Nigerian indigenous fermented foods: their traditional process operation, inherent problems, improvements and current status

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Nigerian indigenous fermented foods (NIFF) are reviewed in this report outlining their traditional status as well as any significant scientific and/or technological steps or modifications introduced towards developing them to the status of modern processed food. The NIFF consist of a wide range of products sourced from cereals ('burukutu', 'pito', 'kwunu', 'ogi', 'otika'), fruits ('agadagidi', cacao wine, 'eketeke', 'ugba'), legumes ('daddawa', 'iru', 'ogiri', 'ogboroti'), tubers ('abacha', 'elubo', 'fufu', 'gari', 'loiloi', 'kokobele'), tree sap ('ogogoro', palm wine), meat and seafoods ('afonnama', 'azu-okpo', 'nsiko', 'oporo'), and milk ('maishanu', 'nono', 'warankasi'). The problem inherent in the technology of their process operations forms part of the characteristic features of the traditional family and/or ethnic method of fermenting local staples. These were found to result from the following limitations associated with different aspects of indigenous fermentation processes, thus: a production environment which fails to observe good manufacturing practice (GMP) or code of hygiene; lack of knowledge of the process(es) and their characteristics; absence of any control in that the processing variables like pH, temperature, humidity, and quality of water were then unknown and were unable to be used to regulate the process; lack of awareness of the nutritional and/or toxicological implications of fermentation and its products. Development came up as results of assessing the characteristics of the NIFF systems with a view to improving on the equipment, substrates, culture as well as process control and product quality. These efforts have yielded a reduction in the duration of fermentation, and emergence of products that were free of health risks and which were of consistent quality capable of mass production through the use of mechanized equipment and sterile packages. These include 'dadawa' cubes, bottled palm wine, packaged dry cassava flours, 'gari', 'soy-ogi' and palm oil. Copyright © 1996 Published by Elsevier Science Ltd on behalf of the Canadian Institute of Food Science and Technology

Keywords: Nigerian indigenous fermented foods, traditional process operations, inherent problems, research, assessment, microbiology, process control, nutritional, toxicological, improvement, development, current status.

1. INTRODUCTION

Chemical changes in foods brought about by enzymes from living microorganisms constitute fermentation. It has been established that there are nutrient-rich crops in Nigeria which are fermented and used as foods or as food condiments (Collard & Levi, 1959; Akinrele, 1970; Ekundayo, 1977; Onyekwere, 1977; Ogundiwon, 1978a,b; Tehine & Ogundiwon, 1978; Achinewhu, 1983a,b; Kuboye, 1985; Odunfa & Oyeyiola, 1985; Pierson et al., 1986; Uzogara et al., 1990).

Generally, these crops are not used as foods in their unfermented state because some of them contain toxic or anti-nutritional factors. Fermentation leads to a general improvement in the shelf life, texture, taste, aroma, as well as nutritional value (Kuboye & Akinrele, 1977; Odunfa & Oyeyiola, 1985; Uzogara et al., 1990).
The Nigerian indigenous fermented foods (NIFF) constitute a group of foods that are produced in homes, villages and small scale cottage industries. They are sold to the rural populace who buy them for food and social ceremonies. The fermented foods are derived from substrates like roots, legumes, cereals, oilseeds, nuts, meat, fish, milk, palm tree, sap, etc. (Oguntunde, 1989; Uzogara et al., 1990; Akohundu & Iwuoha, 1992).

In the distant past, there were no verified data on the economic, nutritional, technical and quality control implications of the NIFF. Only recently have food technologists, human nutritionists, microbiologists and other applied scientists carried out multi-faceted, complementary studies on NIFF so that developments can be achieved.

The aim of the present paper is to present the NIFF in their traditional preparation and uses and to discuss significant scientific or technological steps or modifications introduced in NIFF towards improvements and/or advancements which contribute to development.

2. INDIGENOUS FERMENTED FOODS IN NIGERIA

2.1. Classification and processing methods

Nigerian indigenous fermented foods (NIFF) can be classified according to the food groups from which they were derived.

2.1.1. Plant-based

The plant-based fermented foods consist of those sourced from cereal, legumes, fruits, tree crops and root and stem tubers.

2.1.1.1. Cereal-sourced

(a) *Pito* and *Burukutu*

‘Pito’ is a cream-coloured liquor while ‘Burukutu’ is a brown-coloured suspension. Both are brewed concurrently by fermenting malted or germinated single cereal grain type or a mixture of grains.

The method is thus: Soaking the grains for 1 day, draining of soak water, germinating for 2 days, sun-drying, milling into flour, mixing the flour with water, boiling for 3-4 h to form slurry, settling and decanting, addition of fresh water and re-heating for 3 h. The mixture is allowed to stand at room temperature for 24 h. More water is added and the mixture is reheated for 3 h. Cooling and separation follow. A supernatant and sediment are obtained which are allowed to ferment for 1 day at room temperature resulting in ‘pito’ (top clear supernatant) and ‘burukutu’ (a thick brown suspension), (Ekundayo, 1969, 1977; Faparusi et al., 1973; Uzogara et al., 1990).

(b) *Kwame-zaki*

This is a watery gruel made from fermented millet paste and is very popular in northern Nigeria, where it serves as a breakfast dish.

To prepare it, the millet (*Pennisetum typhoideum*) is ground in a mortar and pestle to remove the husk or testa and release the kernels. The kernels are washed and left to dry on a mat out in the sun. The dried kernels are ground into flour, which is then suspended in a little cold water and stirred into a pot of hot water — continuous stirring is effected until a thick smooth paste is formed. The paste is left to ferment and cool to ambient temperature for 1-3 days, which leads to the development of a sour flavour (Uzogara et al., 1990).

