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Essential Features of Local Food Fermentations in Nigeria

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Abstract

The essential and unique features of traditional food fermentation processes in Nigeria were reviewed. Fermentation which has been an age-long biotechnological process is still relevant in the present dispensation. Nigeria has many varieties of fermented foods whose fermentation processes remain a household art. These involve both solid state and submerged liquid fermentations. Temperature, pH, water activity and oxygen availability are all parameters that affect the rate of fermentation but their measurements are not scientifically done. Conditions are created to optimize these parameters in order to achieve proper fermentation. The effective management of these fermentation conditions results in the appropriate biomass concentrations needed for each type of fermentation which is spontaneous. Plant and animal materials form the substrate for their fermentations while the microorganisms play important roles by modifying the substrate physically, nutritionally and organoleptically. Fermentation time varies depending on the substrate, environmental conditions and the nature of product desired. Fermentation environment has often led to high variability in product quality. The fermenters are rudimentary but achieve the type of fermentation desired of a product. Fermentation handlers fall short of standard hygienic practice but the fermented foods have enjoyed a well founded safety and fair keeping quality. There is high prospect for local food fermentation in Nigeria because of high patronage and acceptance. There is however, still a need for improvement in hygiene standard in the processing environment, packaging and the use of starter culture for the fermentation processes.

Key words: Local food fermentation, Nigeria, Features, Fermentation measurements, Fermentation conditions.

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1. Introduction

Fermentation is one of the oldest biotechnologies for the production of food products with desirable properties such as extended shelf-life and good organoleptic properties [1]. There are several examples of fermentation processes which lead to an increase in nutritional value or digestibility [2] of food raw materials. Food fermentation technologies have evolved through years of experience and contributed one-third of the food consumption all over the world particularly in rural household and village communities as one of the oldest means used for food preservation. Food fermentation maintains the desirable biochemical changes and unique properties of raw materials and provides popular wholesome and nutritious food for daily diet [3]. Research on the exact statistics of the Nigeria population consuming locally fermented food products has not been carried out, but it is understood that locally fermented foods serve as a bulk of the rural population diet as well as that of the urban population as condiments forming part of their diet. Traditional fermented protein-rich foods offer excellent opportunities for improving the diets of people in tropical countries providing rich source of starch, vitamins, proteins and minerals [4]. Foods derived from fermentation are major constituents of the human diet all over the world [5]. In some regions mainly in African countries, fermentation plays important role in the nutrition of infants and young children as it is used for the preparation of complementary foods [6].

In traditional fermentation processes, natural microorganisms are employed in the preparation and preservation of different types of foods. These processes add to the nutritional value of foods as well as enhancing flavour and other desirable qualities associated with digestibility and edibility. The fermentation technologies are often characterized by the use of simple non-sterile equipment, chance inoculum, unregulated conditions, sensory flocculation, poor durability and unattractive packaging of the processed products. This is as against industrial fermentation which involves the intentional use of fermentation microorganisms such as bacteria and fungi to make products useful to humans. Some commodities contain chemicals such as citric acid, acetic acid and ethanol which are made by fermentation [7]. The rate of fermentation depends on the concentration of microorganism cells, cellular components and enzymes as well as temperature, pH and for aerobic fermentation, oxygen. Product recovery frequently involves a concentration of the dilute solution. Unique attributes of local fermentation process is mainly in the process control which varies substantially leading to variation in products quality such as inconsistent taste and aroma which are dependent on cultural background and location. Traditional process controls include the equipment use as well as the way the fermentation process is monitored locally; the temperature is monitored based on the weather condition and environmental temperature which changes the rate of fermentation. For instance, condiments are fermented locally in an enclosed environment to create enough heat required to speed up the fermentation rate. Fermented beverages are allowed to ferment naturally and local sensory evaluation is periodically carried out to ascertain the ideal alcoholic content required. 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 contribute significantly to the diets of many people [8].

These traditionally fermented food processes are regulated by some closely applied elements which are observed locally during the period of the fermentation. These elements determine the success of the fermentation process and they are often measured by norms, cultural belief, experience, as well as knowledge passed from time to time. With increasing industrialization and urbanization, efforts are presently geared towards the development of large-scale factory production facilities for these foods where the quality of the finished product will be assured [9]. Knowledge of these types of local food fermentation processes in Nigeria is often passed on from generation to generation as a household art. The aim of this review is to ascertain the elements of local food fermentation processes in Nigeria.

