Study on the bacteriological quality of fura sold in Wukari, North-East Nigeria.

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Abstract

The bacteriological quality of *fura* sold in Wukari metropolis was evaluated. A total of nine samples, three from each of the wards (Puje, Avyi, and Hospital) and laboratory prepared sample (control) were evaluated for bacteria load and the presence of bacteria using standard microbiological techniques. Results show that the pH in water of all the samples is within the acidic range of 4.10 to 4.56. The bacteria loads of the laboratory prepared *fura* showed a total count of 1.62 × 10^6 cfu/g, lactic acid bacteria (LAB) count of 1.04 × 10^6 cfu/g, coliform and staphylococcal count of 1.2 × 10^2 cfu/g and 1.3 × 10^2 cfu/g respectively. The total bacteria count of the commercial *fura* samples ranged from 1.94 × 10^7 cfu/g to 2.44 x 10^7 cfu/g. The total lactic acid bacteria count ranged from 2.36 × 10^4 cfu/g to 1.52 × 10^6 cfu/g. Total coliform count ranged from 1.06 × 10^6 cfu/g to 1.84 × 10^7 cfu/g while the total staphylococcal count ranged from 2.0 × 10^6 cfu/g to 1.02 x 10^7 cfu/g. Bacteria isolated from the various samples and their occurrences show that *Lactobacillus* species and *Leuconostoc* species were highest (100%), followed by *Staphylococcus aureus* and *Micrococcus* species (90%), *Klebsiella* species (70%) and then *Proteus* species (40%). *Bacillus* species and *Pseudomonas* species had (30%) of occurrence each while *Escherichia coli* and *Streptococcus* species were the least with (20%) occurrence each. The high bacteria count and the presence of potential pathogenic bacteria in some of the samples is an indication that the *fura* samples were contaminated and this can potentially pose health hazard to the consumers. Hence the need for public enlightenment for handlers and producers of *fura* food to ensure good manufacturing practices in production and storage of the product to avoid outbreak of infections associated with the organisms encountered in this study.

Keywords: Fura, Bacterial quality, coliform, Staphylococcal count, Lactic acid bacteria.

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Introduction

Fermentation of cereals for the production and preservation of food has been practiced throughout Africa [1,2]. A variety of cereal-based fermented food are produced at both mini-industrial and household in most parts of Africa such as kenkey (Ghana), injera (Ethiopia), mahew (Benin), poto-poto (Congo), agidi, ogi, kunun-zaki, fura (Nigeria), uji and togwa (Tanzania) and kisra (Sudan) which are mostly used as weaning foods for infants and children as well as adult [1-4]. The fermentation process leads to food preservation and increase in the organoleptic properties due to the production of lactic acid and other compounds that enhances the taste and flavour of the product [5].

Fura is an indigenous fermented cereal based foods majorly consumed in the Northern part of Nigeria. It is a thick ball snack that is produced mainly from millet or sorghum and spices such as ginger, pepper, black pepper and gloves. It is a semi-solid dumpling meal made from millet or sorghum and is used traditionally as stable food in most West African countries including Nigeria and Ghana [2,6,7]. During the preparation of *fura*, the cereal grains, Millet or sorghum are soaked in water and allowed to ferment overnight and then drained. The grains are allowed to dry, ground into fine powder and then mixed with hot water with continuous stirring to form a smooth paste which are then molded into balls and cooked. The molded balls are allowed to ferment for 1-4 days at room temperature. The balls are pounded and re-molded and then sun-dried which can also be dry-milled into powder which is reconstituted in water to get *fura* meal. Also, the cooked dough balls can be broken and mixed with fermented milk (nunu) to form *fura* de nunu which can serve as a complete food providing energy and protein [1,2,8].

The fermentation process in *fura* is achieved through spontaneous fermentation using indigenous bacteria and yeast inherent in the cereals. However, reports indicate that lactic acid bacteria genera such as *Lactobacillus, Pediococcus, Streptococcus* and *Enterococcus* species as well as yeasts such as *Saccharomyces cerevisiae, Pichia anomala* and *Candida* species are associated with cereal fermentation [2,9,10]. During fermentation, lactic acid and other organic acids accumulate resulting to a decrease in the pH due to microbial activities thereby inhibiting the growth and survival of spoilage and pathogenic organisms depending on the type of organism and the temperature of the medium [2,11]. However other organisms have been isolated from *fura*. For instance, isolated *Lactobacillus, Pediococcus, Streptococcus, Leuconostoc*, *Enterococcus, Enterobacter aerogenes, Klebsiella pneumonia, Proteus vulgaris, Enterobacter sakazakii, Serratia liquefaciens, Escherichia coli. Issatchenkia orientalis*, *Saccharomyces cerevisiae*, *Pichia anomala*, *Candida tropicalis*, *Saccharomyces pastorianus*, *Yarrowia lipolytica*, and *Galactomyces geotricum has been reported* [1].

