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Review

Economic implication of industrialization of a popular weaning food "ogi" production in Nigeria: A review

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Socio-economic relevance of fermented food in developing countries is evident. However, the production of this category of food is still achieved under primitive conditions. Ogi a fermented product from maize, sorghum or millet is usually transformed into gruel or porridge when heated. About a quarter of Nigeria population is said to consume Ogi on a weekly bases. This coupled with increasing industrialization and urbanisation in the country may however dictate the need for large-scale production of Ogi. The proposal for industrialisation of this process will lead to a deliberate and calculated combination of chemical or mechanical steps to aid the manufacture of this product. However, the growth of small-scale or large industries for this product may be confronted with some limiting factors prevalent in most third world countries. Ogi production have some similarities in unit operations when compared with corn starch production, therefore the same technologies may be adopted with appropriate modification in the production of Ogi and this will provide employment to a number of people. This review is with a view to establish the need to mechanise the process and as well as point out the technological and economical implication.

Key words: Ogi, biotechnology, upgrading potentials, industrialization process, economical implication.

INTRODUCTION

Ogi is a staple cereal fermentation product found predominantly in Southern Nigeria and is usually the first native food given to babies at weaning. It is produced generally by soaking maize grains in warm water for 2-3 days followed by wet milling and sieving through a screen mesh. Nnanyelugo and Onofiok (2004) reported the use of Ogi as a weaning food in western Nigeria to supplement breastfeeding between ages of 3-6 months. However; this may be inadequate to meet the nutritional demands of growing infants (Nnanyelugo and Onofiok, 2004). It has also been shown that Ogi liquor has both antibacterial (Adebolu et al., 2007) and antifungal properties (Adebayo and Aderiye, 2010).

Ogi is usually prepared from fermented maize, sorghum or millet in West Africa (Akingbala et al., 1981). It is a popular breakfast cereal and infant weaning food in Nigeria (Akingbala et al., 1981; Banigo and Muller, 1972a, b; Adeyemi, 1983; Odunfa, 1985; Aworh, 2008). It can be diluted into solids content of 8 to 10% and boiled into a pap, or cooked and turned into a stiff gel called

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Table 1. Research studies* on manufacturing/production/fermentation process of Ogi.

Author (year of publication)	Title
Akinrele (1966)	A biochemical study of the traditional method of preparation of Ogi and its effect on the nutritive value of corn.
Banigo (1969)	An investigation into the fermentation and enrichment.
Akinrele (1970)	Fermentation studies on sorghum during the preparation of a traditional African starch- cake food.
Banigo and Muller (1972a)	Manufacture of Ogi (A Nigeria fermented cereal porridge). Comparative evaluation of corn, sorghum and millet.
Banigo and Muller (1972b)	Carboxyclic acid pattern in Ogi fermentation
Banigo et al. (1974)	Utilization of high lysine corn for the manufacture of “Ogi” using a new improved processing system.
Ekpenyoung et al. (1977)	Fortification of maize flour based diets with blends of cashew nut meal, African locust bean and sesame oil meal.
Olatunji (1977)	Production and utilization of local dry corn milled products in Nigeria.
Akingbala et al. (1981)	A laboratory procedure for the preparation of Ogi, a Nigerian fermented food.
Adeyemi, (1983)	Dry milling of sorghum for Ogi manufacture.
Akingbala et al. (1987)	Steeping of whole and dry milled maize kernels in Ogi preparation.
Okoli and Adeyemi (1989)	Manufacturing of Ogi from malted (germinated) corn (*Zea mays*): evaluation of chemical, pasting and sensory properties.
Adeyemo et al. (1992).	Biochemical analysis of germinating white maize (*Zea mays*).
Calderon et al. (2003)	Fermentation by *Lactobacillus fermentum* Ogi E1 of different combinations of carbohydrates occurring naturally in cereals: consequences on growth energetic and α-amylase production
Aminigo and Akingbala (2004)	Nutritive composition of Ogi Fortified with okra seed meal. .
Inyang and Idoko (2006)	Assessment of the quality of Ogi made from malted millet
Ojokoh (2009).	A comparative study on the effect of traditional and improved methods of fermentation in the production of Ogi food
Omemu and Adeosun (2010)	Evaluation of hazards and critical control points of Ogi in small scale processing centers in Abeokuta.

*According to the year of publication.