2. Some Locally Fermented Foods in Nigeria

Nigeria possesses unique varieties of fermented foods, whose fermentation processes remain a household art today. The fermented foods in Nigeria can be classified into groups according to the substrate or raw materials employed [10]. These fermented foods are obtained from various groups of food products such as tubers (cassava product) garri, lafun, fufu. Cereals (maize, sorghum, millet) *ogi*, *pito*, *burukutu*. Legumes (locust beans, oil bean, soy beans) *iru*, *ugba*, *okpehe*, *dawadawa*. Fruit (melon) *Ogiri*. Beverages: palm wine and finally, animal proteins (milk) *wara,* [11] (Table 1).

Table 1. Some Locally Fermented Foods in Nigeria.

Substrate	Product	Microorganism	Reference
Sorghum	*Burukutu*	*Saccharomyces cerevisiae*	[12-14]
Cassava	*Fufu*	*Leuconostoc spp.,* *Lactobacillus spp.* *Corynebacterium spp.* *Candidia tropicalis.,* *streptococcus spp.*	[14]
Maize, Sorghum	*Pito*	*Geotrichum candidium* *Lactobacillus*	[15-6]
Milk	*Wara*	*Candida* *Lactobacillus spp.* *Lactococcus spp.* *Streptococcus spp.* *Pediococcus spp.* *Leuconostoc spp.*	[17], [8], [9], [18]
Cassava	*Lafun* chips	*Propionibacter spp.* *Leuconostoc spp.* *Corynebacteriun spp.*	[14]
Castor seed	*Ogiri-igbo*	*Candida tropicalis.* *Bacillus spp.* *Pseudomonas spp.* *Micrococcus spp.*	[19-20]
Mellon seed	*Ogiri-egusi*	*Streptococcus* *Bacillus subtillis* *B. megaterium* *B. firmus* *E. coli* *Alcaligenes spp.* *Proteus pedioccus*	[21]
Locust bean	*Iru /Dawadawa*	*Bacillus subtillis* *B. licheniformis.* *Staphylococcus* *Saprophyticus*	[22-23}
Mesquite	*Okpeyei /*	*B. subtilis*	[24-26], [17]

	okpehgehe	*B. licheniformis* *Formis megaterian* *Staphylococcus epidemidis*	
Cassava	*Garri*	*Micrococcus spp.* *Leuconostoc spp.* *Geotrichum candidum* *Scolecttichum graminis* *Bacteriodes spp.* *Tallospora aspera* *Actinomyces spp.* *Passolora bacilligera* *Varicosporium species* *Lactobacillus spp.* *Culocidospora gravida* *Diplococcium spicatum*	[8-9], [18]
African oil bean	*Ugba/ukpaka*	*Bacillus subtilis* *Staphylococcus spp* *Micrococcus spp* *Corynebacterium spp*	[27-28]
Fluted pumpkin seed	*Ogiri-ugu*	*Bacillus spp.* *E. coli* *Staphylococcus spp.* *Pseudomonas*	[20], [29]
Cotton seed	*Owoh*	*Bacillus subtilis* *B. licheniformis* *B. pumilis* *Staphylococcus spp.*	[30-31]

3. Types of Fermentation

Traditionally, fermentation is carried out by the solid-state fermentation (SSF) or submerged liquid fermentation (SLF). Solid state fermentation is both economically and environmentally advantageous in that SSF cultivation can be carried out in simpler and therefore more cost effective bioreactors; the enzymes produced typically can be used directly in their crude form without need for purification or concentration steps [32]. Traditionally, due to moisture requirements, the commercial production of bacteria enzymes has been achieved by SLF, which utilizes free-flowing substrates (e.g. molasses, broth).

3.1. Solid State Fermentation (SSF)

SSF is considered a bioprocess carried out in the near absence or absence of free water; although the substrate must contain enough moisture to encourage growth and metabolic activity of the microorganisms. The solid matrix could be either the inert material to promote growth or the carbon source and other nutrients needed by the microorganisms. The solid medium comprises both the substrate and the solid support on which the fermentation takes place. The substrate used is generally composed of vegetal byproduct such as wheat bran [33-36].

