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Evaluation of hazards and critical control points of *ogi* in small scale processing centres in Abeokuta, Nigeria

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ABSTRACT
Objectives: To investigate processes and procedures that contribute to microbial contamination during the processing of *ogi* and to identify points where controls could be applied to control the hazards
Methodology and results: The hazard analysis of *ogi* processing consisted of observing the raw materials and the environment, documenting all steps of the process and collection of samples at different stages of processing for microbiological analysis. Data on the socioeconomic background of the processors showed that all of them are female and none acquired the knowledge of processing *ogi* through formal education. The microorganisms isolated included *Escherichia coli, Pseudomonas sp, Lactobacilus plantarum, Saccharomyces cerevisae, Candida krusei, Aspergillus niger and Penicillium sp.*
Conclusions and application of findings: Raw materials, steeping and fermentation (souring) were identified as the critical control points (CCPs) in ogi processing. Control measures recommended include education of processors, good hygienic practises and use of clean water.
Key words: *Ogi,* critical control points, hazards, fermentation.

INTRODUCTION
Ogi is a lactic acid fermented product from maize, sorghum or millet and is one of the most important products of traditional food processors in Nigeria. *Ogi* is traditionally produced and marketed as a wet cake wrapped in leaves or transparent polythene bags. It is either boiled into a thin porridge, "pap", or a thick porridge, "*eko*" or "*agidi*", before consumption. Cooked *ogi* is served as a common weaning food for infants, and a convenient meal for convalescing and nursing mothers in several West African countries (Odunfa & Adeyele, 1985; Adeyemi, 1993). In some communities in south western Nigeria, uncooked *ogi* is usually diluted with water and administered to people having running stomach to reduce the frequency of stooling (Steinkraus, 1996; Aderiye & Laleye, 2004).

The traditional production process involves soaking of maize grains in cold water for 1-3 days after which the water is decanted. The soaked grains are wet milled and sieved using muslin cloth and the filtrate is fermented for 2-3 days to yield wet *ogi*, which is a sour, white starchy sediment (Akinrele, 1970; Odunfa & Adeyele, 1985).

Fermented foods, particularly those produced under controlled conditions, have a good record of safety and are relatively rarely implicated in outbreaks of diseases. There are, however, more concerns with traditional and artisanal productions, where the application of fermentation is based largely on experience and knowledge

gained through trial and error by generations of food producers.

The unhygienic conditions under which local production occurs, e.g. unclean processing environment, use of contaminated water and equipments, contamination from producer and poor storage are limitations to the microbiological quality of *ogi* and pose a risk to human health. To take advantage of the benefits that fermentation offers, and at the same time minimize its risks, it is important to examine the fermentation process carefully and to develop a plan where hazards associated with the different production steps are identified and controlled. The HACCP procedure identifies, evaluates, and controls hazards which are significant for food safety (Motarjemi *et al.,* 1996). A hazard is any biological, chemical, or physical property that may cause an unacceptable consumer health risk (unacceptable contamination, toxin levels, growth, and/ or survival of undesirable organisms) while a critical control point is any point, process step or activity where a potential hazard for food safety can be eliminated, prevented or reduced to an acceptable level (WHO, 1996). By identifying the critical control points (CCPs), industries and enforcement authorities have more evidence on which to devise control measures, train processors and inform consumers.

This study was carried out to assess the hazards associated with consumption of *ogi* and identify the critical control points (CCPs).

MATERIALS AND METHODS

Study population: The hazard analysis was preceded by a survey of 30 processors of traditional fermented wet *ogi* within Abeokuta, Nigeria. All the stages in the processing and fermentation of *ogi* were closely monitored at the processing sites. In addition, information on the socioeconomic background of the processors as well as the state of the facilities at the vending site and aspects related to the preparation of *ogi* were collected through observation and responsive questions. Based on the location, processing method, environmental condition and willingness to participate in the study, three processors were selected for hazard analysis.