"agidi" or "eko" before consumption (Odunfa, 1985). This same product is often eaten along with meat, stew, vegetable soup, steamed bean cake (‘moin-moin’) or fried bean cake (Akara) (Igbedioh et al., 1996). The economic strength of the consumers does influence the choice of the supplements (Teniola and Odunfa, 2001). It has been established that substantial nutrient losses occur during the various stages of production of Ogi. These losses have been evaluated and reported by several workers (Oke, 1967; Banigo and Muller, 1972; Akingbala et al., 1981). A lot of modification has also been introduced into the process as shown in various studies (Tables 1, 2, 3, 4, 5 and 6). Onyekwere et al. (1989) gave a description of the traditional as well as the industrial production of Ogi. Various supplements of Ogi have been developed including: tempeh (Egounlety and Syarief, 1992), soybeans (Adeniji and Potter, 1978; Akinrele et al., 1970), pawpaw (Adeyemi and Soluade, 1993) and cowpea (Akoboundu and Hoskins, 1987; Ojofeitimi et al., 1984). Olukoya et al. (1994) reported the development of an Ogi product (dogik), which have therapeutic properties on the basis of it stability to control diarrhea among infants. Dehydration of Ogi by drum or tray drying was reported to prolong shelf-life of Ogi (Adeniji and Potter, 1978). However, these dehydration methods were found to destroy heat-sensitive nutrients (Adeniji and Potter, 1978).

According to Aworh (2008), the capacity to preserve food is directly related to the level of technological development. The author also stressed that slow pace of upgrading traditional food processing and preservation techniques in West Africa contributes to food and nutrition insecurity in the sub-region. An appropriate transformation of these primitive techniques to modern or mechanized stand the chance of creating employment opportunities in the rural areas, reduce rural-urban migration and the associated social problems (Aworh, 2008). The same author also highlighted that the adoption of inappropriate technologies in food processing, poor management, inadequate working capital and limited access to funds and financial institution are limiting the required growth of small scale food industries in west African countries.

The traditional processing of Ogi often employ fermentation techniques that are characterized by the use of simple non-sterile equipment, introduction of natural

Table 2. Previous studies* on Ogi fortification

Author (year of publication)	Title
Akinrele and Edwards (1971)	An assessment of the nutritive value of maize-soya mixture, soy-Ogi as a weaning food in Nigeria.
Adeyemi and Beckley (1986)	Effect of period of maize fermentation and souring on chemical properties and amylograph viscosity of Ogi.
Egounlety and Syarief (1992)	Study on supplementation of Ogi with Tempeh.
Olukoya et al. (1994)	Production of Dogik: an improved Ogi (a Nigerian fermented weaning food) with potential for use in diarrhea control.
Akingbala et al. (2005)	Effects of color and flavor changes on acceptability of Ogi supplemented with okra seed meals.
Oluwamukomi et al. (2005)	Effect of soy supplementation and its stage of inclusion on the quality of Ogi- a fermented maize meal.
Otunola et al. (1998)	Development and evaluation of maize-Tempeh mixes as an instant food product
Otunola et al. (2006)	Effect of addition of Tempeh on some properties of 'Agidi', a West African fermented maize gel.
Fasasi1 et al. (2007).	Functional and pasting characteristics of fermented maize and Nile Tilapia (Oreochromis niloticus) flour diet.
Adejuyitan et al. (2012).	An evaluation of some properties of Baobab fruit powder and Ogi mixes
Aremu et al. (2011).	Biochemical evaluation of fermented white maize (Zea mays L.) blended with scarlet runner bean (Phaseolus coccineus L.) flour.
Ajanaku and Oluwole (2013)	Determination of nutritional content of sorghum-Ogi weaning food mixed with Crayfish (Paranephrops planifrons)
Oluseyi et al. (2013)	Dietary fortification of sorghum-Ogi using Crayfish (*Paranephrops planifrons)* as supplements in infancy.

*According to the year of publication.

Table 3. Previous studies* on microbial significance in the processing of Ogi.