(c) *‘Ogi’*

This is a fermented cereal gruel. Its porridge has a smooth texture and a sour taste reminiscent of yogurt, with a characteristic aroma (Umoh & Fields, 1981). Steinkraus (1983) quoted Banigo (1977) and Onyewere & Akinrele (1977a) as reporting that the colour of ‘ogi’ depends on the cereal grain used for its production: cream-white for maize (*Zea mays*), reddish-brown for sorghum (*Sorghum vulgare*), dirty grey for millet. It serves as a weaning food all over Nigeria (Akinrele & Bassir, 1967; Banigo & Muller, 1972b; Okoli & Adeyemi, 1989).

The method of traditional Nigerian ogi production was reported by Steinkraus (1983) as described by Banigo et al. (1974). The cereal grains of interest are steeped in earthenware, plastic or enamel pots for 1-3 days to ferment. The fermented grains are wet-milled and wet-sieved to yield the ogi slurry. In some communities there is a further optional fermentation for 1-3 days after wet-sieving.

(d) *‘Otika’*

‘Otika’ is an alcoholic beverage traditionally brewed from sorghum malt and drunk in some parts of Nigeria (Tehinse & Ogundijin, 1978).

The production method is thus: grains of the red variety of guinea corn or sorghum (*Sorghum guineense*) are malted as in the ‘pito’ production. Mortar and pestle are used to mill the malted sorghum into flour. The flour is suspended in water and boiled for at least 3 h, cooled and filtered. The filtrate is left at the prevailing room temperature to ferment for 3 days (or it may be inoculated with liquor from a previous ferment). The fermented beverage is again filtered using ‘ogi’ sieve cloth prior to consumption.

2.1.1.2. Fruit-sourced

(a) *‘Agadagidi’*

This is a fermented beverage prepared from soft, over-ripe banana/plantain.

The preparation method, according to Uzogara et al. (1990) and Abiose & Adejefi (1992), involves packing of peeled, sliced plantains/bananas in an earthenware pot and covering with water. The pot is covered tightly and allowed to ferment at room temperature for a period of 1-5 days after which the juice is strained and...
used as a drink, ‘Agadagidi’, especially in southwestern Nigeria.

(b) Fermented cocoa sap
This is a common traditional alcoholic beverage produced from cocoa sap, drunk in Cross River State, Oyo, Ondo and Ogun States of Nigeria.

According to Uzogara et al. (1990), the preparation simply involves: cutting open ripe cocoa pods (Theobroma cacao), the seeds of which, with their surrounding sugary pulp, are collected and placed in porous raffia baskets and covered with leaves. They are left to ferment for 5–6 days. The fleshy cocoa pulp solubilizes and the seeds are released; the sap (from the pulp) drips from the porous baskets into a calabash/earthenware pot from where it is later consumed as a refreshing drink.

(c) ‘Eketeke’
This is fermented palm oil which is traditionally used in the preparation of ‘ugba’ (fermented African oilbean seeds) salad.

Production of ‘eketeke’ involves placing the freshly-harvested oil palm bunches in a shade, covering completely with leaves for 1 week to ferment. The fruits are removed, cleaned and pounded into a cake in a mortar and pestle. The cake is dry-heated in an open cast iron pan, and finally pressed to release the slightly ‘rancid’ fermented oil, having characteristic flavour (Uzogara et al., 1990).

(d) ‘Ugba’
‘Ugba’ refers to fermented oil bean (Pentaclethra macrophylla) seeds which are utilized by the Ibo and some other ethnic groups in southern Nigeria as a delicacy and soup flavouring (Ikenebomeh et al., 1986).

The processing of the large brown glossy seeds of the African oil bean to obtain ‘ugba’ involves the following: oil bean seeds are boiled in water in a metallic pot over an open fire for 4–12 h to soften the hard brown testa (called the shell). The shells are removed and the kernels are washed. The kernels (cotyledons) are boiled in water overnight over a low flame, allowed to cool, drained, and washed with cold water several times. The washed cotyledons are cut into long thin slices. These slices are mixed with salt, wrapped in small packets with leaves and lightly tied. These are placed in a basket to ferment at room temperature for 2–5 days to yield ‘ugba’. A three-day fermentation provides the delicacy, while 5 days of fermentation produces the soup condiment (Odunfa & Oyeyiola, 1985; Pierson et al., 1986).

‘Ogiri-ugba’, is a food condiment prepared from 3-day fermented oil bean seeds described earlier. To prepare this, according to Uzogara et al. (1990), the fermented slices are pounded/blended into a meal and mixed until a creamy paste is produced. Some charcoal powder is added (optional) to impart a black colour, and the paste is wrapped in small portions with blanched banana leaves, placed in a raffia basket and hung above the fireplace in the kitchen. After 2–8 h the leaves are unwrapped and salt is added, the wraps are replaced and fermentation is allowed for 1 day after which ‘ogiri-ugba’ is ready for use as a soup flavouring.

2.1.1.3. Legume and seed-sourced

(a) ‘Daddawa’
‘Daddawa’ is a fermented soya bean (Glycine max Merrill) product used as a food condiment in northern Nigeria, especially Abuja, Benue and Plateau States.

Its production is described by Uzogara et al. (1990) thus: soya beans are sorted, cleaned and washed in water then soaked in water overnight. The seed coats are removed and the cotyledons washed. The cotyledons are boiled in water in an earthenware or aluminium pot for 2–3 h after which excess water is decanted. The boiled kernels are placed inside a calabash container lined with blanched plantain leaves which are also used in covering the seeds. This is left to ferment at room temperature for up to 5 days. It may also be wrapped in small flat portions and smoked prior to pounding into flour for use in soup or stew.

(b) ‘Iru’ (‘Dawudawa’)
‘Iru’ (Yoruba) (‘Dorowa’ (Hausa), ‘Ogiri-igala’ (Ibo)] is an important food condiment and protein source produced from the fermented African locust bean (Parkia filicoides Welw) (Campbell-Platt, 1980; Odunfa, 1981a; Ikenebomeh et al., 1986).