Fura can be considered to be functional natural food since the raw material (millet) has been reported to have protein content up to 11% protein by weight and are rich in B vitamins such as niacin, B6 and folic acid, iron, potassium, zinc, magnesium, and calcium with no gluten content. They are also rich in phytochemicals, including phytic acid which is believed to lower cholesterol and reduce the risk of cancer. Moreover, cereals regarded as functional foods since they provide dietary fibre, energy, protein, minerals, vitamins and anti-oxidants required for human health [12]. However, *fura* has a short shelf-life of 3 to 4 days at the temperature of about 5°C and 1 to 2 days at room temperature of 25°C while at 35°C it can only last for 18 hours with unacceptable quality, after which they can be deteriorated by microorganisms whose presence poses health risk as they can be source of infection when consumed [2,13]. Moreover, poor handling of *fura* during processing, storage and marketing can predispose it to microbial contamination as they are molded into balls by hand during preparation, and storage may be in an unhygienic containers and environment [14]. Also, improper handling and post-fermentation processing such as pounding in mortar, molding and the point of sale can expose the *fura* product to microbial contamination [1]. Hence, this study evaluates the bacteriological quality of *fura* sold in Wukari, North-Eastern Nigeria.

Materials and Methods

Source of materials

A total of nine (9) *fura* samples were purchased from the three (3) wards in Wukari metropolis (Hospital, Avyi and Puje), three (3) from each ward. A laboratory sample was also prepared from millet, cloves, dried pepper and corn flour purchased from Wukari new market as control. The samples were packaged in sterile plastic containers and immediately transferred to Biology Laboratory of Federal University Wukari for analysis. Samples were stored in the refrigerator at 4°C for further use.

Preparation of laboratory based fura

Fura was prepared in the laboratory following the method described by [8]. Exactly 700 g of millet was weighed using analytical weighing balance (G%G Deutschland). The weighed millet was cleaned of foreign materials, washed with clean water and cleansed with sterile distilled water. The cleaned sample was steeped in sterile distilled water overnight. The steeped sample was drained, spread on aluminum foil and dried using hot air oven (DHG-9101-ISA, U.S.A) at 60°C for 8 hours. The dried samples were ground into powder using laboratory grinder (Model: CT01654, China), and then mixed with hot sterile distilled water until a smooth paste is formed. The paste was molded into balls and left at room temperature to ferment for 48 hrs. The fermented samples were dried at 60°C for 8 h in hot air oven. The dried balls were dry-milled into powder which can be reconstituted with water to form *fura.*

Bacteriological analysis of fura samples

The bacteriological analysis of *fura* samples was performed to determine the bacteria load, and the presence of bacteria in the various samples using the method described by [15]. 1 g from each of the commercial *fura* samples and the control was dissolved in 9 ml of normal saline and serially diluted up to 10^{-7}. Exactly 0.2 ml aliquot was then removed and transferred to Nutrient Agar; de-Man Rogosa and Sharpe agar (MRS), MacConkey Agar and Mannitol Salt Agar plates using the pour plate technique for total bacteria count, total lactic acid bacteria count, total coliform count and total staphylococcal count respectively. Plates were incubated for 24 h aerobically at 37°C while MRS agar plate was incubated anaerobically. After 24 hours of incubation, plates were examined and inspected for bacteria growth and then counted. Distinct colonies were then sub-cultured unto freshly prepared agar medium and incubated at 37°C for 24 h to obtain pure cultures and then identified using the method of [16] and with reference to [17].

Results

Table 1 presented the pH in water of the *fura* samples and the control. All the samples were found to be within the acidic range of 4.10 to 4.56.

The bacteria loads of the laboratory prepared *fura* showed a total bacteria growth of 1.62×10^6 cfu/g. The total lactic acid bacteria count was 1.04×10^6 while the total coliform and staphylococcal counts were 1.2×10^2 cfu/g and 1.3×10^2 cfu/g respectively (Table 2).

Table 3 presents the bacteria load of the commercial *fura* samples. The result showed that the total viable bacterial count ranged from 1.94×10^7 cfu/g to 2.44×10^7 cfu/g. Total lactic acid bacteria count ranged from 1.52×10^6 cfu/g to 2.36×10^4 cfu/g. Coliform count ranged from 1.06×10^6 cfu/g to 1.84×10^7 cfu/g while the staphylococcal count ranged from 2.0×10^6 cfu/g to 1.02×10^7 cfu/g.

