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PROCESSING OF *FUFU* FROM CASSAVA IN NIGERIA: PROBLEMS AND PROSPECTS FOR DEVELOPMENT

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ABSTRACT

Fufu is an important fermented processed cassava product in Nigeria. Similar products are also prepared in a number of other countries in Sub-Saharan Africa. *Fufu* is traditionally processed on a household-scale and has not been industrialised. A number of problems and constraints are associated with current processing; these include: delays in processing fresh roots, the arduous nature and time taken for processing, variable quality of the end product and poor shelf life. Researchable issues have been identified from an analysis of the current situation to enable commercialisation of the product. The issues include the optimisation of retting, use of starter cultures, possibilities for mechanisation and mechanisms for improving shelf life. Such research will have to be supported by socio-economic studies and the need to address issues associated with pollution caused by large scale processing.

Keywords: *Manihot esculenta* Crantz, fermented foods, process development, commercialisation, convenience foods, urbanisation.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a root crop cultivated and consumed as a staple food in many regions of the developing world. The importance of cassava is attributed to its ability to produce reasonable yields on poor agricultural land (de Bruijn and Fresco, 1989). Cassava is well known for its ability to tolerate drought and yet maintain reasonable yields. It can be harvested at any time from 7 months to 3 years after planting (CIAT, 1993). The whole plant can be used; roots and leaves are consumed and stems are used for propagation. The roots are a good source of carbohydrate and are commonly processed to remove naturally occurring toxins and provide storable products that can be consumed or used in the production of secondary products (Lancaster *et al.*, 1982).

In Sub-Saharan Africa, cassava roots are processed by a variety of methods to form products that are used in diverse ways according to local preferences. Processing involves combinations of unit activities such as peeling, slicing, grating, soaking, boiling, steaming, roasting, drying, pounding and milling. Final product characteristics are dependent on the combination of activities used (Longe, 1980; Hahn, 1989; Oguntunde and Orishagbemi, 1991).

Cassava products were classified into four major groups as part of the Collaborative Study of Cassava in Africa (COSCA). These were: roasted granules; steamed granules; flour/dry pieces; and fermented wet pastes (Natural Resources Institute, 1992). The roasted granule product, *gari,* is widely processed in West Africa (Natural Resources Institute, 1992). *Gari* is used in rural and urban areas of Nigeria as a convenience food. It is prepared by the simple addition of hot water or milk. An alternative product is *fufu,* which is a fermented wet paste that is widely consumed in eastern and south western Nigeria and other parts of West Africa such as Sierra Leone (Blanshard *et al.*, 1994). In Nigeria, it has commercial potential that has been reported to be increasing (Nweke and Bokanga, 1994). The rural and urban demand for *gari* is higher than that for *fufu*. *Gari* is the preferred product for higher income consumers because of the ease with which it is prepared for consumption.

Urbanisation is a key issue in Nigeria and is a driving force behind the expanded use of convenience type foods such as *gari*. Other traditional cassava products may have the potential in urban markets and this paper considers the prospects for the development of *fufu* as a convenience food.

IMPORTANCE OF CASSAVA AND *FUFU* IN NIGERIA

Cassava provides a valuable source of calories and is a staple food for about 800 million people in the world (Oyewole, 1992). World production of fresh cassava grew from 70 million tonnes in 1960 to 154 million tonnes in 1991. Nigeria produces the second largest amount of cassava in the world; with annual production of approximately 20 million tonnes of fresh roots (CIAT, 1993).

Several products are processed in Nigeria. In recent years consumer preferences for the various products have been shown to be dynamic. Through the 1960s and early 1970s, cassava was consumed in the following forms: 15% as fresh roots; 5% as *gari;* 60% as *fufu;* 10% as starch; and 10% as flour (Abiagom, 1971). By the early 1980s, the consumption of *fufu* had declined to 14% of all cassava eaten, whilst consumption of *gari* rose to 65% according to a national consumption survey by the Federal Office of Statistics (FOS, 1981). It is considered that the consumer preference for *fufu* has reduced due to its inherent undesirable characteristics of poor odour, short shelf life and tedious preparation (Okpokiri *et al.*, 1985).

