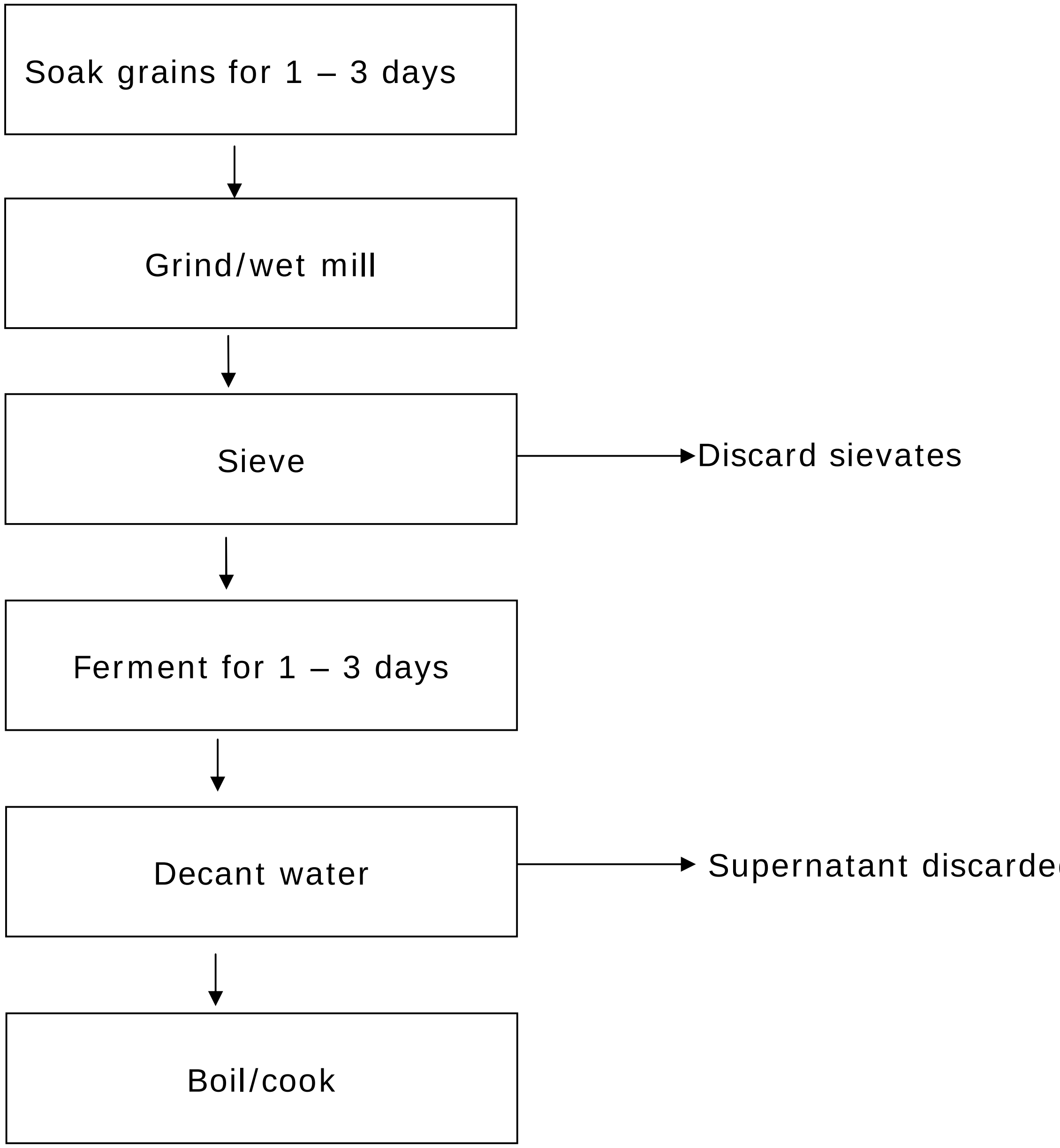

Figure 1: Flow chart of *ogi* production.
(Banigo *et al*., 1974)

Fermented food from melon seed

Ogiri

This is obtained when the hulls of melon seeds are removed and boiled until it becomes soft. The melon seeds are cooked again for 2 – 3 hours after wrapping it in blanched plantain leaves (Ayoade, 1999). The water and oil are drained off and the seeds are fermented for 3 days at ambient temperature. After this period, the seeds are ground in a sterile mortar and some salt is added. The melon seed paste is re-wrapped in plantain leaves and fermented for 4 additional days. Some microorganisms play such as *Bacillus* sp, *Alcaligenes* sp and *Streptococcus* sp significant roles in the fermentation of the melon seeds to form *ogiri* (Barber *et al*., 1988; Ogundana, 1980).