According to Odunfa (1985a), Steinkraus (1985) and Uzogara et al. (1990), ‘Iru’ is produced thus: locust bean seeds are boiled for between 12 h and 2 days to soften the hard seedcoats after which they are dehulled by hand or by gentle pounding. The separated cotyledons are boiled in water with ‘kanwu’ (potash) for 2 h to soften them. The boiled cotyledons are spread in a raffia basket lined with blanched banana leaves and the cotyledons are covered with several layers of banana leaves and left to ferment for 2 to 3 days at the prevailing temperature of the day. Wood ash may be added. The fermented product is then sun-dried for 1–2 days yielding a dark brown or black product. Alternatively, before use, the sun-dried mass can be made into a paste of varying shapes and textures depending on the custom of the ethnic group consuming it.

(c) ‘Ogiri-egusi’
‘Ogiri-egusi’ is a condiment prepared from melon (Citrullus vulgaris Schrad) seeds through fermentation. It is used as a flavouring in sauces, soups and stews in eastern Nigeria (Achinewhu, 1987b).

The preparation method as reported by Steinkraus (1985). Iwuoha & Onuoha (1988) and Barber & Achinewhu (1992) involves the following: melon seeds (dry) are moistened and dehulled. The cotyledons are then boiled for 2–3 h, the boiled seeds are wrapped tightly in layers of blanched plantain leaves, and left to ferment at the prevailing ambient temperature for 3–5 days. At the end of the fermentation period, the seeds are ground into a paste with ash from burnt oil palm leaves and
palm shaft is added to impart a grey colour to the paste. The paste is distributed in small portions into leaves, wrapped up and left near the hearth (fireplace) until the unique (characteristic) aroma of 'ogiri-egusi' develops.

(d) 'Oghororit’’Agbaratit’
This is fermented African oil bean—melon mix used as soup flavouring or as delicacy when boiled.

According to Uzogara et al. (1990), the preparation is effected thus: oil bean seeds and melon seeds are fermented separately for 3 days. Equal measures of the two are mashed together to make a paste. The paste is distributed in small portions into leaves which are wrapped and placed near the fire for proper flavour development, giving rise to 'ogboroti'.

(e) 'Ogiri-isi'
This is also known as 'ogiri-igbo' and 'ogiri-agbor' (Odunf, 1985a). It is a condiment prepared from fermented castor seeds (Ricinus communis) and used in soups and stews in eastern Nigeria (Achinewhu, 1987a).

The preparation according to Anosike & Egwuatu (1981) and Uzogara et al. (1990) is thus: the castor seeds are dehulled, the dehulled seeds are wrapped in blanched plantain leaves and boiled in water for 6–8 h. The boiled seeds which are still wrapped in the leaves are left for 4–6 days to ferment. Later the seeds are mixed with ash from burnt palm leaves and then ground into a paste. The resultant paste is re-wrapped and left for another 3 days near the fire to develop the characteristic flavour (aroma) of 'ogiri-isi'.

(f) 'Ogiri-ugu'
This is also referred to as 'ogiri-nwan'. It is the fermented product from fluted pumpkin (Telfairia occidentalis) beans. It is produced and used as a soup flavouring in southeastern Nigeria (Odunfa, 1985; Achinewhu, 1987a).

The production of 'ogiri-ugu' involves extraction of bean seeds from the pod, boiling for 2 h in water to soften the seedcoat after which the dark coloured water is discarded. The cotyledons are washed and placed in a pot, covered and left near the fireplace for 2 days to ferment and soften. They are then ground into a paste, wrapped in small portions in leaves and placed near a fire until used (Uzogara et al., 1990).

2.1.1.4. Tree sap — sourced
(a) 'Ogogoro' ('Kaikai')
'Ogogoro' is a highly alcoholic liquor obtained through the distillation of fermented palm wine (Kuboye, 1985; Uzogara et al., 1990).

According to Uzogara et al. (1990) the sap tapped from the various palm viz: raphia palm (Raphia hookeri, R. vine-jera) and oil palm tree (Elaeis guineensis) (Kuboye, 1985), is fermented under the prevailing ambient temperature of the room for 7 days before distillation. The distillate is 'ogogoro'.

(b) Palm wine
Palm wine is the fermented sap of palm trees, either raphia palm ('mmanya-ngwo') or oil palm ('mmanya-nkwu') (Uzogara et al., 1990; Uzochukwu et al., 1991).

According to Kuboye (1985) and Uzogara et al. (1990), the palm sap is obtained by the tapping of the inflorescence of these palm trees. The sap is left to ferment for a few hours and the fermentation is complete in about 2 days, giving rise to a milky suspension of microorganisms in a fermented sap that tastes sour and harsh.

2.1.1.5. Tuber — sourced
(a) 'Abacha'
'Abacha' or 'Akpu-mmiri' refers to wet cassava chips consumed as a popular snack in southeastern Nigeria.

To prepare 'abacha', the cassava root tubers (Manihot esculenta Crantz) are washed, peeled, boiled in water for about 1 h and cut into longitudinal slices or chips. These chips are steeped in water for 1–2 days during which the water may be changed once or twice. At the end of the fermentation (during which the taste of the chips becomes almost bland), the chips are finally washed two or three times with fresh cold water. An alternative handling for long term storage is to dry the chips under the sun for several days (Uzogara et al., 1990).

(b) 'Efubo'
This is also called 'lafun' (Kuboye, 1985; Uzogara et al., 1990). It is a fermented cassava dry flour commonly consumed in the western states of Nigeria.

The production involves peeling of cassava roots, washing and cutting into chunks. The chunks are soaked in water in pots or at edges of stream and left for 3–4 days to ferment and soften. At the end of fermentation the softened chunks are dried under the sun for 2 days, ground and sieved to produce 'lafun' or 'elubo' (Uzogara et al., 1990).

According to Kuboye (1985), another method involves soaking of cassava roots to ferment after which they are peeled, dewatered, sun-dried, milled and sieved to yield 'lafun'.

(c) 'Fufu'
'Fufu' (also called 'utara akpu') is the meal of soaked fermented cassava roots which is widely consumed in eastern Nigeria.