Traditional fermentation of *ogi*: The traditional preparation of *ogi* commences with the cleaning of maize grains by manually removing the stones and dirt. The grains (400g) are steeped in water (800ml) for 3 days at ambient temperature (28 $\pm$ 2°C, thereafter the grains are rinsed with water and wet milled. The wet-milled grain is wet sieved using a hand sieve or muslin cloth with about 300 µm pore size. The slurry is left to sediment and ferment (sour) for another 3 days. After sedimentation and souring, the water was decanted, while the wet, clean sediment (*ogi*) is collected and sold to consumers in its wet form in small units packaged in leaves or polypropylene bags (Odunfa & Adeyele, 1985). The traditional processing is subject to modifications by different processors as observed in this study (Fig.1).

Hazard analysis: The hazard analysis consisted of observing the raw materials used, the surroundings processing and the packaging practices of *ogi* to identify sources and modes of actual or potential contamination. Samples of the main raw material at different stages of processing as well as the processed ready-to-sell *ogi* were collected from the selected processors and subsequently analysed for presence of microbes with potential risk to human health. Samples (250g for maize grains; 250ml for wet *ogi*) were collected from each processor and placed in sterile containers, held in ice pack and taken to the laboratory within 4h of collection for analysis. Based on information obtained on-site, a flow diagram of the common preparation procedure employed by the processors was prepared to provide a clear, simple, and complete description of all steps in the process. Potential sources of contamination from raw materials, equipment, utensils and persons processing the *ogi* were noted. To determine whether a step or procedure was a CCP, we considered whether control could be applied at that point, and whether a loss of control could result in a potential hazard.

Isolation and enumeration of microorganisms: From each sample (10g/10ml) was homogenized in 90ml sterile peptone water (pH 7.0) to obtain a 1:10 dilution. Further 10-fold dilutions were prepared from this and 0.1ml each of the highest dilutions was cultured by the pour plate method (Harrigan & McCance, 1976). Enumeration of the total aerobic viable count, lactic acid bacteria, Total coliform and Staphylococcal counts was done on Plate Count Agar (Oxoid CM325, Hampshire, UK), de Mann Rogossa and Sharpe (MRS)

agar (Oxoid CM 361), Eosin methylene blue (EMB) agar (Oxoid) and Baird Parker agar (Oxoid) incorporated with tellurite and egg yolk emulsion, respectively. The PCA and MRS plates for bacteria were incubated at 30 °C for 48–72 h. One set each of MRS and PCA plates were incubated under anaerobic conditions stimulated using a CO_2 gas generating kit (Oxoid, Hampshire, UK). Yeasts and moulds were enumerated on Sabouraud dextrose agar (SDA, Oxoid, CN 41) incubated at 25°C for 72hr. All the media used were prepared according to the manufacturers' instructions.

Characterization of isolates: At intervals, all colonies from a sector of incubated plates were picked, purified by repeated subculturing before being examined microscopically for Gram reaction, cell morphology, motility, pigmentation and sporulation (Harrigan and McCance, 1976).

Confirmation of coliform organisms were carried out by inoculating colonies into lactose broth with Durham tubes and incubating at 37°C and 44°C for 24h and another 24h in the absence of gas production. The presence of gas constituted a presumptive test and the broth was streaked out on EMB agar incubated at 37°C for 42h. Typical colonies on EMB plates appearing bluish black with greenish metallic sheen which are characteristics of *E. coli* or brownish colonies often convex and mucoid which are characteristics of *Enterobacter aerogenes* confirmed the presence of coliform organisms. Isolates were stored on nutrient agar slants at 4°C for further confirmatory tests which included IMVIC test, carbohydrate utilization, reaction on TSI, gelatin liquefaction, nitrate reduction, urease production and motility.

Confirmation of typical colonies of *S. aureus* on Baird–Parker agar was on the basis of the results of catalase, coagulase, phosphatase production, nitrate reduction and carbohydrate utilization (Umoh *et al.,* 1999).

Fungal isolates were stained with cotton- blue lacto- phenol and observed microscopically for cell shape, size and sporulation. Physiological characteristics used for yeasts include ability to ferment certain sugars anaerobically and ability to grow aerobically with various compounds each as sole source of carbon or nitrogen (Assimilation test) (Kreger-van Rij, 1984; Barnet *et al.,* 1990)

Identification of isolates: Bacteria and yeasts were identified on the basis of the results obtained from biochemical characterization, analyzed using Bergey's manual of systematic bacteriology (Sneath *et al.,* 1986) and the yeasts identification program of Barnett *et al.,* (1990). The results were further confirmed using the API identification kits (API System, France). Moulds were identified by their colonial features as well as micro-morphology of their sporulating structures and conidia according to Onions *et al.,* (1981).