Table 1: *pH of the Fura samples studied.*

Sample code	PH
PJS1	4.28
PJS2	4.22
PJS3	4.25
AVS1	4.31
AVS2	4.20
AVS3	4.32
HPS1	4.40
HPS2	4.56
HPS3	4.37
Control	4.10

PJS1-3=Puje samples; AVS1-3=Avyi samples; HPS1-3= Hospital ward samples.

Table 2. *Bacterial load of laboratory prepared Fura.*

Media Used	Bacteria Count (CFU/g)
Nutrient agar	1.62×10^6
MRS Agar	1.04×10^6
MacConkey agar	1.2×10^2
Mannitol salt agar	1.3×10^2

The occurrence of the organisms showed that *Lactobacillus* species and *Leuconostoc* species were present in all the samples, *Staphylococcus aureus* and *Micrococcus* species were present in all samples except control, *Pseudomonas* species was present in only samples PJS1, HPS2, and control, *Bacillus* species present in PJS2, PJS3, HPS2 and control. *Escherchia coli* was present in only PJS2 and HPS1, *Klebsiella* species was present in PJS1, PJS3, AVS2, AVS3, HPS1, HPS2, and HPS3 and *Proteus* species was present in AVS1, AVS3, HPS1 and HPS3, while *Streptococcus* species was present in AVS1 and AVS2 (Table 4).

Figure 1 shows the occurrence of the organism in the samples. The result showed that *Lactobacillus* species and *Leuconostoc* species were the most common 10(100%), followed by *Staphylococcus aureus* and *Micrococcus* species 9(90%), *Klebisiella* species, 7(70%), *Proteus* species, 4(40%) and *Bacillus* species and *Pseudomonas* species, 3(30%) while *Escherichia coli* and *Streptococcus* species were the least with 2(20%) occurrence respectively.

Discussion

Fura is an indigenous fermented cereal-based and very nutritious food mostly consumed in Northern Nigeria. However, it can be a source of disease transmission due to contamination by pathogenic microorganisms during preparation, storage and marketing. In the present study, the pH in water of all the *fura* samples studied were within the acidic range of 4.10 to 4.56. This acidic property can be traced to the addition of species such as ginger, dry pepper, cloves and alligator pepper or to the presence of some lactic acid producing bacteria during overnight fermentation process [18]. The pH values of *fura* in this study agree with the report of pH values ranging from 4.10 to 5.00 in *fura* samples in Ghana [1]. This is also similar to the pH values of cereal-based fermented beverages, which reported the pH of kunun-zaki (a non-alcoholic cereal-based fermented beverage) samples in the range of 4.00 to 4.30 in Ogun state Nigeria [19]. The low pH values are desirable since report indicates that it inhibits the growth and survival of spoilage organisms and give fermenting organisms an advantage [2,20,21]. This low pH values can also be attributed to the presence of lactic acid bacteria which produced acid during fermentation which lower the pH.

The bacteria load of the laboratory prepared *fura* showed high bacteria and lactic acid bacteria loads with relatively low count on coliform and staphylococcal counts. The counts observed could be due to the laboratory conditions as well as the length of fermentation. Similar observation has been reported on ogi, a cereal based fermented gruel [15,22]. The counts for commercial *fura* showed that the total bacteria count ranged from 1.94×10^7 cfu/g to 2.44×10^7 cfu/g. The counts were quite high; however, similar count ranging from 2.0×10^7 cfu/g to 2.23×10^8 cfu/g has been reported on *fura* de nono samples [23]. Also, the result of the present study is higher than the report, which reported bacteria load of 3.2×10^4 cfu/ml to 4.7×10^4 cfu/ml in *fura* samples at Bauchi, Nigeria [14]. The high bacteria load could be attributed to contamination by the utensils used during processing and the hygiene of the producers. It could also be attributed to the inherent microorganisms in the raw materials and contamination through the environment as well as the processing equipment and processing water [1,15].