The production is effected thus: the tubers are peeled, washed, cut into thick chunks and steeped in water in earthenware pots or in a slow-flowing stream for 4–5 days to ferment, soften and produce a characteristic of retted cassava meal. The tubers are disintegrated in clean water, sieved and allowed to settle for decantation of water. The sediment is the 'fufu' (raw) which can be consumed by hydrothermal gelatinization to form stiff dough (Hahn, 1989; Uzogara et al., 1990).

(d) 'Gari'
'Gari' is a granular starchy food made from the bitter variety of cassava root (Manihot utilissima Pohl; M.
esculenta Crantz) tubers by fermenting the grated pulp, followed by semi-dextrinizing, drying, and grading (Ogunsua, 1977; Okafor, 1977a; Onyekwere & Akinrele, 1977b). It is popular among Nigerians, especially in the south (Uzogara et al., 1990).

The traditional gari production procedure involves peeling of cassava roots, grating into fine pulp using aluminium sheets perforated with nails and fixed on wooden frames. The grated pulp is placed in Hessian sacks which are tied up and compressed with heavy stones or wood. The sacks are left outside or under a shed to drain and ferment for up to 4 days. The fermented pulp, which is semi-dry and harsh to taste, is sifted using hand-made fabrics, and the finer grains are toasted (with or without palm oil) on shallow cast iron pans heated on an open fire, sifted again and packaged (Collard & Levi, 1959; Okafor, 1977a; Onyekwere, 1977; Kuboye, 1985; Steinkraus, 1985; Hahn, 1989; Uzogara et al., 1990).

(e) ‘Loi-loi’
‘Loi-loi’ is a kind of ‘fufu’ which is popular among the Riverine States of Nigeria, especially Rivers, Cross River and Akwa Ibom States.

The preparation is thus: cassava roots are peeled, washed, and soaked for 2 days in water to partially soften and ferment them. The roots are then ground into a paste using the village mill. The paste is mixed with fresh cold water and left to ferment for 1 day. Sieving is carried out to obtain a crude starch suspension. This is put into a cloth bag and dewatered resulting in starch which can be dispersed in a little cold water and stirred into hot boiling water until a smooth paste (stiff dough) is formed to produce prepared ‘loi-loi’ (Uzogara et al., 1990).

(f) ‘Kokobele’
This is a dried flour derived from fermented cocoyam tubers — the tannia variety (Xanthosoma sagittifolium). It is usually reconstituted in water and boiled with pepper, tomatoes, palm oil, fish and spices to enhance its flavour. It is a common food in Ondo State in western Nigeria.

It is produced thus: the cocoyam tubers are peeled, washed, sliced and steeped in water at room temperature, and left to ferment for 2–3 days. At the end of fermentation the steep liquor is drained off and discarded while the cocoyam slices are sun-dried for 3–5 days and then milled into flour, giving rise to ‘kokobele’ (Uzogara et al., 1990).

2.1.2. Animal- and seafood-based
The animal- and seafood-based foods are made up of the fermented foods sourced from flesh and milk.

2.1.2.1. Flesh-sourced
Meat and fish products with strong smells resulting from fermentation are used as soup flavouring and in certain other dishes along the coastal areas of southern Nigeria, as well as the Lake Chad area of northern Nigeria.

The processing varies but basically consists of hanging the product at the prevailing tropical climate as conditioning prior to preparation for final consumption or spreading in a thick heap to dry for 1–5 days, during which fermentation takes place resulting in the development of a characteristic aroma. Examples of products produced from this process are beef tripe (‘afo-nnاما’), fish (‘azu-okpo’), crab (‘nisko’), crayfish or shrimp (‘upon’ or ‘oporo’) (Uzogara et al., 1990).

2.1.2.2. Milk-sourced

(a) ‘Maishamun’ and ‘Nono’
These are the soft butter and cheese, respectively obtained from fermented cow’s milk, common in northern Nigeria.

Fresh raw milk from cow is boiled for up to 3 h and allowed to stand for 1 day at room temperature inside a calabash pot. Butter floats on top of the suspension while sediments (cheese) are also obtained after decantation. The soft butter is ‘maishanu’ while the cheese is moulded to give ‘nono’ (Uzogara et al., 1990).

(b) ‘Warankasì’
This is a soft unripened cheese obtained by fermenting milk from either goat or cow. This food is popular among the Fulanis.

According to Ogundiwin (1978b), Uzogara et al. (1990), and Fashakin & Unokwedi (1992), ‘warankasì’ is produced thus: milk is manually drawn from the animal udder and mixed with some drops of the juice from the leaves, buds or stems of the sodom apple plant (Calotropis procera). The mixture is allowed to sour by a natural fermentation at ambient temperature for over 12 h. The fermented mixture is heated gently for 40–75 min during which the contents form a junket. This is allowed to ‘break’ or form a streak on the surface scum which is carefully removed with a calabash scoop and the white curd is exposed. Intensified heating is carried out to stop the (enzyme) activities, to allow for flavour development and texture formation in the finished product. The resulting ‘wara’ is put into moulds and the whey is allowed to drain off for a few minutes. The carrot-shaped cheese is thrown back into its whey from where it is consumed.

Table 1 shows the distribution of NIFF in Nigeria at a glance.

2.2. Problems associated with Nigerian indigenous fermented food (NIFF)

A critical view of the NIFF as they are used in traditional family or ethnic arts reveals that the production processes are laden with problems.