Solid state fermentation typified by *garri* production, uses grated or sliced cassava pieces that are allowed to ferment while exposed to the natural atmosphere or pressed in a bag. Food condiments such as *okpehe*, *ugba/ukpaka* is produced by SSF in an enclosed environment, traditionally nylon, leaves wrap, jut sacks etc. where fermentation takes places. "*Iru*" and "*Ogiri*" are the two most important popular indigenous fermented condiments produced from legumes and oil seeds [37]. '*Iru*' is the Yoruba name for the fermented condiment produced from African locust bean (*Parkia biglobosa*) [38]. It is also known as '*dawadawa*' in Hausa and by different names among ethnic groups [39]. Both use solid state fermentation where the substrate are wrapped with leaves and allowed to ferment for days.

3.2. Submerged Liquid Fermentation (SLF)

Submerged liquid fermentation involves total or complete immersion of the substrate into water (increased water activity) in the presence of free flowing water. Most times the extract is the required product while other times the inert material is the product. *Fufu* is a submerged fermentation product that is traditionally produced as a wet paste. *Lafun* is produced by submerged liquid fermentation of peeled sliced cassava roots in water for 3 to 5 days [40] or by immersion of peeled or unpeeled cassava in a stream or stationary water or in an earthen ware vessel and fermented until roots become soft [41]. *Burukutu* is a popular indigenous alcoholic beverage of a vinegar-like flavour, consumed in the Northern Guinea Savanna region of Nigeria, Republic of Benin and Ghana [42-43]. It is mainly produced from grains of guinea corn (*Sorghum vulgare* and *Sorghum bicolor*). *Pito* is produced from local cereal such as maize, sorghum or millet and some of these are produced on a substantial scale. *Pito* production is the result of mixed lactic/ethanolic fermentation and bears a little resemblance to European style beer [44].

Varieties of grains such as millet, sorghum and maize are immersed in water for a period of 3-5 days to produce *ogi*. Palm wine is an alcoholic beverage produced from the sap of various species of palm tree such as the Palmyra date palm and coconut palm [45-46]. The white liquid that is initially collected tends to be very sweet and non-alcoholic before it is fermented by naturally occurring micro flora.

4. Fermentation Measurements

4.1. Environmental Parameters

4.1.1. Temperature

Temperature affects the rate of fermentation depending on the nature of the substrate. A rise in temperature favours a particular fermentation and may be deleterious to the others. Occasionally microbial activities in the fermentation may lead to a rise in temperature.

Industrially, oil bean is fermented to obtain ugba; temperature increases from about 30.8 ^{o}C to 34.5 ^{o}C – 38.5 ^{o}C with the first 24-36 hours of fermentation and decreases gradually afterwards to 30-32.3 ^{o}C at the end of fermentation [47, 28]. During both *fufu* and *ogi* fermentation processes the temperature of the fermenting materials increases as fermentation progresses. Locally the fermentation temperature is controlled by creating a stable atmosphere within the fermentation environment. *Ugba* is wrapped with leaves or nylon to provide slightly raised temperature above the normal environmental temperature. Usually weather conditions as well as seasonal changes affect the fermentation of *fufu*, *ogi*, *ugba*, and *lafun*. Low atmospheric temperature reduces the rate of fermentation in contrast to high atmospheric temperature which hastens the fermentation within short period of time. During the Harmattan (cold) season (14-16^{o}C) the fermentation process is enhanced traditionally by partially heating part of the steeping water before they are added to the slices of cassava tubers in case of *fufu* and *lafun* production. Sorghum for the production of *ogi* is steeped for an extended period of time to allow maximum fermentation. Another method of hastening the rate of fermentation for improved and better fermentation includes exposure to sunlight and addition of hot water during fermentation to raise the temperature within the fermentation vessel. Suitable temperatures for locally fermented foods are shown in Table 2.

Table 2. Temperatures of Locally Fermented Foods in Nigeria.