Fermented food from locust bean and oil bean seeds

Iru

This is a fermented food condiment from African locust bean (*Parkia biglobosa)* used in Nigeria for making stews and soups (Odebunmi *et al.,* 2010). The locust bean is boiled in water for 12 -24 hours so as to soften hard cotyledon (Kuye and Sanni, 1999). The beans testa which is black is removed by either rubbing between the hands, under the foot or by gently pounding it in a wooden mortar. The addition of sand or wood ash could act as abrasive by facilitating the removal of the testa. It is then boiled for 30 minutes to 2 hours, molded into small ball and wrapped in banana or pawpaw leaves. A softening agent called '*Kuru*' containing sunflower seed and trona or '*Kaun*' (sodium sesquicarbonate) may be added while boiling to soften the cotyledon (Aworh, 2008). It is then covered with additional leaves while placed in raffia mats to ferment for 2 – 3 days.

The fermentation of the locust bean takes place in moist solid state and involved contact with appropriate microorganism at ambient temperatures. At completion of the fermentation, there is formation of mucilage and overtones of ammonia are produced by the breakdown of the amino acids during fermentation (Onyenekwe *et al.,* 2012). The predominant microorganisms are *Bacillus subtilis, Bacillus licheniformis* and *Bacillus firmus* (Odunfa, 1981). It was observed that the *Bacillus subtilis* fermented the locust bean strongly by producing the most acceptable *iru* when compared to other microorganisms used (Odunfa and Adewuju, 1985). This was as a result of the proteolytic activity of the microorganism. The *Bacillus subtilis* grows on ammonia or nitrogen source and does not require growth factors and also produces antibiotics which can inhibit the growth of other microorganisms such as *Streptococcus lactis*, *Streptococcus uvarum* and *Streptococcus faecium* (Campbell-platt, 1980).

Ugba

This is made from oil bean seed (*Pentaclethra macrophylla*). It is prepared by boiling the oil bean seed in water for about 4 – 12 hours (Obeta, 1983). The cooked seeds are removed from Kernels and washed. It is then boiled again to remove the bitter components in the seeds since these components are soluble in water (Kolawole and Okonkwo, 1985). The washed cotyledons are cut into their slices which are mixed with salt, put in a clean pot without water, covered and fermented for about 5 days at ambient temperature (Achinewhu, 1982). *Ugba* is consumed as a basic food or used as a flavouring agent.

The microorganism isolated at different stages of fermentation of the ugba are mainly proteolytic *Bacillus subtilis* and coagulase negative *Staphylococcus* sp. *Bacillus subtilis* is more predominant as its population equally increases throughout the fermentation while that of *Staphylococcus* decreases. Other microbes involved in the fermentation of *ugba* include *Micrococcus luteus*, *Micrococcus roseus*, *Bacillus circulans* and *Bacillus macerans* (Obeta and Ugwuanyi, 1996). *Bacillus* sp is responsible for the characteristic aroma of *ugba* (Kuye and Sanni, 1999). The microorganisms involved in the fermentation of *ugba* are microbes around us from air, handling and utensils used in slicing the cooked cotyledons.

Table 1: Selected fermented foods in Nigeria

Fermented product	Raw material	Microorganisms implicated
Ogi	Maize	*Lactobacillus plantarum* *L. fermentum* *S. cerevisiae* *Candida krusei* *Corynebacterium* spp *Acetobacter* spp
Gari	Cassava	*Leuconostoc mesenteroide* *L. plantarum* *Bacillus subtilis* *Candida krusei*
Fufu	Cassava	*L. plantarum* *L. brevis* *B.* subtilis *C. krusei*
Iru	Seeds of Parkia	*Bacillus* spp *Staphylococcus* sp
Ogiri	Seeds of castor oil	*Bacillus* subtilis *Alcaligenes* sp *Streptococcus* s *Staphylococcus* sp
Ugba	Seeds of oil bean	*Leuconostoc mesenteroides* *Bacillus* sp *Staphylococcus* sp *Micrococcus* sp

(Kuye and Sanni, 1999)

Significance of food fermentation

1. enhancement of organoleptic properties

A food that is fermented becomes palatable as there will be improvement on the organoleptic properties, texture, aroma and flavour (Chelule *et al.*, 2010). The organoleptic properties of the fermented food make them more important since it has wider acceptance than the unfermented foods (Osungbaro, 2009).

2. Provision of nutritional quality

It is known that staple foods for the low income populations like the cereals have poor nutritional value (Chelule *et al.*, 2010). Improvement in the nutritional value and digestibility of foods has been associated with lactic acid bacteria fermentation (Nout, 2009). The enzymes like amylase, proteases, lipases and phytates modify the primary food products through hydrolysis of polysaccharides, phytates, proteins and lipids (Adeyemi, 2008).

The quantity of proteins, quality of proteins and the content of the water soluble vitamins increases, while the antinutrient factors (ANFs) in the foods decline during fermentation (Santos *et al.*, 2008). This leads to increased bioavailability of minerals such as zinc, calcium, phosphorous iron and amino acids (Murwan and Ali, 2011).