The problems can be considered in the categories of production environment, microbiology in processing, process control, and nutritional and toxicological status.
Table 1. Distribution* of indigenous fermented foods (NIFFs) in Nigeria

<table>
<thead>
<tr>
<th>Class of foods</th>
<th>Specific food sources</th>
<th>Indigenous places</th>
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<tbody>
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<td>Cereals</td>
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<td>North, Mid-West</td>
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<td></td>
<td>Ogi</td>
<td>East, West</td>
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<tr>
<td>Fruits</td>
<td>Agadagidi</td>
<td>South-West</td>
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<td></td>
<td>Cacao wine</td>
<td>South-East, West</td>
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<td></td>
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<td>South</td>
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<tr>
<td>Legumes</td>
<td>Iru (Dawadawa)</td>
<td>North</td>
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<td></td>
<td>Daddawa</td>
<td>Middle belt</td>
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<td></td>
<td>Ogiri-egusi</td>
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<td></td>
<td>Ogiri-isi</td>
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<td></td>
<td>Ogiri-ugu or Ogiri-nwan</td>
<td>South-East</td>
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<tr>
<td>Tree sap</td>
<td>Palm wine</td>
<td>South</td>
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<tr>
<td>Tuber</td>
<td>Gari</td>
<td>South, North</td>
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<td></td>
<td>Fufu</td>
<td>East</td>
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<td></td>
<td>Lafun</td>
<td>West</td>
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<td></td>
<td>Abacha</td>
<td>East, South-East</td>
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<td></td>
<td>Elubo</td>
<td>West</td>
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<td></td>
<td>Loiloi</td>
<td>Riverine States</td>
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<td></td>
<td>Kokobele</td>
<td>West</td>
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<tr>
<td>Flesh</td>
<td>Afonnama</td>
<td>East, Mid-West</td>
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<tr>
<td></td>
<td>Azu-okpo</td>
<td>South</td>
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<td></td>
<td>Nsiko</td>
<td>South</td>
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<tr>
<td></td>
<td>Uponi or Oporo</td>
<td>South</td>
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<tr>
<td>Milk</td>
<td>Maishanu and Nono</td>
<td>North</td>
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<td></td>
<td>Warankasi</td>
<td>North (Fulani)</td>
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*The places listed are birthplaces for the arts of production and predominant utilization but inter-ethnic/state trades and relocation have widened the scope of the spread of each NIFF throughout the country and beyond.

2.2.1. Production environment

In our traditional setting where the production level is that of subsistence housekeeping, the processing environment is very unpredictable: the equipment used is rudimentary (calabash, earthenware, leaves, baskets and cloth), the hygiene of handlers, equipment and facilities is not checked, the water used, especially at the edges of streams cannot be said to be potable; tropical climate (temperature and humidity) cannot be said to be the optimum for all fermentation and storage purposes. All these factors affect the quality of final product and the health of ultimate consumers.

2.2.2. Microbiology of process

A lot of the information was flawed — there was no way to assure a consistently uncontaminated environment for the fermentation: the microbial composition of the inocula was unknown — identification of type, the identity of the contaminating microbes, the age and purity of each culture, the predominant microbes, and the conditions of pH, temperature, ionic strength, information on foods that best favoured the microbial performance in fermentation.

2.2.3. Process control

In view of the limitations in NIFF as outlined in section 2.2.1 above, and also because there was no scientific protocol in food process operations, the practice of process control was virtually impossible to maintain. Fermentation periods were chosen according to human judgement. The quality and quantity of water and substrate to be used was not regulated or standardized, heating processes were not controlled or measured. All the above-mentioned factors resulted in inconsistent quality.

2.2.4. Nutritional toxicological status

The lack of knowledge or information on the effect of fermentation on the nutritional quality of the final products stood as a problem in that consumers were unaware of the actual nutritional worth of the foods except the organoleptic attributes. Also the type and degree of danger posed by the consumption of fermented products which are unfit for human consumption due to the handling process or post-fermentation contamination were not known. Any death resulting from these above-named sources could not be established conclusively.

2.2.5. Basic food preservation ethics

Local processing centres will have to be established in order to control or forestall the inherent problems (2.2.1–2.2.4) and their perpetuation. At the moment, health personnel from some government hospitals from time to time organise good manufacturing practice
(GMP) and basic hygiene workshops for the women and girls who engage in street foods trade and sell NIFFs and other ‘ready-to-eat’ foods (Oguntunde, 1989) in school premises. The impact of this training is not far-reaching because it does not touch all the diverse NIFFs being distributed to consumers and the staff involved are not grounded in food processing technology. They are mostly home economists, medical microbiologists and dietitians.

3. IMPROVEMENT IN THE NIGERIAN INDIGENOUS FERMENTED FOODS

The advent of education, training and specialization affecting some Nigerians and other interested foreign nationals in the fields of food microbiology, food science, biochemistry, human nutrition, fermentation technology, food processing and related fields coupled with very little data on the significance of Nigerian indigenous fermented foods (NIFF) led to the modern development in this area of traditional food processing and preservation technology.

These new food researchers set out to carefully identify methods involved in fermentation and the features of the original/traditional treatment and uses of the NIFF as well as the problems associated with those foods (see section 2 above). The next efforts were to study the indigenous fermentation processes in order to assess the characteristics (Table 2) with a view to introducing systematic modifications with resulting improvements in various aspects of the NIFF technology (Table 3).

3.1. Scientific evaluations of characteristics of NIFF processes

Systematic studies have been carried out over the years to evaluate the characteristics of the cultures involved in NIFF (Table 2). Also the biochemical, nutritional and toxicological changes in the food systems brought about by fermentation have been assessed.

3.1.1. Microbial assessments


3.1.2. Assessments of the biochemical and related changes

Research on biochemical and related changes in NIFF have been conducted by several workers concerning different food groups.

Cereal-based: the production of lactic, acetic and butyric acids (the main acids contributing to the desired flavour or sourness of ogi) have been found to be directly effected by Lactobacillus plantarum, the predominant organism in the fermentation (Banigo & Muller, 1972a). During fermentation, hydrolysed starch of maize is converted to organic acids at reduced pH (Akinrele, 1970).

When the ‘otika’ wort was separately inoculated with cultures of baker’s yeast (Saccharomyces cerevisiae), brewer’s yeast (S. carlsbergensis) and palm wine turb, all samples reached < 50% attenuation in less than 30 h (Tehinse & Ogundiwin, 1978).