Fermented Food	Temperature	Reference
Garri	31 – 33 °C	[48]
Lafun	30 – 35 °C	[49]
Fufu	30 – 35 °C	[49]
Ogi	28 – 32 °C	[50]
Pito	28 °C	[51]
Burukutu	30 °C	[52]
Iru	35 °C	[22]
Ugba	30 – 33 °C	[28]
Okpehe	28 - 29 °C	[25]
Ogiri	29 – 30 °C	[22]
Palm wine	28 – 32 °C	[53]

4.1.2. pH

Microorganisms vary in their optimal pH requirement for growth. Most bacteria favour conditions with a near neutral pH 7. The varied pH requirements of different groups of microorganisms is used to good effect in fermented foods where successions of microorganisms take over from each other as the pH of the environment changes. For local alcoholic beverage, a fall in pH is observed by an alcoholic off flavour emitted from the fermentation system. *Garri* is produced traditionally by grating peeled cassava roots, dewatering the resultant pulp and roasting the dewatered fermented product [54]. Heat of milling before rehydration possibly inactivated more linamarase activity leading to reduced rate of HCN production. This may have permitted an earlier relief from cyanide inhibition of fermentation microorganisms [55] resulting in more acids produced and consequently lower pH. In palm wine fermentation process samples are poured out each day and passed among friends, families and relatives in form of a local sensory evaluation to test the alcoholic content depending on their acceptable limits. Same technique is applicable to *burukutu*, and *pito* fermentation to ascertain the level of acidity required by the consumers. Indigenous protein condiments are based on alkaline fermentation, the aim of the fermentation process differs from local alcoholic beverages fermentation. The pH of common fermented food in Nigeria is shown in Table 3.

Table 3. pH of Common Fermented Foods in Nigeria.

Fermented Foods	pH	References
Garri	pH 3.40 – 3.00	[56]
Lafun	pH 6.3 – 4.3	[49]
Fufu	pH 6.8 – 4.3	[57]
Ogi	pH 6.4	[50]
Pito	pH 4.2	[42]
Burukutu	pH 3.8	[42]
Iru	pH 7.9	[23]
Ugba	pH 5 – 8.7	[27]
Okpehe	pH 6.8 – 7.9	[26]
Ogiri	pH 8.1 – 6.5	[21]
Palm wine	pH 4.8 – 3.0	[53]
Wara	pH 4.6	[58]

4.1.3. Water Activity (aw)

Bacteria endospores and some fungal spores have special requirements, such as optimum aw values for initiating germination, and out growth (minimal aw for germination is usually higher than the minimum aw for sporulation). In addition, the production of secondary metabolites (toxins) is affected by aw. Therefore sporulation, germination and toxin production are affected by aw along with other environmental factors [59-60]. Locally processed staple foods, condiment and alcoholic/nonalcoholic beverages are prone to spoilage due to high water content and activity; this lead to shorter shelf life and poor storage stability. Indigenous method of production is primarily sun drying after fermentation for product like *lafun*; the final moisture content is locally estimated by splitting into halves and observing the crispiness produced. *Garri*, after fermentation, is sieved and pan fried with direct heat. Other times after partial frying they are sundried to obtain a crispy texture. *Fufu* is processed into dough of which the water content is not as low as lafun and garri. Protein condiments such as *ugba* and *Ogiri* have slightly high water activity compared to *Okpehe* and *Iru* which keeps longer than the later.

4.1.4. Oxygen Availability

Some of the fermentation bacteria are anaerobes, while others require oxygen for their metabolic activities. Some Lactobacilli in particular, are microearophillic; that is they grow in the presence of reduced amounts of oxygen. It determines the type and amount of biological product obtained; the amount of substrate consumed and the energy released from the reaction. In an ideal fermenter, oxygen availability is enhanced by agitation which is not applicable in the local fermentation system. Often, the fermentation vessels employed locally are closed while others are left open. This is typical with *fufu* fermentation as well as *lafun* fermentation where the cassava roots can be fermented in a closed container while they could also be soaked on still waters and river banks. Occasionally in extremely cold weather condition, grated cassava roots are fermented in a properly closed container to reduce oxygen availability and hasten fermentation producing a more sour taste of the *garri* product.

Traditionally, oxygen is rarely controlled as most fermentations are been opened to check the extent of the fermentation daily. *Okpehe*, *Ugba*, *Iru* and *Ogiri* are usually tied tightly in a closed environment to avoid excessive oxygen during their fermentation in order to improve their flavour and aroma which is the major purpose for their fermentation.