Author (year of publication)	Title
Akinrele et al. (1970)	The development and production of soy Ogi.
Onyekwere and Akinrele (1977)	Ogi, a Nigerian fermented maize beverage.
Odunfa (1985)	African fermented foods.
Osungbaro (1990a)	Effect of differences in varieties and dry milling of maize on the textural characteristics of Ogi (fermented maize porridge) and Agidi (fermented maize meal).
Egounlety and Aworh (1991)	Production and physiochemical properties of tempeh-fortified maize based weaning foods.
Olasupo et al. (1997)	Identification of *Lactobacillus* species associated with selected African fermented foods.
Nago et al. (1998)	Characterization of Beninese traditional Ogi, fermented sorghum slurry: physicochemical and microbiological aspects.
Sanni et al. (2001)	Influence of processing conditions on the nutritive value of Ogi-Baba, Nigerian fermented sorghum gruel.
Teniola and Odunfa (2003)	Microbial assessment and quality evaluation of Ogi during spoil age.
Ojo and Akanbi (2004)	Rheology of Soy-Ogi: Effect of concentration and temperature.
Omemu et al. (2007)	Significance of yeasts in the fermentation of maize for Ogi production.
Osungbaro (2009)	Physical and nutritive properties of fermented cereal foods
Wakil and Daodu (2007)	Physiological properties of a microbial community in spontaneous fermentation of maize (*Zea mays*) for Ogi production
Akinleye et al. (2014)	Evaluation of microorganisms at different stages of production of Ogi in Alimosho community, area South West, Lagos, Nigeria**.**

According to the year of publication.

inoculums, unregulated conditions, sensory fluctuations, poor durability and unattractive packing of the processed products which result in unpredictable quality of the product (Olanrewaju et al., 2009; Oyewole and Isah2012). According to Agarry et al. (2010), with increasing industrialization and urbanization, efforts are presently

Table 4. Previous studies* on antimicrobial influence of Ogi and Ogi by-product.

Author (year of publication)	Title
Adebolu et al. (2012)	Antibacterial activity of microorganisms isolated from the liquor of fermented maize Ogi on selected diarrheal bacteria.
Oluwafemi and Adetunji (2011).	Antimicrobial activities of lactic acid bacteria isolated from traditionally- fermented maize (Ogi) against *Candida albicans*
Onwuakor et al. (2014).	Effect of varied culture conditions on bacteriocin production of four *Lactobacillus* species isolated from locally fermented maize (Ogi).

*According to the year of publication.

Table 5. Previous studies* on improving indigenous fermented foods.

Author (year of publication)	Title
Okafor (1981)	A scheme for the improvement of fermented foods of Africa South of the Sahara in global impacts
Okafor (1983)	Processing of Nigerian indigenous fermented foods– A chance for innovation.
Onyekwere et al. (1989)	Industrialization of Ogi.
Sokari (1992)	Improving the nutritional quality of Ogi and Gari. Applications of biotechnology to traditional fermented foods.
Steinkraus (1996)	Indigenous fermented food involving an acid fermentation.

According to the year of publication.

Table 6. Previous studies* on drying and storage of Ogi

Author (year of publication)	Title
Adeniji and Potter (1978).	Properties of Ogi powders made from normal fortified and opaque – 2-corn.
Achi (2005)	The potential for upgrading traditional fermented foods through biotechnology
Ohenhen and Ikenemoh (2007)	Shelf stability and enzyme activity studies of Ogi: A corn meal fermented product.
Afolayan et al. (2010)	An Investigation into sorghum based Ogi (Ogi-Baba) storage characteristics.
Bolaji et al. (2011a)	Effect of storage temperature on some Ogi properties
Bolaji et al. (20011b)	Evaluation of changes in pasting properties of Ogi during storage
Ladunni et al. (2013).	Effects of drying method on selected properties of Ogi (Gruel) prepared from sorghum (*Sorghum vulgare*), Millet (*Pennisetum glaucum*) and Maize (*Zea mays*).
Bolaji et al. 2014).	Mathematical modeling of drying pattern and thermal properties of Ogi produced from four maize varieties.
Bolaji et al. (2014)	Soaking and drying effect on the functional properties of Ogi produce from some selected maize varieties.
Bolaji (2015).	Mathematical modeling of drying pattern of Ogi produced From Two Types of Maize Grain.

According to the year of publication.

geared towards the development of large-scale factory production facilities for these foods where the quality of the finished product will be assured.

This review is with a view to establish the need to mechanise the process and as well as point out the technological and economical implication. The review looks at the past research efforts in Ogi production with a view to highlight area that requires improvement and recommends further studies that needs to be done especially in dehydration on commercial production with focus on standardization of the process for commercial purposes.