Fruit-based NIFF: results of gas-liquid chromatographic (GLC) analysis of ‘Agadagidi’ process showed that methanol was formed and predominated in the first 2 days but was replaced by ethanol from the third to the last (5th) day of the fermentation.

In the production of cacao wine, Adesioye (1991) observed that cocoa pod (fruit) juice containing 18.6% soluble solids, yielded up to 10.5% alcohol (v/w) at the end of fermentation even when Saccharomyces spp isolated from oilpalm sap or cashew juice were used.

During ‘ugba’ processing, fermentation was found to cause reduction in its minerals (Ca, Mg, K and P) contents (Achinewhu, 1983a), effect substantial increase in thiamin (vitamin B1), riboflavin (B2) and niacin (Achinewhu & Ryley, 1986) and also increased the protein content (Achinewhu, 1983b: Iwunha & Ike, 1991). Soluble nitrogen increased, total unsaturated fatty acids increased (Achinewhu, 1986), which aided hydrolysis of protein, leading to increase in pH from 5.0 to 8.7 (Pierson et al., 1986). Alpha-amylose, proteolytic and lipolytic enzymes activities (which reached a maximum at 24–36 h) were found to relate to changes in the chemical composition of ‘ugba’ (Njoku & Okemadu, 1989).

Legume-based NIFF: a sequence of microbial succession has been reported in ‘daddawa’ processing: Bacillus spp were consistent throughout while Staphylococcus spp occurred only during the last 3 days of fermentation (Popoola & Akueshi, 1985). Achinewhu (1978a) observed that niacin, riboflavin and thiamin were produced during the fermentation of fluted pumpkin (‘ogiri-ugui’), and castor seeds (‘ogiri-ii’). Also Achinewhu et al. (1991) reported that free amino nitrogen (FAN) and total microbial counts increased during fermentation of melon seeds (‘ogiri-egusi’) and were at their maximum at 35°C. 1% NaCl and 43-2% moisture. Barber and Achinewhu (1992) reported that in ‘ogiri-egusi’, fermentation effected pH increase from 6.5 to 8.1 and that a combination of Bacillus sp and Alcaligenes sp is capable of producing the quality characteristics of a good ‘ogiri-egusi’: that beyond the maximum titratable acidity (which occurs at 35°C about the 1st day), it decreases by as much as 27-42% at the 7th day.
Table 2. Predominant microbes involved and their optimal conditions for activity in the Nigerian Indigenous Fermented Foods (NIFF)

<table>
<thead>
<tr>
<th>Class of foods</th>
<th>NIFF</th>
<th>Predominant microbes involved</th>
<th>Optimum conditions for performance/fermentation</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ogi</td>
<td><em>Lactobacillus plantarum</em>, <em>Streptococcus lactis</em>, <em>Saccharomyces cerevisiae</em></td>
<td>pH 6.35-3.42, 1-3 days, 27°C ± 1°C</td>
<td>Banigo &amp; Muller (1972a), Banigo et al. (1974), Fields et al. (1981), Odunfa (1985a)</td>
</tr>
<tr>
<td></td>
<td>Cacao wine</td>
<td>Yeast</td>
<td></td>
<td>Odunfa (1985a)</td>
</tr>
<tr>
<td></td>
<td>‘Daddawa’</td>
<td><em>Bacillus spp</em>, <em>Staphylococcus spp</em></td>
<td>4 days, 37°C ± 2°C</td>
<td>Popoola &amp; Akueshe (1985)</td>
</tr>
<tr>
<td></td>
<td>‘Ogiri-egusi’</td>
<td><em>Bacillus subtilis</em>, <em>B. megaterium</em>, <em>firmus</em>, <em>Escherichia</em>, <em>Proteus</em>, <em>Pediococcus</em> &amp; <em>Acaligenes spp</em></td>
<td>3 days, pH 8.1-6.5</td>
<td>Odunfa (1981b), Barber &amp; Achinewhu (1992)</td>
</tr>
<tr>
<td></td>
<td>‘Ogiri-isi’</td>
<td><em>Bacillus spp</em>, <em>Pseudomonas spp</em>, <em>Micrococcus spp</em>, <em>Streptococcus</em></td>
<td>3 days, 29°C-30°C, pH 8.1-6.5</td>
<td>Barber et al. (1988), Uzogara et al. (1990)</td>
</tr>
<tr>
<td>Tree sap</td>
<td>Palmuwine and ‘ogogoro’</td>
<td><em>Sarcina lutea</em>, <em>Shico saccharomyces pombe</em>, <em>saccharomyces cerevisiae</em>, <em>S. flurentius</em>, <em>S. chevelleri</em>, <em>M. maki</em>, <em>Leuconostoc mesenteroides</em>, <em>Lactobacillus plantarum</em>, <em>Sarcina lutea</em>, <em>Acetanacter</em>, <em>Leuconostoc dextranicum</em>, <em>Lactobacillus casei</em></td>
<td>2 days, 27°C ± 1°C, pH 6.5-3.5</td>
<td>Bassir (1962), Faparusi (1971, 1973), Okafor (1974), Ojoma et al. (1984), Uzochukwu et al. (1991)</td>
</tr>
<tr>
<td></td>
<td>‘Ogiri-ugu’/ Ogiri-nwan</td>
<td><em>Bacillus spp</em>, <em>E. coli</em>, <em>Staphylococcus spp</em>, <em>Pseudomonas spp</em></td>
<td>3 days, 25°C-30°C, pH 8.1-6.5</td>
<td>Odunfa, (1985a), Barber et al. (1989)</td>
</tr>
</tbody>
</table>

**Tuber-based:** during cassava processing, linamarin is hydrolysed in the presence of native linamarase to glucose and cyanohydrin, and subsequently the latter is broken down to acetone and hydrocyanic acid by hydroxynitrile lyase. At pH 5–6, free cyanide is released, more rapidly under gentle heating of the cassava mash (Oke, 1984; Cooke and Cock, 1989).