Statistical analysis: The data obtained were subjected to statistical analysis (means, correlation and ANOVA using SPSS 12.0 for windows.

RESULTS

Producer A lived in a 3-bedroom apartment at Obantoko area in Abeokuta; production is done at the backyard and no animal was seen around the compound. Water for processing is obtained from the tap and stored in covered overhead tank within the compound. Garbage or waste is normally disposed in a waste disposal container far from the processing site. Softened maize grains are milled at a commercial base. After sieving, the producer allows the *ogi* to ferment for about 48hours before wrapping in polyethylene nylon and sold. Leftover wet *ogi* is left in water and sold whenever there is demand for it.

Producer B lived in one of the eight rooms in a big compound at Osiele Area in Abeokuta. The producer shared the compound with other 6 families. The producer had no formal education and is married with six children. Some of the children assisted her in *ogi* preparation. Chickens and goats were seen roaming in the compound. The producer also reared pigs which were kept in a confined area (pen). The chaff from *ogi* was normally fed to the goats and poultry reared. Garbage or waste is normally disposed in a waste disposal container near the production site. The water used for processing is obtained from tap and stored in drums and containers well covered. Occasionally, when tap water was not available, well water was used for processing. The producer has a milling machine used in milling the softened maize grains and other commercial products such as tomatoes and beans. Wet milled *ogi* is sieved with a muslin cloth, allowed to ferment overnight, wrapped in transparent polyethylene nylon and vended in the popular Osiele market and motor park by the children.

Producer C also lived in a one room apartment with other people at Sabo area. She is aged and had no formal education. The producer reared livestock

such as poultry, birds and goats which were seen roaming around the compound. Water used for processing is obtained from well and stored in plastic containers and clay pots which were not all covered. Softened maize grains were milled at a commercial milling machine. Muslin cloth was used in sieving, thereafter; the *ogi* was left to undergo overnight fermentation. The processor processed part of the wet *ogi* into thick porridge called *agidi* or *eko* and wrapped in leaves. The remaining wet *ogi* are also wrapped in leaves and taken to the markets early in the morning for sale.

Table 1 shows the microbial counts at different stages of *ogi* processing for the three local processors. The maize grains used as raw material had mean TAPC ranging from 6.00 for processor C to 6.65 logcfu/g for processor B. the ready to sell *ogi* had TAPC ranging from 6.11 log cfu/g (producer B) to 7.19 log cfu/g (producer C). No coliform was isolated from the maize grains used by all the producers, however coliform counts of ready to sell *ogi* was 2.94 logcfu/g, 4.88 logcfu/g and 4.94 logcfu/g for processor B, C and A respectively. Lactic acid and yeasts were isolated at all stages of fermentation for all the processors. Mould counts on the maize grains ranged from 7.02 logcfu/g to 7.21 logcfu/g. At 24hours of soaking, the mould counts had reduced significantly ($p<0.05$) to 1.20 logcfu/g for producers A and 1.00 logcfu/g for processors B and C. Moulds were not isolated beyond 24 hr of soaking for all the processors.

A gradual reduction in pH was observed during fermentation for all the processors. The final pH of the ready to sell *ogi* was 4.9, 4.0, and 5.2 for processor A, B, and C respectively.

Table 2 shows the distribution of the different microorganisms isolated during the processing of *ogi.* The bacteria isolated include *Escherichia coli, Pseudomonas sp., Klebsiella sp., Staphylococcus aureus* and Staphylococcus *epidermidis.* The yeasts isolated were *Saccharomyces cerevisiae, Candida krusei, Geotrichum fermentum* and *Rhodotorula graminis.*

Table 3 shows the hazards associated with each step in the processing of *ogi.* Results showed that the raw material (maize) is a source of contamination which can be due to chemical, physical or vegetative pathogens. Washing, steeping, sieving and packaging are other sources of contamination which can be due to physical contaminations, chemical and microbiological quality of the water, handling and equipments used during steeping, sieving and packaging. Summary of the HACCP shows that soaking/ steeping and fermentation are some of the critical control points during the fermentation of *ogi.* Flow charts showing hazards and CCP during processing of *ogi* is presented in Fig.1