Table 3. *Bacterial load of commercially prepared Fura samples.*

Sample Code	Total Bacteria Count (CFU/g)	Total LAB count (CFU/g)	Total Coliforms Count (CFU/g)	Total Staphylococcal Count (CFU/g)
PJS1	2.0×10^7	1.32×10^6	6.4×10^6	3.6×10^6
PJS2	2.06×10^7	1.06×10^6	1.84×10^7	3.0×10^6
PJS3	1.96×10^7	3.60×10^5	8.8×10^6	2.0×10^6
AVS1	1.92×10^7	2.36×10^4	8.4×10^6	6.6×10^6
AVS2	1.94×10^7	1.00×10^6	6.4×10^6	3.8×10^6
AVS3	2.36×10^7	5.10×10^4	1.06×10^6	4.6×10^6
HPS1	2.26×10^7	1.26×10^5	1.26×10^6	1.02×10^7
HPS2	1.98×10^7	1.52×10^6	8.4×10^6	7.6×10^6
HPS3	2.44×10^7	4.21×10^4	5.6×10^6	9.6×10^6

PJS1-3= Puje samples; AVE1-3= Avyi samples; HPS1-3=Hospital sample; CT=Control sample; Cfu/g=Colony forming unit per gram; LAB=Lactic acid bacteria.

Table 4. *Occurrence of bacterial isolates in the commercial and laboratory prepared Fura samples.*

Organisms	SAMPLES									
	PJS1	PJS2	PJS3	AVS1	AVS2	AVS3	HPS1	HPS2	HPS3	CONTOL
Bacillus species	-	+	+	-	-	-	-	-	-	+
Escherichia coli	-	+	-	-	-	-	+	-	-	-
Klebsiella species	+	-	+	-	+	+	+	+	+	-
Proteus species	-	-	-	+	-	+	+	-	+	-
Pseudomonas species	+	-	-	-	-	-	-	+	-	+
Staphylococcus aureus	+	+	+	+	+	+	+	+	+	-
Streptococcus species	-	-	-	+	+	-	-	-	-	-
Lactobacillus species	+	+	+	+	+	+	+	+	+	+
Leuconostoc species	+	+	+	+	+	+	+	+	+	+
Micrococcus species	+	+	+	+	+	+	+	+	+	-

PJS1-3= Puje samples; AVE1-3= Avyi samples; HPS1-3= Hospital sample; CT= Control sampl; + = Postive; - = Negative.

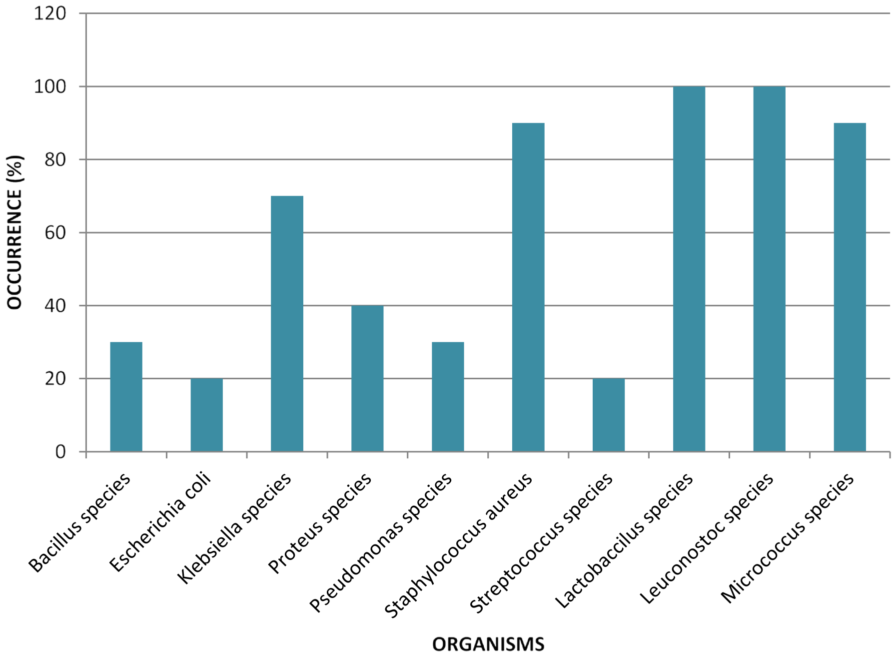

***Figure 1.** The occurrence percentage of the isolated bacteria in the various samples.*

Total lactic acid bacteria count ranged from 1.52×10^6 cfu/g to 2.36×10^4 cfu/g. similar report has been recorded on sorghum-based ogi where the count of lactic acid bacteria ranged from 4.4×10^7 to 1.4×10^8 cfu/g [15]. The high lactic acid bacteria count could be attributed to the low pH values which favoured their growth or the fermentation conditions that tend to favour the growth of lactic acid bacteria (LAB) [24]. Increase in lactic acid bacteria population of sorghum during sourdough bread production which is consistent with the present finding has been reported [25].