3. Preservative Properties

Research has shown that there is a preservative activity that local fermentation has on fermented products like cereals and fruits (Adeyemi, 2012). This is lowering of the pH value through the production of acid. The acid produced inhibits the growth of pathogenic microbes which are implicated on food spoilage and food poisoning thereby prolonging the shelf life of fermented foods (Olukoya *et al.*, 2011). This in turn makes the foods safe for consumers in terms of transportation, stability and storage (Chelule *et al.*, 2010).

4. Antibiotics production

Lactic acid bacteria produce antimicrobial agents such as bacteriocin and peptides that induce antimicrobial activities against food spoilage microorganisms and food borne pathogens, but do not affect the microbes producing them.

LAB fermentation is used to prevent diarrheal disease since they modify the composition of intestinal microorganism thereby acting as deterrents to pathogenic enteric bacteria (Olukoya *et al.*, 2011). They are also applied as a barrier against non-acid tolerant bacteria, which are ecologically eliminated from the medium due to their sensitivity to acidic environment (Agarry *et al.*, 2010).

5. Detoxification During Fermentation

Through infestation of foods by microbes such as bacteria, yeast, moulds and viruses, a number of toxins such as fumonisin and aflatoxin are eliminated in foods (Ari *et al*., 2012). Making use of lactic acid bacteria in fermentation detoxifies toxins and is a milder method since it preserves the flavour and nutritional value of foods (Chelule *et al.*, 2010). Furthermore, fermentation degrades mycotoxins without having adverse effects on the nutritional values of foods (Ari *et al.*, 2012).

6. Decreased cooking time

Research has shown that processing foods to destroy any anti-nutrient will eventually facilitate processing and cooking and improve the nutritional quality of fermented foods like cereals and legumes. This is mostly associated with fermented soybean products (Egbere, 2008) and ogi from maize (Wikipedia, 2012).

7. Improvement of health

Fermented food products consumed like fermented milks (e.g. yoghurt) have therapeutic values as they contain high concentrations of pro-biotic bacteria which lowers the cholesterol level in blood (Jyoti, 2010). It also improves digestion and nutrient absorption, balances the bacteria in the gut to hinder constipation, lactose and gluten intolerance (Abdel *et al.*, 2009). Raw fermented foods are rich in enzymes and the human body needs these enzymes to properly digest and make efficient use of the food (Egbere, 2008).

Research has shown that the slurries of Nigerian fermented carbohydrate foods like fufu and ogi have shown great health promoting properties which makes it relevant in the control of gastroenteritis in humans and animals (Aderiye *et al.*, 2007).

Factors that influence the development of fermented foods

(i) Salt Concentration

The lactic acid bacteria are known to tolerate high salt concentration which gives them advantage to proliferate over non-salt tolerant microorganisms. *Leuconostoc* sp is known to majorly initiate lactic acid fermentations because they have high salt tolerance levels (FDA, 2011).

(ii) Temperature

Different groups of bacteria function within certain temperature range which is relevant to different fermentation processes (Lee *et al.*, 2011). Some bacteria have optimum temperature between 20 to 30 ^{0}C, higher temperatures of 50 – 55 ^{0}C and colder temperatures of 15-20 ^{0}C while lactic acid bacteria and *Lactobacillus* species function best at 18 – 22 ^{0}C (FDA, 2011).

(iii) Hydrogen ion concentration (pH)

For most bacteria, their optimum pH is around 7.0 while some survive at low pH levels. Acid tolerant bacteria such as *Streptococcus* sp and *Lactobacillus* sp play significant roles in dairy and vegetable product fermentations (FDA, 2011).

(iv) Water activity

Generally, bacteria require fairly high water activity of about 0.9 and above to thrive. Only few species of bacteria could survive water activities lower than the above as yeasts and fungi proliferate in foods with low water activities (Prescott *et al.*, 2003).

(v) Nutrients

All microorganisms require nutrients to carry out their metabolic activities (Egbere, 2008). Fermentative bacteria require substrates such as simple (e.g. glucose) or complex carbohydrates (e.g. starch) (FDA, 2011). Limiting the substrate quantity availability of these microbes will adversely affect their growth since they have high energy requirements.

(vi) Oxygen availability

Fermentative bacteria could be anaerobes or aerobic depending on their requirement for oxygen to undergo metabolism (Wikipedia, 2011). *Lactobacillus* sp are microaerophilic as they grow in reduced atmospheric oxygen. Insufficient oxygen being available during aerobic fermentation becomes a limiting factor since it is what determines the product, the energy released and the amount of biological product obtained from the reaction (Lee *et al.*, 2011).

Conclusion

Locally fermented foods are produced by the various activities of microorganisms which have profound effects on the characteristics of the food. The rich microbial diversity in various sources of fermented foods reflects the fact that locally in our various homes, people do harness indigenous microbiota for spontaneous fermentation. Different microorganisms are found to have played significant roles at different stages of the fermentation of these foods.

Appropriate approaches geared towards the enhancement of the qualities of indigenous foods in Nigeria will be indispensable towards the growth and sustenance of the food industries.

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