**Animal (milk)-based:** the active enzyme in the processing of ‘warankasi’ is calotropain, which hastens the coagulation of milk protein to yield a curd (Ibiama & Griffith, 1987). The composition, biochemical and chemical characteristics of the product depend on method employed and composition of milk (Ogundiwin & Oke, 1985, 1985).
Table 3. Some improvements introduced in the processes/products of the Nigerian Indigenous Fermented Foods (NIFF)

<table>
<thead>
<tr>
<th>NIFF</th>
<th>Highlights of some improvements in the processes/products</th>
<th>Reference/Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Ogi'</td>
<td>(a) Use of improved grains, pure culture and coupled with mechanism handling of operations to improve organoleptic quality of product.</td>
<td>Banigo et al. (1974)</td>
</tr>
<tr>
<td></td>
<td>(b) Steeping of whole grains in hot water to soften them prior to milling to reduce steep duration.</td>
<td>Adeniji and Potter (1978)</td>
</tr>
<tr>
<td></td>
<td>(c) Use of dry-milling of maize in ogi production as a convenient method.</td>
<td>Banig &amp; Adeyemi (1975)</td>
</tr>
<tr>
<td></td>
<td>(d) Use of boiling to replace steeping of grains leading to the production of acceptable ogi within 24 h as against the traditional 72-96 h.</td>
<td>Umon &amp; Fields (1981)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adeyemi (1983)</td>
</tr>
</tbody>
</table>

'Gari'        | (a) Use of 4-day culture as starter/inculum to effect fermentation in 24 h on a succeeding cassava root (tuber steep.) | Collard & Levi (1959)                                 |
|               | (b) Achieving longer shelf-life in gari through mechanised system with hygienic processing environment, better sizing of particles and packaging of end product. | Onyekwere (1977)                                     |
|               | (c) Use of process variables to control fermentation process. | Steinkraus (1985)                                     |
| Palm-wine     | Use of sterile implements as well as introduction of pure culture to effect fermentation for consistent quality palmwine production. | Uzochukwu et al. (1991)                              |

### 3.1.3. Nutritional assessments
Several workers have assessed the nutritional levels and qualities of some of the NIFF products.

**Cereal-based:** During the fermentation of 'ogi', phosphorus is released from phytate (Lopez et al., 1983). During this period, niacin and riboflavin contents are increased (Kuboye, 1985). Furthermore, in a feeding trial with 50 suckling rats at birth, the pups became malnourished and most of them died, showing that 'ogi' was inadequate as a weaning food. Further analyses showed that the indigenous fermentation process effected the following reductions (\%) in the 'ogi': 13.86 (protein), 9.33 (lipid), 53.95 (fibre), and 38.46 (ash) (Ebuchi & Akinwande, 1991).

A report on 'burukutu' and 'pito' by Ihekoronye & Ngoddy (1985) suggested that fermentation enhances B vitamins in the drinks.

'Otika' was reported to contain maltose 18 mg ml⁻¹, alcohol 5.4% (v/w), sucrose 3.67% (w/v), and lactic acid 0.048% (w/v) (Tehimie & Ogundiyin, 1978).

**Fruit-based:** Kuboye et al. (1978) reported that 'agadagidi' contains up to 6.57% alcohol. Fermentation improved the protein quality (Achinewhu, 1983b) and nutritive value (Isiche & Achinewhu, 1988) of 'ugba'.

**Legume-based:** 'Iru' ('dawadawa') contains 18-47% protein, 31.43% fat (Eka, 1980). It is high in Ca, Fe and lysine but lacks methionine and cystine (Uzogara et al., 1990); it is also high in riboflavin and cysteine (Uzogara et al., 1990). There is a marked increase in reducing sugars in 'iru' (Odufia, 1989) and 'ogiri' (Odufia, 1982) due to fermentation.

**Tree sap-based:** Fermented palm sap (palm wine) is a good source of biomass (protein/yeast), amino acids and organic acids (Uzogara et al., 1990; Uzochukwu et al., 1991).

**Tuber-based:** Gari contains (% d.b) starch (87.8), sugars (0.5), protein (1.0), minerals (1.1), fibre (0.6) and lipids (0.1) (Oke, 1984).

**Animal (milk)-based:** 'Warankasi' was reported to contain 44.56% protein, 47.50% fat, ash 6.82%, carbohydrate 1.12% (Fashakin & Unokiwedi, 1992). The protein efficiency ratio (PER) and net protein ratio (NPR) (Fashakin & Unokiwedi, 1993) were 92.80% and 89.73% of casein, respectively.

### 3.1.4. Toxicological and other health-related assessments
Several studies have been carried out on the toxicological and other health-related status of some NIFF products:

**Cereal-based:** there have been reports that fermented products involving Lactobacillus spp and lactic acid bacteria (LAB) have the following effects: viricidal (Gilbert et al., 1983), anti-leukemic (Esser et al., 1983), antitumour (Oda et al., 1983; Shahani et al., 1983). This is important in that acidic fermentation processes of cereals in Africa (West Africa) have Lactobacillus spp and some LAB as the predominant micro-organisms (Akinrele, 1970; Okafor, 1979; Fields et al., 1981; Odufia & Adeyele, 1985).

**Fruit-based:** fermentation has been reported to considerably reduce/eliminate flatus-forming oligosaccharide (stachyose, verbascose, and raffinose) in 'ugba' (Achinewhu, 1986). There are strong indications of residual growth-depressing factors (e.g. caffeoyl-p-trescine) in 'ugba' (Mears & Mabry, 1971; Mbadiwe, 1978).

**Legume-based:** traditionally-fermented castor oil seeds ('ogiri isi') has been reported to be contaminated by fungi (Mazi & Ekwuji, 1992) possibly from the processing environment. This is indicative of possible exposure of its consumer to mycotoxin (e.g. aflatoxin).