Historical evaluation of Ogi production

So many areas have been explored by many researchers with respect to quality, quantity and traditional and

modern method of Ogi production in the West African country (Tables 1 to 6). Previous studies in the production of Ogi were on fermentation process (Akinrele, 1970; Banigo et al., 1974; Akingbala et al., 1981; Banigo and Muller, 1972; Sokari, 1992), traditional and modern methods of production of "Ogi (Onyekwere et al., 1989), nutritional potentials (Akinrele, 1970; Oke, 1967; Banigo and Muller, 1972b; Akinrele and Bassir, 1967; Akinrele and Edwards, 1971; Fashakin and Ogunsola, 1982), chemical composition of Ogi (Banigo and Muller, 1972; Akinrele, 1970), social status of Ogi (Mensah et al., 1988; Igbedioh et al., 1996) and fortification (Egounlety and Syarief, 1992; Adeniji and Potter, 1978; Akanbi et al., 2003; Adeyemi and Soluade, 1993; Ojofeitimi et al., 1984; Olukoya et al., 1994). The use of high lysine corn for improving the nutritional value of Ogi was reported by Banigo et al. (1974) and microbial activities and involvement in the production of Ogi were reported by some researchers (Akingbala et al., 1981; Akoboundu and Hoskins, 1987; Akinrele, 1970; Odunfa and Adeyele, 1985; Olasupo et al., 1997; Teniola and Odunfa, 2002; Ogunbanwo et al., 2003a, 2003b). Inyang and Idoko (2006) studied the quality of Ogi made from malted millet. Microbiological and nutritional studies showed that the lactic acid bacterium, *Lactobacillus plantarum*, the aerobic bacteria *Corynebacterium* and *Aerobacter*, the yeasts *Candida mycoderma*, *Saccharomyces cerevisiae* and *Rhodotorula* and molds *Cephalosporium*, *Fusarium, Aspergillus* and *Penicillium* are the major organisms responsible for the fermentation of Ogi (Akinrele, 1970). Odunfa and Adeyele (1985) found that *L. plantarum* was the predominant organism in the fermentation responsible for lactic acid production. Ogunbanwo et al. (2003a), worked on characterization of bacteriocin produced by *Lactobacillus plantarum* F1 and *Lactobacillus brevis OG1* and Ogunbanwo et al. (2003b) determined the influence of cultural conditions on the production of bacteriocin by *Lactobacillus brevis OG1*.

POTENTIAL PROCESS CHALLENGES IN THE COMMERCIAL PRODUCTION OF OGI

Despite exploration of all these areas in the production of Ogi, the changes induced by the soaking period and processes on engineering properties (physical, mechanical, rheological, thermal and structural properties) are very scanty in the literature. These may be necessary in standardization of the industrial process. It should be noted that soaking, milling, sieving and heat application are necessary in the production of Ogi and subsequent products. Furthermore, this information will be relevant in design of equipment and the process necessary in the optimization and standardization of commercial Ogi production (Bolaji, 2014). The knowledge gleaned from such endeavor may be used to determine the optimal processing conditions. The standardization of the process will be necessary in commercial production of Ogi and will help in determining the minimum time and energy required in the production process. The amount of water necessary during the rehydration and optimal time to achieve target dehydration goal is reported by Bolaji (2015).

Primary necessities in Ogi industries

Commercialization of Ogi definitely will require appropriate technology, packaging material and market for the products. The nature of the product may be wet (slurry form) or recently proposed form (powder). The technology may be new or adopted from the technology of corn starch production. The technology and environment can greatly be influenced by the economics of the nations and investors, consumer culture, government policies, provision of necessary amenities and product forms and packaging (Peters and Timmerhaus 1991; World Bank, 1994; Ijaiya and Akanbi, 2009).

Economic challenges

There is the pressing need to upgrade traditional technologies of food processing and preservation into industrial standard. However, rapid growth and development of small-scale food industries in West Africa could be hindered by implementation of inefficient or inappropriate technologies, poor management, inadequate working capital, limited access to banks and other financial institutions, high interest rates and low profit margins (Fox 1994; Benson 2005).

Small-scale food enterprises which in most cases rely on locally fabricated equipment may lack spare parts for equipment maintenance and repair as a major problem constraining their growth (Fox, 1994; Ijaiya and Akanbi, 2009). The World Bank (1994) established a strong relationship between infrastructures and industrial growth to economy of the nation. Infrastructure is relevant to create platform for viable structures and network to undertake social and economic activities (Ijaiya and Akanbi, 2009; World Bank, 1994). This is generally viewed as the wheel of economy (Ijaiya and Akanbi, 2009; World Bank, 1994; Adeboye, 1989).