In Nigeria, the production of fufu is concentrated near the coast and declines in importance further north. These coastal areas provide the abundant water supply needed for *fufu* production (Nweke, 1994). Nweke (1994) reported that granules (*gari*) and fresh roots are more common where the market access infrastructure is relatively well developed in high population density areas. These observations suggest roasted granule (*gari*) processing is more commercialised than the processing of other cassava products.

According to the survey of Oyewole and Sanni (1995), most processors still prefer to process a large proportion of their cassava roots into *gari* rather than other products. The preference for *gari* could be because its processing has become highly mechanised.

Processing of cassava products in Nigeria

The most important cassava products in Nigeria are *fufu*, *gari* and *lafun*. These are described below.

Fufu

A generalised scheme for traditional *fufu* processing in south west Nigeria is shown in Figure 1. Small variations, such as partial steaming and pounding of rolled balls of *fufu* mash, are practised by the Ibo and Efik tribes of eastern Nigeria (Grace, 1971; Etejere and Bhat, 1985). Apart from work at the Federal Institute for Industrial Research, Oshodi, where a *gari* processing plant was adapted to produce *fufu* (FAO, 1984; Subrahmanyam, 1990), no mechanised process exists for *fufu* production on an industrial scale. *Fufu* is at present produced mainly by rural processors at both household and a small scale, mainly in eastern and south western Nigeria.

Peeling is normally done manually by women and girls using hand knives. The rate per person can be as high as 400 kg per 8 hours. After the cassava roots have been peeled, they are washed and made ready for soaking. Some processors do not peel cassava before soaking and instead remove the peel from the softened roots. It is generally considered that this produces a poorer quality product.

The peeled and washed cassava roots are cut manually into chunks of different sizes using a hand knife and soaked in streams, drums or earthen pots of water for 3-5 days to undergo a lactic acid fermentation. During soaking, the pH value decreases, the roots soften, and this facilitates the reduction in potentially toxic cyanogenic compounds (Ayernor, 1985; Westby, 1994; Oyewole and Odunfa, 1992; Westby and Choo, 1994).

When sufficiently soft, the roots are taken out, broken by hand and the fibres removed by sieving. At present, processors sieve manually by adding water to the retted mass on a nylon or cloth screen. The fibre produced as a by-product is commonly used for animal feed, either in its wet form or after drying. The starch suspension is allowed to sediment in a large container for about 24 hours. After sedimentation, the water is decanted while the fine, clean filtrate (mainly starch) is dewatered by putting it into raffia or cotton bags, pressing with heavy stones and leaving it overnight to remove excess water. The *fufu* is collected and sold to the consumers as a wet paste in small units packaged in plastic or polypropylene bags (Hahn, 1989).

To prepare *fufu* for consumption, a quantity of the slurry containing about 25% *fufu* solids in water is boiled directly in an open pan. After constant stirring using a wooden rod, a strong paste or dough is formed (Etejere and Bhat, 1985; Kwatia, 1986; Ayankunbi *et al*., 1991; Anon, 1994). Cooked *fufu* is usually eaten warm with fish, meat, vegetable stew or soup.

Lafun

Lafun is similar to Nigerian *fufu*. The main differences are that *lafun* is a dried product that has a good shelf life and *fufu* is a wet product that has a much lower fibre content. For *lafun*, fresh cassava roots are chopped into pieces that are soaked under water for 3-4 days or until they are soft. The fermented roots are peeled, broken up into small pieces and sun-dried on mats, flat rocks, cement floors or racks on the roofs of houses. The dried material is milled into flour. Alternatively, chips are made directly from fresh roots whereby the fresh cassava roots are cut into chunks and dried by sun drying. *Lafun* is prepared in a similar way to *fufu*.

Gari

Gari is widely produced in Nigeria and other West African countries (Nweke, 1994). Fresh roots are peeled and grated. The grated pulp is put in sacks that are pressed using a jack or heavy objects to express excess liquid from the pulp while it is fermenting. After 3-4 days, the dewatered and fermented mass is sieved and the resulting fine pulp is roasted in a pan. Palm oil is often added during roasting to stop the product from burning. This has the additional desirable effect of changing the colour of the product from white to yellow.