4.2. Carbon Cycle Variables

4.2.1. Biomass Concentration

The commonest microorganisms responsible for fermentation generally are acid-forming lactic acid bacteria (LAB) such as *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Enterococcus*, *Streptococcus*, *Aerococcus* and *Pediococcus* [61, 9, 62]. The LAB are a group of gram positive bacteria, non-respiring, non-spore forming rods and cocci from the genera *Lactobacillus*, *Leuconostoc*, *Pediococcus* and *Streptococcus* are the main species that play a key role in safety and acceptability of the product of carbohydrates in tropical climate [63]. The traditional method, although the simplest way to achieve cassava retting, involves a complex microbial process [64-65]. In a research by Ijabadeniyi [66], the mean total bacterial count in the samples of *garri*, *lafun*, and *Ogiri* were 14.3 x 10^4, 13.2 x 10^5, and 10.2 x 10^6 cfu/g respectively. The bacteria load and fungal load were highest in *Ogiri* followed by *lafun* and last by *garri*. It can be inferred that *Ogiri* was most susceptible to contamination by microorganisms which may be due to mode of preparation and handling. Inhibition of the growth of other microorganisms is a common phenomenon during lactic acid fermentation. This is indicated to be a desirable effect since the growth of these anaerobic bacteria could produce unpleasant flavours in fermented foods [67]. This trend is in agreement with the reports of Maftah *et al.*, [68] and Ogunbanwo *et al.*, [65]. In their studies, there were reductions in the survival of the enteropathogens with time, during the fermentation of sausages and cassava mash. In another similar study, a reduction in the bacterial load of steeped maize from 10^6 to 10^2 cfu/g after 24 h of fermentation had been indicated. This was attributed to the interaction among the microbial flora of indigenous fermented foods that usually caused an apparent reduction in the total bacterial counts of non-lactics [69].

During the fermentation of the cassava mash the total bacterial counts were observed to range from 1.1 x 10^7 to 1.3 x 10^8 cfu/ml while the lactic acid bacterial counts ranged from 4.0 x 10^5 to 4.1 x 10^7 cfu/ml with respect to the percentage of LAB present during the fermentation period. When compared to the total bacterial counts, the percentage of incidence was observed to range from 3.63 to 43.1%, with the lowest and highest concentrations observed at 0 h (an hour after the start of fermentation) and 96 h respectively [70]. In maize grain during the period of fermentation, the total bacterial counts ranged from 6.0 x 10^7 to 1.6 x 10^8 cfu/ml, with the lowest and highest counts observed at 0 and 72 h respectively. The lactic acid bacteria were observed to experience a steady increase with increase in the fermentation period ranging from 4.2 x 10^6 cfu/ml at 0 h to 6.3 10^7 cfu/ml 96 h [70].

4.2.2. Substrate

Fermented foods are prepared from plants and animals by processes in which microorganisms play important role by modifying the substrate physically, nutritionally and organoleptically. *Dadawa* fermentation is very similar to that of *Okpehe* prepared from the seeds of *Prosopis africana*, *Ogiri* prepared from melon seeds (*Citullus vulgaria*) and castor oil bean (*Ricirus cummunis*). *Pito* is widely consumed in Ghana and Southern Nigeria. It contains 3% alcohol [71]. *Iru* or *Dadawa*, made from washing boiling and fermenting the African locust bean seeds (*Parkia biglobosa*) according to Odebumi *et al.*, [72] and Onyenekwe *et al.*, [73] is the most important natural food condiment for flavouring soups and stew in Nigeria. *Fufu* is the fine paste obtained after peeling, slicing soaking, fermenting, grading and cooking whole cassava roots. Substrate employed in the fermentation of *fufu*, *lafun* and *garri* is cassava and is considered the highest producer of carbohydrate among crop plants despite its vast potentials. The presence of the two cynogenic glycosides, linamarin calculating for 93% of total content [74] and lotaustralin or methyl linamarin, hydrolyzed by the enzyme linamarase to release toxic HCN, is the most important problem limiting cassava utilization. In Africa, cereal grains such as maize, sorghum and millet are common substrates for producing a wide variety of fermented products. Cereal grains consist of an embryo (germ) and an endosperm enclosed by an epidermis and a seed coat (husk). Starch in the endosperm is found as granules of different sizes [75]. The germ is basically a package of nutrients (amino acids, sugars, lipids, minerals, vitamins, and enzymes) the husk mainly comprised cellulose, pentosans, pectin and minerals [76]. The grains are malted, milled and fermented to produce thin gruels and alcoholic beverages known by various names in different parts of Africa [77].