This was believed to have positive effect on productive activities, encourage investment, wider movement of goods and people, facilitate information flow and encourages diversified economy (Benson, 2005; Ijaiya and Akanbi, 2009). However, Ijaiya and Akanbi (2009) pointed out a strong negation to this in Nigeria because of the poor deplorable state of most infrastructures. According to Ayodele (1998), about 3000 megawatts (MWs) which was 51% available in 1996 contrary to the expected 5860 MWs installed capacity from thermal (gas and steam) and hydroelectricity, witnessed some decline

subsequently. This has therefore hampered the effective commercialization and mechanization of some traditional technologies.

This among many necessary infrastructures should provide conducive environment for productive activities to take place and facilitate the generation of economic growth (Adeboye, 1989). Ijaiya and Akanbi (2009) stated that efficient infrastructure network can stimulate new investment in other sector (African development Bank (ADB), 1999). The poor provision of infrastructural services and uneven distribution may be a threat to industrialization (;Adeboye 1989;ADB, 1999; Ijaiya and Akanbi, 2009).

Standardisation and commercial production of Ogi

Industrialisation involves comprehensive relationship between workers, employers, equipments, process and society. Industrialisation will necessitate development of new machines, processes and services. These are usually provided for by modern technology (Ijaiya and Akanbi, 2009). Nigeria population is estimated at 168-170 million people out of which about a quarter in the country by estimation consume Ogi for at least once a week (Steinkraus, 1996; Aderiye and Laleye, 2003). The demand in the cities with increasing population is not met because is in a short supply, since most women are engaged in different types of job (Teniola, 1990). Ogi is mostly produced at the household level in majority of the states in the country.

The consumption pattern of some Nigerians fermented product like Ogi and eko was reported by Aderiye and Laleye (2003) among other fermented product popularly consumed in the South West of Nigeria. The variation of the quality attributes of this product subjected to varying processing methods need be addressed. Also, the demands by varieties of consumers will require development. This will necessitate the manipulation of the physical, mechanical, biological and environmental factors such as temperature, moisture content, pH and acidity in increasing the shelf life and optimization of the production process.

Aworh (2008) reported that weaning food like Ogi require sophisticated technology in tuning the process to industrial production of weaning foods. Commercial production of Ogi will result in deliberate and calculated combination of unit operations to improve process. Possible expectation from the industrialisation may contain a continuous or semi continuous processing plant with soaking tank, capable of self draining into a milling section, mechanical sieve, sedimentation tank where it is separated into paste or subsequently processed into dried Ogi powdered based on demand. The food produced is expected to be wholesome, provide good taste, help the house hold economy and provide cultural benefits. Above all, must be appealing to the entrepreneurs. Shelf stability is also important factor in the industrial process. However, the commencement of any industrial process should be after a credible feasibility study. This seems to be apparently missing in the literature. According to Aworh (2008), the traditional methods of food processing and preservation in West Africa remain at the empirical level; this is rather unfortunate. The processes are still very crude, not standardised, and are not based on sound scientific principles (Aworh, 2008). The possibility of large-scale industrial production is discouraging.

Major unit operations of Ogi production involve the steeping, milling, sieving, decanting, sedimentation and packaging depending on the form (wet or dry state) (Akinrele, 1970; Banigo et al., 1974; Akingbala et al., 1981; Banigo and Muller, 1972; Adeniji and Potter,1978; Sokari, 1992). The first step in preparing the preliminary design of Ogi is likely to establish the bases for designing these specific unit operations. Additionally, simplified flow diagram of the standardised processes and operation must be developed with good understanding of the unit operations. A preliminary material balance may be necessary however subject to subsequent modification and improvement.

The design of Ogi plant is expected to accommodate healthy and safe arrangement of machines, structures, systems or processes to perform desired functions dependent on many physical, economic, cultural and legal factors. This proposed plant must reflect harmonization of the location, plant layout, raw materials and materials for construction, structural design, utilities, buildings, storage, materials handling, safety, waste disposal, federal, state and local laws and patents (Peters and Timmerhaus, 1991). Ogi plant project may definitely involve a wide variety of skills: the researchers, market analysis, design of individual pieces of equipment, cost of estimation, where necessary, consultancy and plant-location surveys. In all of these, the services of engineers and professionals will definitely be required. Estimating the cost of materials and services is however inevitable. This cost estimation should include the total equipment or material cost, installation costs, maintenance costs and replacement costs (Peters and Timmerhaus, 1991).