**Tree sap-based:** traditionally fermented palm sap (palm wine) has been reported to contain precursors of N-nitrosamines (nitrates, nitrites, and dimethylamine) which have carcinogenic potentials (Maduagwu & Bassir, 1979). 'Ogogoro' has a high (35.2%) alcoholic...
content (Goma, 1989) which would expose consumers to intoxication. *Tuber-based:* inadequate processing leads to residual cyanide up to toxic level (i.e. > 50 ppm) (Coursey, 1973; Oke, 1984; Cooke & Cock, 1989). A nutritional problem (the tropical ataxic neuropathy) has been observed in Nigeria due to intake of cyanide (Osuntokun, 1973) while in eastern Nigeria, an endemic goitre associated with consumption of cassava diet has been reported (Ekpechi, 1973). However ‘gari’ has generally been noted for safe cyanide levels (i.e. << 50 ppm, Omueti et al., 1993) among cassava products.

*Miscellaneous:* most processing/preservation operations of NIFFs frequently involve the use of a local food additive, ‘kanwa’ or trona (i.e. sodium sesqui-carbonate) which is known to be high in sodium (Uzogara et al., 1988). Hypertensives are exposed to greater danger when they consume these foods which are prepared with both the table salt and ‘kanwa’ because such foods become sodium-laden (Wilson, 1986). This situation is of great significance especially as it is known that ‘kanwa’ is the second most used salt in Nigerian rural homes (Abiose and Adedeji, 1992).

### 3.2. Efforts to upgrade NIFF technology

Over the years, systematic and deliberate efforts were made by researchers through the introduction into some of the NIFF processes well co-ordinated trials to cause improvements through hygienic handling by the use of sanitary facilities (Onyekwere, 1977; Uzochukwu et al., 1991), production and utilization of pure culture (Collard & Levi, 1959; Banigo et al., 1974), process control by carefully manipulating process variables like inocula, pH, substrate quality, substrate particle size, temperature (Banigo et al., 1974; Onyekwere, 1977; Kuboye, 1985; Odunfa, 1985a; Steinkraus, 1985; Fashaki & Unokwedi, 1993). Specific examples are shown in Table 3.

### 3.3. Effects of the scientific developmental efforts on NIFF technology

The results of the research and improvement efforts above brought the current state of development in the NIFF technology: the cumulative outcomes of the events reported above (see 3.2) are that processing/fermentation durations were drastically reduced in many instances; health risk-free, consistent-quality products were produced and preserved in packaged forms; products and processes were adapted to mass production.

New products with tested longevities are available in the market, (at least in the rural and urban Nigeria and West Africa), like ‘dadawa’ cubes (improved ‘dawadawa’ by Cadbury Nigeria plc based on the technology described in Figure 3), bottled palm wine (Nigerian Institute for Oil Palm Research, NIFOR, Benin, and Federal Institute of Industrial Research, Oshodi, FIIRIO, Ikeja), ‘soy-ogi’ (FIIRO), palm oil (NIFOR and LBN), cassava products (gari, flour, chips) (Onyekwere, 1977). Other processes and/or products that have been improved upon but not mentioned in this section are highlighted in Table 3 and Figures 1–3.

The diverse endeavours made towards developing NIFF have resulted in the following levels of advancement: isolation of micro-organisms; determination of the roles of the organisms; selection and genetic improvement of organisms for improved performance; process improvement; improvement in raw materials used; laboratory simulation of NIFF production; pilot plant production; and industrial plant production.

Despite the establishment of small-scale gari industries which operate on the industrial principles as

![Fig. 1. Nigerian gari pilot plant process (Akinrele et al., 1971).](image-url)
Nigerian indigenous fermented foods

Maize (or millet or sorghum)

Clean

Temper

Dehull (Palty mill)

Air separation

Hammer mill

Roller mill

Hammer mill

Discard hulls

Roller mill

Whole grain flour

Dehulled flour

Slurry

Slurry

Inoculate

Cook

Incubate 32°C

24–28 hr

Ogi (uncooked)

Inoculate

Add water

Incubate 32°C

24–28 hr

Ogi (partially cooked)

Dehydrate

Boil

Ogi porridge

Add water

Dried instant Ogi

Boil

Add water

Ogi porridge

Ogi porridge

Raw locust bean

Dehulling (Burr mill)

Boiling in retort

(15 lb/sq in for 1 h)

Draining and cooling (40°C)

Inoculation

(Dehydrated B. subtilis spores)

Spreading on stainless steel trays

lined with sterilized absorbent paper

Covering with sheet of waxed paper

Incubation (35°C)

Mixing with NaCl (7% w/w)

Drying in a vacuum

Packaging

Dawadawa

Fig. 3. Modern production of dawadawa (iru).

Fig. 2. Improved Nigerian ogi manufacturing system (Banigo et al., 1974).

specified by FIIRO (Adeyemi & Balogh, 1984), the local manufacturers who still depend on the age-old traditional art still dominate the markets. The reason is that their product is relatively cheap; only the top-bracket income group can purchase the modernized gari.

Dadawa cubes are inexpensive, and therefore, within the purchasing power of many individuals among the local and urban communities. Organised food preparation outfits like urban public canteens, schools and companies’ cafeterias/restaurants, and hospital kitchens utilize the modernized condiments.

The improved palm wine is more costly than the traditional type but cheaper than conventional beers: the rich choose it while the peasants, uneducated elders and community leaders (titled men) opt for the NIFF type, except when it is in short supply.

4. CONCLUSIONS

Nigerian indigenous fermented foods (NIFF), which number about 30, are prepared from seven categories of local staples at the household and cottage level through the traditional family and/or ethnic methods of food processing and preservation.

These NIFF have inherent problems as they were processed and used in their purely traditional setting. Recently, Nigerians and some foreigners who acquired expertise in the fields of food processing, human nutrition and health sciences have identified those problems, set out and effected improvements so that currently a very substantial percentage of NIFF have been improved to the status of modern processed foods.

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Nigerian indigenous fermented foods


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