Gari is preferred by urban consumers because it is a pre-cooked convenience food. It is commonly consumed either by soaking in cold water with sugar or salt and taken with coconut, peanut, fish or bean porridge, or as a paste made with hot water and eaten with vegetable sauce. Certain processing steps in *gari* making, such as grating, milling and water expressing, are mechanised (Lancaster *et al.*, 1982; FAO, 1984; Igbeka *et al.*, 1992; Nweke *et al.*, 1992; Nweke and Bokanga, 1994). This explains the higher income elasticity of demand for *gari* than for other cassava products when these were determined for food crops in Eastern Nigeria were estimated (Nweke *et al.*, 1992).

Other minor products

At the household level starch is produced in either a wet form or more commonly dried. Cassava roots are peeled, washed and grated. The grated pulp is steeped for 2-3 days in a large quantity of water, stirred, and filtered through a piece of cloth. The filtrate is allowed to stand overnight and is then decanted. The sedimented starch is air dried in the shade. *Abacha* is another product that is commonly produced in parts of south east Nigeria but is rare elsewhere. Its production involves boiling roots and cutting them into small flat pieces. The sliced pieces are soaked overnight to make wet *abacha* or sun-dried for the dried form. *Abacha* is boiled in water before consumption.

CONSTRAINTS TO THE DEVELOPMENT OF *FUFU* PROCESSING

Variable quality

Fufu is considered by consumers to be of good quality when it has a smooth texture, characteristic aroma and is creamy-white, grey or yellow in colour (Akingbala *et al.*, 1991; Oyewole and Odunfa, 1992; Blanshard, 1994). The quality of *fufu* has been reported to vary with processor and season (Oyewole and Sanni, 1995).

The variability in *fufu* quality has been attributed to various local practices during the soaking (fermentation) stage of processing. Processors indicate that for sufficient retting to occur, shorter fermentation periods (2-3 days) are required during the dry (hot) seasons, while longer periods (3-5 days) are required during the rainy (cold) season. Data collected during the COSCA survey confirmed that in Nigeria considerable variations in the soaking period for *fufu* production are practised (Figure 2). The production of *fufu* is largely home based and fermentation is usually left to chance inoculation from the environment (Oyewole, 1990; Oyewole and Sanni, 1995). The vessels used for previous batches usually serve as a source of inoculum for the initiation of fermentation (Oyewole, 1997). Little or no control is involved in the processing and this may influence the quality of *fufu*.

Other factors that could be responsible for the variable quality of *fufu* include the size to which the roots are cut prior to soaking (Okafor *et al.*, 1984), varietal differences in dry matter content (Hahn, 1989), and the quality of the roots or the water used for processing.

Delays in processing fresh roots

Cassava roots brought from the farm to the market are often stored at ambient temperature for two to three days prior to processing either due to transportation problems between the farm sites and the processing centres or delays in processing caused by the slow manual processing operations that are often employed (Idowu and Akindele, 1994). Physiological deterioration of cassava occurs only a few days after harvest (Wenham, 1995) and this may contribute to the variable quality of *fufu*.

Long processing times

Various researchers (Oyewole and Odunfa, 1992; Blanshard *et al.*, 1994; Ampe *et al.*, 1994) have reported effective retting of not less than 60 hours for temperatures of between 30 and 35°C in the laboratory. These data correspond with typical processing conditions in Nigeria. Fermentation time is an issue for processors: for example some processors expose their fermenting roots to direct sunlight as a means of accelerating the process. Other processors adopt 'short-cuts' such as fermenting the roots for less than two days or processing immature cassava roots, reportedly to enhance financial gain (Oyewole and Sanni, 1995).

Cyanogens in the final product

In terms of nutritional quality, potential toxicity in cassava is due to the presence of the cyanogenic glucosides, linamarin and lotuastralin. Although health problems have been attributed to cyanide exposure from insufficiently processed cassava, there are only few reports of acute poisoning in Nigeria (Osuntokun, 1981; Akintonwa and Tunwashe, 1992). It is generally considered that the processing techniques used for cassava in Nigeria are capable of reducing the cyanogen content to low levels (Obigbesan, 1994). The mechanisms of cyanogen reduction during fermentation have been determined (Westby and Choo, 1994).