In the light of the above, a closer look at the technology of corn starch production is well established (Blanchard, 1992; Galitsky et al., 2003; Hohmann and Rendleman, 1993; Johnston and Singh, 2001) and shows similarities with Ogi production: These are soaking or steeping, draining, wet milling and sieving. Drying may be included where necessary for the sake of increasing its shelf life. Corn starch technologies may be an appropriate guide in the design, construction and running of Ogi processing plant as shown in Figure 1.

The modified Ogi production process should exclude de-germing, removal of corn oil and separation of starch and gluten which exist in corn starch production (Figure 1). The cereal is soaked for 24 to 72 h, drained, wet milled and sieved; the Ogi slurry is produced. Collected

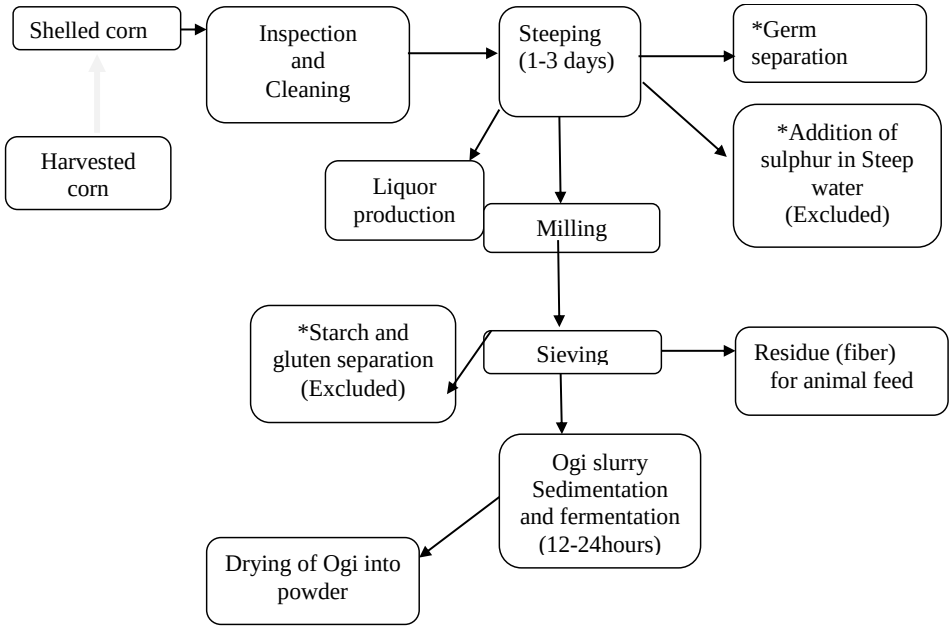

Figure 1. Flow chart of modification for Ogi production process for corn starch production.

steep-water is often discarded however, may be transformed into liquor as been practiced in the corn starch production while residual collection after sieving can be converted to animal feed. According to Adebolu et al. (2012), antibacterial activity of microorganisms isolated from the liquor of fermented maize Ogi on selected diarrhoeal bacteria show some level of effectiveness.

The cell free extracts of *Lactobacillus brevis* and *Lactobacillus plantarum* from the liquor inhibited the growth of all the test organisms with diameter zone of inhibition ranging from 6.0 - 9.0 mm and 5.0 - 7.0 mm, respectively. This is in support of cooperation of liquor production into commercial production of Ogi

Conclusion

Many areas have been explored by many researchers with respect to quality, quantity, nutritional, preservation and potential alternative method of production. Ogi's social status is high, because its products are widely consumed virtually in all the 36 states of Nigeria from three predominant cereal: (maize yellow and white, sorghum and guinea corn). The proposed processing plant should be located where the minimum cost of production and distribution can be achieved.

Wet corn milling in starch and corn syrup and Ogi processing share some similarities in unit operation like steeping, draining, milling and sieving or screening. This implies that some of the technologies can be adopted and modified for Ogi processing without new design of entire equipment or plant. However, there must be some investigation to determine the level of appropriate adoption, modification and application.

The rapid growth and development of small-scale food industries in West Africa should be encouraged by the provision of necessary facilities, industrial policies and environment. Access to low finance will facilitate the translation of traditional process into industrial process.

Conflict of interests

The author(s) did not declare any conflict of interest.

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