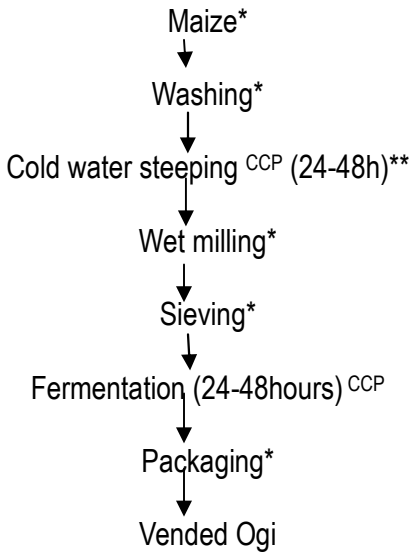

Figure 1: Flow diagram of *ogi* processing.

Legend

*Hazard of contamination likely;

** Hazards of microbial growth likely

CCP Critical control point.

Table 1: Microbial counts and pH at various stages of *ogi* processing.

Producers	Processing steps	Mean counts log cfu/ml)						pH
		TAPC	SC	CC	LAB	YC	MC	
A	Maize grains	6.65	6.21	0.00	4.69	4.48	7.04	6.3
	Maize at 24hr steeping	7.03	5.73	1.55	6.47	6.26	1.20	5.5
	Maize after washing	7.08	6.41	2.56	6.44	6.50	0.00	4.9
	Maize after wet milling and sieving	6.13	6.32	2.66	7.41	5.02	0.00	6.5
	Ready to sell ogi	7.02	7.64	4.94	8.85	5.64	0.0	4.9
B	Maize grains	6.50	6.21	0.00	4.65	4.76	7.21	6.7
	Maize at 24hr steeping	6.77	5.73	1.75	6.34	6.34	1.00	5.9
	Maize after washing	6.81	6.41	2.90	6.47	6.65	0.00	6.1
	Maize after wet milling and sieving	6.27	6.32	3.55	7.56	5.46	0.00	6.4
	Ready to sell ogi	6.11	6.64	2.94	9.01	6.22	0.00	4.0
C	Maize grains	6.00	6.23	0.00	4.56	4.32	7.02	6.4
	Maize at 24hr steeping	6.48	5.03	1.23	6.57	6.72	1.00	5.5
	Maize after washing	6.53	6.54	2.67	6.23	6.75	0.00	5.0
	Maize after wet milling and sieving	6.20	6.43	3.1	7.47	6.02	0.00	6.4
	Ready to sell ogi	7.19	7.76	4.88	7.98	6.16	0.00	5.2

Table 2: Distribution of isolated microorganisms in samples collected at different stages during the processing of *ogi.*

Isolate	Maize grains	Maize at 24hr steeping	Maize after washing	after wet milling and sieving	Ready to sell ogi
Escherichia coli	-	+	+	+	+
Pseudomonas sp.	-	+	+	+	+
Klebsiella sp.	-	+	+	+	+
Lactobacillus plantarum	+	+	+	+	+
Lactobacillus	+	+	+	+	+
Staphylococcus epidermidis	+	+	+	+	+
Staphylococcus aureus	-	+	+	+	+
Saccharomyces cerevisiae	+	+	+	+	+
Candida krusei	+	+	+	+	+
Geotrichum fermentum	-	+	+	+	+
Rhodotorula graminis	+	-	-	-	-
Aspergillus flavus	+	-	-	-	-
Aspergillus niger	+	-	-	-	-
Penicillium sp	+	-	-	-	-
Rhizopus oligosporus	+	-	-	-	-

Table 3: Process Identification of hazards for *ogi* processing.

Process step	Hazard	Source	Control measure
Maize	Chemicals:		
	Mycotoxin	Storage	Supplier Quality Assurance (SQA)
	Physical:		
	Insects , stones	Rural processors	SQA
	Microbiological:		
	Moulds	Storage	Good hygienic practise (GHP); SQA
Steeping/ soaking	Vegetative pathogens	Food handlers, environment,	Good manufacturing practises (GMP)
	Stones		
	Heavy metals	Water by processors	GHP/GMP
Washing	Heavy metals	Water by processors	GMP
	Vegetative pathogens	handlers	GHP, GMP
Wet milling	Filth, dirt and foreign matter.	Milling equipment, environment,	GHP, GMP
	Vegetative pathogens	Water	
Sieving	Vegetative pathogens	Water/equipment, handlers	GMP
Packaging	Vegetative pathogens	Packaging material, Handlers	GHP, GMP

Table 4: Summary of the HACCP control charts of *ogi* production.