Physical aspects of processing

In a survey carried out among 50 processors, mainly women, in ten localities around Abeokuta, south west Nigeria, the manual peeling of cassava roots using a hand knife was considered to be tedious and time consuming (Oyewole and Sanni, 1995). Root size and shape vary among cultivars of cassava. Roots with irregular shapes are difficult to harvest and to peel by hand and this leads to great losses of useable root material. Also smaller roots require more labour for peeling (Hahn, 1989). Apart from peeling, sieving is another unit operation that is time consuming though not considered too labour-intensive.

Poor shelf life

Fufu is a high moisture content (*ca.* 50%) product which renders it highly perishable. It is consumed immediately after preparation or stored until required in baskets or plastic bags for not more than a week. Poor shelf-life of *fufu* is a serious limitation for large-scale processors and consumers.

PROSPECTS AND FUTURE RESEARCH NEEDS FOR THE COMMERCIALISATION OF *FUFU*

The extent to which the market for *fufu* may be expanded would therefore depend largely on the degree to which its quality can be improved to make it attractive to the higher-income consumers without significant increases in the processing costs. Such an approach would provide income-generating opportunities for processors (who are mostly women), retailers and the community in general. The following researchable issues have been identified with a view to controlling and standardising the *fufu* processing method for large-scale commercial production.

Optimisation of retting

Retting (or root softening) is a key stage in the processing of *fufu* (Westby and Twiddy, 1992; Westby and Choo, 1994). Okafor *et al.* (1984) and Oyewole and Odunfa (1992) reported that small pieces of cassava ret quickly during fermentation, whereas Ampe *et al.* (1994) and George (1994) reported contrary observations. Processors cut the roots into variable piece sizes and this may influence the quality of the product. The use of larger piece sizes has been reported to produce *fufu* with good texture and consistency and characteristic aroma (Oyewole and Odunfa, 1992). Further clarification of the influence of piece size on retting time and the quality of *fufu* is required. This is very important for maintaining product quality standards during large-scale processing.

Starter cultures

The use of starter cultures is an issue commonly raised in relation to fermented foods in developing countries (Westby *et al.*, 1997). The potential advantages associated with the use of starter cultures for *fufu* are decreased fermentation time, reliable and consistent quality and improved cyanogen elimination.

There are three main simple, low-cost, technologies: natural inoculation; transfer of an old batch of fermented product to a new batch (back-slopping); and indigenously derived cultures (Westby *et al.*, 1997). Oyewole (1990) and Okolie *et al*. (1992) have each reported successfully producing acceptable *fufu* by the use of isolated pure starter cultures. The viability of using pure starter cultures at household level needs careful consideration. The financial costs to the processor and problems of propagating and disseminating such cultures would be expected to be major limiting factors. Such inocula may, however, be more appropriate for very large-scale processing where the extra costs involved can be offset against the demand for consistent quality.

Ampe *et al*. (1994) reported that inoculation of water with liquid from previous fermentations prior to retting helps in cyanogen reduction and decreased variability in the quality associated with spontaneous fermentation for *fufu* production. It would be cost effective to promote the use of undefined starter cultures (back-slopping) to ensure consistent quality of *fufu* at all scales of operation.

Mechanisation

Machines are not used by small-scale processors although some aspects of the *fufu* processing are considered time-consuming and labour intensive by processors and hence cause bottlenecks in the production (Oyewole and Sanni, 1995).

Manual peeling was considered by women processors as the most labour-intensive step and as such a major constraint. Investigation of appropriate means to mechanise this operation should be considered. A possible technology is currently used in Brazil and involves the debarking of the cassava root prior to processing (Westby and Cereda, 1994). This is done mechanically using a tumbling action that rubs the roots together. The debarking technology would reduce the amount of labour required and the physical losses of root material. A cost-benefit analysis of this technology for larger scale processors is required. The technology would also be relevant to *gari* processing.

As an alternative to peeling, unpeeled roots can be soaked in water and the peel removed from the softened roots. This is a very easy process, but it is generally considered that it results in *fufu* with poor colour. There is a need to investigate processing of roots without peeling and determine if any simple interventions can be made to avoid discoloration of the product.