Coliform count in the commercial *fura* samples in the present study ranged from $1.0^6 \times 10^6$ cfu/g to 1.84×10^7 cfu/g while the staphylococcal count ranged from 2.0×10^6 cfu/g to 1.02×10^7 cfu/g. Total coliform count of the samples were also high. However, the lowest coliform and staphylococcal count were observed in the control sample. Similar observations have been reported by other researchers in *fura* and *fura* da nunu samples [1,14,23,26]. The Coliform bacteria are indicators of some degree of potentially hazardous faecal contamination. The high bacterial counts found could be as a result of microorganisms already present on the cereal grains from which the *fura* was produced, which continue to grow in the product. Also, it could be attributed to contamination during storage, processing and handling [26-28], especially from water used for processing probably due to inadequate supply of portable water in the study area [15].

In the present study, the organisms identified from the various samples of *fura* are *Bacillus* species, *Escherichia coli*, *Klebsiella* species, *Proteus* species, *Pseudomonas* species, *Staphylococcus aureus*, *Streptococcus* species, *Lactobacillus* species, *Leuconostoc* species and *Micrococcus* species. The organisms isolated from the control sample were mostly the lactic acid bacteria. This observation is consistent with previous work that reported that the presence of *Lactobacillus*, *Pediococcus*, *Streptococcus*, *Leuconostoc*, *Enterococcus*, *Enterobacter aerogenes*, *Klebsiella pneumonia, Proteus vulgaris*, *Enterobacter sakazakii*, *Serratia liquefaciens* and *Escherichia coli* in *fura* [1]. Similarly, *Lactobacillus* sp., *Enterobacter* sp., *Micrococcus luteus* and *Bacillus cereus* have been isolated from *fura* samples [14]. Moreover, similar observation and organisms have been reported by previous researchers on *fura* samples and other cereal-based foods [15,22,29,30]. The presence of *Pseudomonas* species, *Staphylococcus aureus*, *Escherichia Coli*, *Bacillus* species, *Proteus* species, *Klebsiella* species and *Streptococcus* species can be attributed to the fact that they are commonly found in the environment and have been reported to be common contaminants of food [26]. However, their presences in some of the commercial samples in this study are of public health concern since some of the organisms are associated with some form of disease conditions. For instance, *Staphylococcus aureus* causes disease in human such as folliculitis, scalded skin syndrome, impetigo, pneumonia, erysipelas, toxic shock syndrome, cellulites, meningitis foodborne intoxication due to their ability to elaborate heat stable toxins [31-33]. *Pseudomonas* species is widely distributed in soil and water and can therefore contaminate food products [34] which could lead to infection when ingested. *Klebsiella* species can cause fever, neck stiffness, urinary tract infections, meningitis, pneumonic and nosocomial infections [35]. Some strains of *Escherchia coli*, cause hemorrhagic charrhoea, and intoxication. *Bacillus* can also cause foodborne intoxication while *Proteus* and *Streptococcus* species are also implicated in urinary tract infection, nausea, vomiting and diarrhea in human [31-33].

The percentage occurrence of the isolates from *fura* in the present study showed that *Lactobacillus* species and *Leuconostoc* species were the most common 10(100%), followed by *Staphylococcuss aureus* and *Micrococcus* species 9(90%), *Klebisiella* species, 7(70%), *Proteus* species, 4 (40%) and *Bacillus* species and *Pseudomonas* species, 3(30%) while

Escherichia coli and *Streptococcus* species were the least with 2(20%) occurrence respectively. This result agreed with the report of higher percentage occurrence of lactic acid bacteria in *fura* and nunu respectively [1,36]. Also, it is reported that the lactic acid bacteria are the predominant organisms in cereal fermentation [2,37]. Moreover, lactic acid bacteria have been found to predominate the fermentation of maize and sorghum for ogi production [15,22]. Although, *Staphylococcus aureus*, *Klebisiella* species, *Proteus* species, *Bacillus* species, *Pseudomonas* species, *Escherichia coli* and *Streptococcus* species have been isolated from *fura* and other cereal based foods as shown by researchers, their presence as contaminants are treat to public health, hence the need for proper hygienic measures during preparation and storage of *fura* foods [1,15,22,38].

Conclusion

The present study has shown high bacteria, coliforms and staphylococcal load in the commercial *fura* samples studied. Also, it has shown the presence of potential pathogenic bacteria which are of public health significance. These organisms are associated with unhygienic environments, poor handling during processing, marketing and storage. Therefore, there is need for regulation and public enlightenment to enable *fura* to be produced in a hygienic environment and with good manufacturing practice to avoid outbreak of diseases that could be associated with the organisms encountered in this study.

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