5. Properties of Fermentation

5.1. Fermentation Time

Fermentation time varies depending on the substrate and to some extent on the final product required. Traditional fermentation which is carried out in an uncontrolled condition is usually prone to changes in fermentation time. Cassava tubers fermented at high weather temperature is likely to have a shorter fermentation time compared with that at low atmospheric temperature. Cassava roots for garri production are fermented for periods ranging from 24-120 h depending on the acceptability; for eastern Nigeria they prefer the fermentation to be within 24-48 h while western Nigeria would rather ferment the root to about 72-120 h giving a more sour taste. According to a study by Meuser and Smolnik (1980) each stock of cassava mash was fermented for 72 h. Where the cassava roots are fermented for less than this period, an incomplete fermentation occur leading to hard root in which the inert material cannot be extracted properly. On the other hand where the roots are over steeped, the end product becomes too objectionable to consumers. Fermented condiments undergo different fermentation periods; *Iru*/*Dawadawa* takes 3-4 days to ferment. With a longer fermentation period the product becomes too marshy to be molded into balls. Ugba is produced from the sliced seeds of *Pentaclethra macrophylla*. These slices are mixed well with salt and wrapped in banana leaves. A three day fermentation provides the delicacy, while 5 days of fermentation produces the soup condiment [47]. *Ogiri-egusi*, *Ogiri-Igbo*, takes 3 days to ferment and *Ogiri-ugu* will take as far as 5 days to ferment. In 4-5 days *Okpiye*/*Okpehe* will complete its fermentation and *Owoh* will take 3 days to ferment. Nigeria unripen cheese (*wara*) will take about 4-5 h to ferment.

Locally, palm wine fermentation has no fixed duration; fermentation within two hours after tapping yields an aromatic wine of up to 4% alcohol content mildly intoxicating and sweet. The wine may be allowed to ferment longer, up to a day or two, to yield a stronger, more sour and acidic taste. The traditional preparation of maize

Ogi involves soaking of maize in water for 1 to 3 days followed by wet milling and sieving to remove bran and the germs [78-79, 10]. 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 (Odunfa, 1985a). *Burukutu* and *pito* after steeping for two days, fermentation is allowed to proceed for up to 5 days in a basket.

5.2. Fermentation Environment

Indigenous fermentation of *fufu* process is initiated as a result of chance inoculation by microorganisms from the environment. Although convenient, there is concern about its reliability the control of which is the basis of all technological measures. This is used to obtain product of a defined quality. The presence of unspecified microorganisms complicates the control of the fermentation process and leads to the production of objectionable odours. Such problems have led to the development of several other processing techniques suitable for odourless *fufu* [80-81]. The fermentation is controlled by several microorganisms, one of which has positive effects such as product preservation, flavour development, cyanide reduction and change in functional properties [82]. In locust bean fermentation to *ugba*, the temperature increases from about 30.8 ^{o}C to 34.5 – 38.5 ^{o}C within the first 24-36 h of fermentation and decreases gradually afterwards to 30-32.8 ^{o}C. At the end of the fermentation [47, 28] moisture content was found to increase throughout the period of fermentation (52-56.90% to 71.20-73%) [47, 28, 83]. The increase is believed to be due to the hydrolytic activities of the microorganisms. If favorable environmental condition is allowed, a particular community of microbes can determine the quality of a specific food [42].

5.3. Fermenters

Fermenters used in cassava fermentation for *fufu* and *lafun* include plastic/ceramic containers, river banks or still water by the stream. These fermenters give little or no protection against contamination or uninvited microorganisms. *Garri* fermentation is carried out in jute sack or sometimes in plastic containers before they are transferred into the bag for pressing. *Ogiri* and *Okpehe* are tied tightly in nylon to ferment or wrapped with various layers of leaves. This is done to create an anaerobic environment with enough heat locally necessary for the fermentation to be initiated. Cassava and *ugba* are fermented industrially in a bottle covered with aluminum foil which offers better protection against accidental micro-flora and other environmental sources of contamination; as compared with the locally fermented *ugba/ukpaka* which are wrapped with leaves. Palm wine fermentation is done in the keg in which they are tapped in. Wara is fermented locally in the milking vessel which is mostly calabash bowl. Experimentally they are fermented in sterile containers, nylon or bottles which are covered to limit bacteria load. Fermenters for *ogi* are mostly closed stainless or plastic containers.