Addressing problems associated with the perishability of fresh cassava

The perishability of fresh cassava is something that individual enterprises will have to take into account when planning their processing operation. There would have to be guarantees of reliable sources of fresh cassava. The low cost cassava storage technique, which has been adapted for use in Ghana (Bancroft and Crentsil, 1996), provides the opportunity of extending the shelf life of roots to 6-8 days. This extension may be sufficient to overcome problems associated with fluctuations in supply and poor transport networks. The technique would need validation under commercial conditions with the varieties used for *fufu* processing.

Improved shelf life

Drying is a potential method for producing a shelf-stable form of *fufu*. The resultant product could then potentially compete with *gari* as a convenience food provided it could be produced at a price acceptable to the consumers and with acceptable quality characteristics. Although solar drying methods are attractive because of their low cost, they are subject to weather conditions (Westby and Cereda, 1994; Sanni, 1992; Sanni *et al.*, 1995). Okpokiri *et al.* (1985) reported good quality dried *fufu* when wet *fufu* was dried in the oven at 55°C for the first 8 hours and the temperature was gradually increased (time not specified) to 80°C. Drying of *fufu* in an oven at 60°C for 48 hours has also been reported to reduce the strong odour of *fufu* but the products were sticky, bland and the quality unacceptable compared to wet *fufu* when assessed by a taste panel (Akingbala *et al.*, 1991). Systems for artificial drying that retain the characteristic qualities of *fufu* should be investigated.

Fufu powder is assumed to be hygroscopic in nature and would be expected to gain or lose moisture depending on the relative humidity of the atmosphere. This will make it susceptible to deteriorative biological and chemical changes during storage and marketing. Knowing that the ability to store dried *fufu* will be a key issue, there is a need to establish the temperature dependence of moisture adsorption and desorption characteristics of the dry product and the influence of storage conditions on the quality of the product.

Socio-economic aspects of processing a convenience form of *fufu*

With the current high levels of urbanisation in Nigeria, consumers are demanding foods that are more convenient. This market niche can be filled by imported goods, but it would be better to rely on locally-produced traditional products. The continued success of cassava as a staple food in urban centres and as a source of steady income for rural households will, to a large extent, depend upon its ability to compete with grains (Berry, 1993) and with yam. Dried *fufu* is one such product that could be introduced to consumers. Prior to its introduction to the market, there is a need to ascertain the cost-benefits of the scaled-up processing of the product. Thus, factors such as raw materials supply, production and product cost should be evaluated to assess the feasibility of industrial-scale production.

In addition to the cost-benefit analyses, there is the need to assess the socio-economic acceptability of dried *fufu*. The reasons why *fufu* appeals to low-income groups and not high-income group need to be determined. It is also necessary to assess whether the introduction of dried *fufu* would be acceptable relative to the traditional fresh and cooked *fufu* on one hand and *gari* on the other. It is important to know this before the technology is developed further.

Other socio-economic issues that will have to be considered include: the availability of credit for investment in machinery and raw materials; the level of business management and entrepreneurial; and access to market and market information. The wider policy environment will also have an impact on the success or failure of enterprises based on *fufu* processing.

Pollution problems associated with large-scale processing

Liquid waste with high Biological Oxygen Demand from *fufu* processing is a potential problem particularly when processing is scaled up. The waste also has a characteristic odour that is often found offensive. At present *fufu* is only produced on a small scale, hence these issues are not great problems.

A case-study of *gari* processing in Ibadan, Nigeria, by Sanni (1994), where the effluent from the de-watering press was directly discharged into drains and streams, highlighted the problems of pollution resulting from large processing centres. Another reported case is the pollution problems associated with starch extraction during cassava-starch production in Brazil (Westby and Cereda, 1994). It is anticipated that the pollution problems associated with large-scale *fufu* processing would be more like those of starch because of the need to wash the fermented material through a sieve before allowing the *fufu* to sediment. A low-cost treatment technique that would have wide applicability for cassava-processing industries needs to be developed. It is important that the methodologies devised can cope with seasonal and intermittent flows of waste water.