Process step	Hazard	Control measure	Critical limits	Monitoring procedure	Corrective action
Soaking	Growth and contamination by pathogenic and spoilage organisms	Use of clean water, timing of steeping, cleaning of utensils	Portable water Clean utensils	Sensory observation, Inspection of utensils	Educate the processor
Fermentation	Survival of acid tolerant pathogens	pH control, proper timing, use of clean utensils	pH 3.6–3.9, Good hygiene.	pH, sensory and visual inspection	Educate the processor

DISCUSSION

The HACCP approach determines quickly and relatively cheaply the points in food processes that are critical to safety, while taking into account local habits and culture (Abdulsalam and Kaferstein, 1994). The profile of the *ogi* processors surveyed in this study showed that all the processors are female and none of the processors surveyed acquired the knowledge of *ogi* training through any formal education. This agrees with the report of Motarjemi (2002) that the developments in food fermentation have been based on experience gained through trial and error by consecutive generations of food producers and households who have used the technology for the domestic preparation and preservation of foods. Though this lack of formal education by processors presents a major pitfall because most of the processors lack a comprehensive

understanding of the underlying principles of the fermentation process and the requirements for ensuring quality and safety. This may lead to unsafe products depending on the process, environmental conditions and the condition of the raw materials (Motarjemi, (2002).

The isolation of *Escherichia coli* and *Staphylococcus aureus* at different stages during processing and also in the ready to sell *ogi* may be attributed to contamination from processors/vendors, water used for steeping and sieving, utensils and probably the animals present in the environment. Several reports had shown that food handling personnel play important role in ensuring food safety throughout the chain of food production, processing, and storage (Umoh *et al.,* 1999; Omemu *et al.,* 2005; Omemu and Aderoju, 2008).

One of the critical control points during *ogi* processing is the raw materials (maize and water), since maize can support mould growth resulting in aflatoxin contamination. The presence of moulds such as *Aspergillus niger, Penicillium sp* and *Rhizopus s*p on the surfaces of raw maize grains and during the early stage of fermentation has been reported (Odunfa and Adeyele, 1985; Omemu *et al.,* 2007a,b). They are most likely part of the grains surface microflora that is undesirable in many foods because of their mycotoxin producing potentials (Jonsyn, 1989; Jespersen *et al.,* 1994).

Water used in the soaking, milling and sieving the *ogi* may be contaminated. In several developing countries including Nigeria, the primary challenge is the lack of water, rather than its quality (Ehiri *et al.,* 2001). All the processors surveyed admitted that taps often go dry for several weeks and that they rely on well water when this happens. Studies carried out by Oyemade (1998) in Southern Nigeria and Ehiri *et al.,* (2001) in Eastern Nigeria showed very high levels of contamination in water sources used for processing. As part of good hygienic practice, safe water should be used in processing *ogi* and for washing hands and utensils so as to minimize the final bacterial load.

Steeping and fermentation (souring) at ambient temperature for 24-48hr days are identified as CCPs during *ogi* processing. Fermentation during *ogi* processing usually results in lowered pH as a result of lactic acid production. Rapid reduction of pH to about 3.8-4.0 during fermentation ensures the disappearance of Gram negative bacteria and other spoilage or pathogenic organisms which may be present in the food due to the lowered pH (Amoa- Awua *et al.,* 2007).

The factors contributing to the contamination of *ogi* include dirty environment, poor quality of water and lack of formal education by processors. The lack or low level of formal education of most of the traditional food processors posed a challenge to introducing GMP and HACCP into their operations. Introducing these concepts called for an attitudinal change on the part of processors who had been used to a certain mode of operation over the years (Amoa-Awua, 2007). There is a need to simplify the HAACP to a level which could be integrated meaningfully into the operations of the traditional processors and also to educate the producers on the hazards and CCPs of *ogi* production.

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