5.4. Fermentation Handlers

According to Steinkraus [84-86], fermented foods have a safety record even in the developing world where foods are manufactured by people without training in microbiology or chemistry. These problems make the safety of fermented foods debatable and questionable in developing countries. Some authors have shown that *Escherichia coli*, *Salmonella enteritidis*, *Listeria monocytogenes* and *Shigella* have high survival rate in fermented foods [87]. Local handlers of fermentation processes possess little or no ability to effectively handle and control basic parameters of this fermentation leading to variation in organoleptic and sensory properties of these products in various locations. Poor knowledge of this fermentation occasionally results to growth of undesirable microorganisms which is likely to alter the fermentation sequence. Cassava and its products, like other food materials, have the potential for supporting the growth of both pathogenic and spoilage microorganisms [88]. The microorganisms can be introduced directly from handlers or the environment during processing, transportation, storage and hawking.

5.5. Safety of fermented foods

Fermented foods are treasured as major dietary constituents in numerous developing countries because of their keeping quality. Undue ambient conditions enhance nutritional quality and digestibility, improve food safety, and are traditionally acceptable and accessible [89-90]. In a research by Martin and Robert [91], food fermentation has a long tradition of improving the safety, shelf life and acceptability of foods. Although fermented foods generally enjoy a well-founded reputation for safety, some notable outbreaks of food/borne illnesses associated with fermented foods have occurred. Microbiological risk assessments (MRA), as it has emerged in recent years, provide the scientific basis for the control and management of risk. Aspects of fermented food processes are discussed under the various stages of risk assessment and data are presented that would inform more detailed risk assessments. Reyhan and Gamze [92] revealed that the presence of probiotic bacteria such as the consumption of live lactic acid bacteria (LAB) included in lactic acid fermented foods has been a regular part of the food intake of humans for a long time. Lactic acid is the simplest and often the safest way of preserving food. They also made mention that "probiotic bacteria" can colonize and proliferate in the intestinal track of humans and animals to prevent the growth of intestinal pathogens.

5.6. Prospect of Local Food Fermentation in Nigeria

The microbiological safety of the fermented foods examined 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 [17]. In oil bean fermentations of the developing countries, this type of starter cultures will enhance process standardization and uniform product quality [93]. It will also eliminate the chances of contamination by potential food poisoning and other disease causing and spoilage microorganisms. Undoubtedly, one of the improvements in the future will be the use of starter cultures that have been genetically engineered. The development of such strain with better and stable genetic properties is a challenge to microbiologist. These may offer nutritional benefits in the form of increased protein production as well as compatibility of multistrain fermentations carried out under non-sterile conditions [94]. The fermentation process for condiment production is still being carried out by the traditional village-art method. There is need to apply modern biotechnological techniques like the use of starter cultures in improving traditional food processing technologies [8]. Selection of starter cultures for large-scale industrial processes may require genetic modification to introduce a number of properties. These may offer nutritional benefit in the form of increased protein production or compatibility to mixed culture fermentations. Fermented condiments have a characteristic organoleptic quality, which probably are the most important factors for consumers. There are few data on the flavour components of fermented condiments and how this can be improved by fermenting microorganisms [95]. It has been suggested that most fermentation processes could be improved by using starter cultures, and also by back slopping, which entails application of brine from prior fermentation cycle [89, 96]. Starter cultures have been found to reduce fermentation time as well as guarantee product quality. In the traditional method of manufacturing, the fermentation of the legume seeds is achieved by indigenous micro flora or the addition of fermented material from a previous production through back slopping. Thus, it may be assumed that undefined starter cultures have traditionally been employed in the manufacture of these products [97-100, 95].

6. Conclusion

Fermented beverages, staple foods, and condiments serve as a source of food for millions of people in Nigeria. Food is fermented in various locations according to various cultures and beliefs. It is usually accompanied by uncontrolled elements and parameters such as temperature, pH, time, biomass concentration, substrate, oxygen availability, fermenters, and water activity environment. Proper knowledge of these processes by the handlers is paramount. This review proposes proper knowledge of the essential elements of local fermentation processes in order to improve on these processes for a better quality product and enhanced keeping quality. Each elements of local fermentation has a way which they are measured locally to achieve a product best desired by these local fermentation handlers.

7. Conflicts of Interest

The author(s) report(s) no conflict(s) of interest(s). The author along are responsible for content and writing of the paper.

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