CONCLUSION

Fufu is an important cassava product in Nigeria that is currently declining in production. Part of this decline can be attributed to its limited shelf-life and the fact that it is less convenient to use than some of the other processed cassava products such as *gari*. Another limitation associated with the product is its variable quality.

Through an analysis of the limitations affecting *fufu* processing, a number of researchable issues to enable the commercialisation of the processing of the product have been identified. These issues focus on the commercial development of *fufu* as a convenience food with a long shelf-life. The technical problems surrounding the optimisation of drying and storage of a dried products need to be addressed. Research is also required on the development and adaptation of machinery for large-scale processing. The processing of a dried form of *fufu* can contribute to reducing the variability associated with the traditional product. The optimisation of the retting process and the use of appropriate starter culture are also issues that need to be addressed in the processing of a consistent end-product.

In addition to the technical issues mentioned above, there a number of socio-economic and environmental issues that deserve consideration in the commercialisation of *fufu*. Key socio-economic issues include: the economics of processing; consumer acceptability of a dried form of the product; acceptability of the product to different income groups; availability of credit for purchase of machinery and raw materials; access to markets; and the levels of business and entrepreneurial skills of potential producers. Pollution problems have been associated with large-scale cassava processing and care is needed in the design of processing plants to ensure that environmental considerations receive due attention.

The successful development of *fufu* processing in Nigeria will depend not only resolving the technical issues surrounding processing of a stable product, but also by taking into account and where necessary addressing related social, economic, environment and policy issues.

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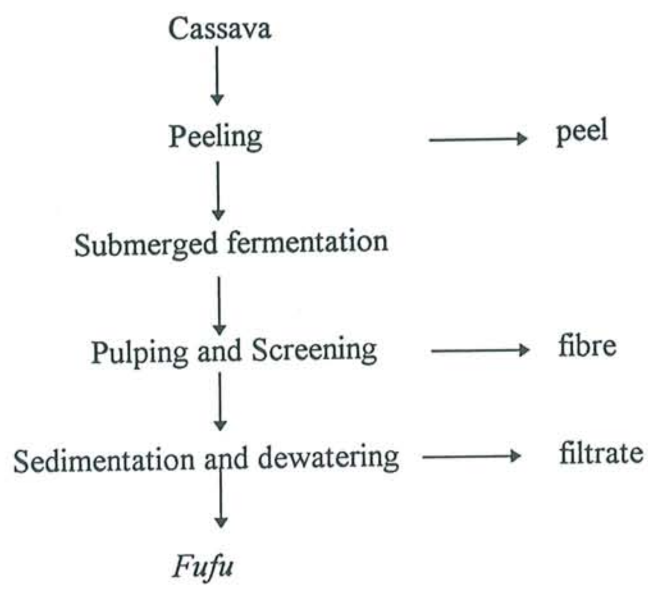

Figure 1. Fermented cassava *fufu* production in south west Nigeria (Oyewole and Sanni, 1995)

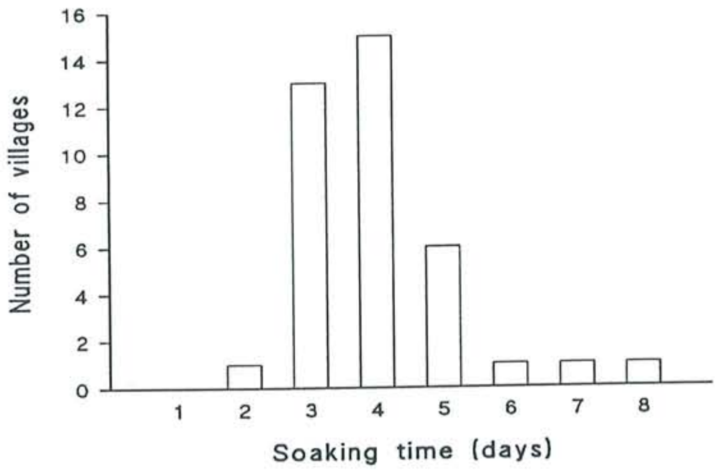

Figure 2. Variations in soaking time for cassava during *fufu* production (unpublished COSCA data).