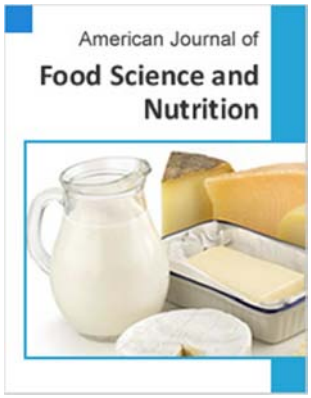
American Journal of Food Science and Nutrition
2017; 4(4): 48-51
http://www.aascit.org/journal/ajfsn
ISSN: 2375-3935

AASCIT American Association for Science and Technology



Keywords
Bacterial Quality,
Sorghum,
Fermentation,
Lactic Acid Bacteria,
Ogi

Received: April 29, 2017
Accepted: July 11, 2017
Published: August 25, 2017

Some Studies on the Bacteriological Quality of Sorghum-Based Commercially Prepared Fermented Ogi (Akamu) in Wukari, Nigeria

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Citation
Alloysius Chibuike Ogodo, Ositadinma Chinyere Ugbogu, Dawn Ify Agwaranze, Faith Unekwuojo Ihiabe. Some Studies on the Bacteriological Quality of Sorghum-Based Commercially Prepared Fermented Ogi (Akamu) in Wukari, Nigeria. *American Journal of Food Science and Nutrition*. Vol. 4, No. 4, 2017, pp. 48-51.

Abstract
The bacteriological characteristics of commercially prepared sorghum-based ogi (akamu) in Wukari metropolis was evaluated and compared with the laboratory prepared sorghum based ogi. A total of nine samples were purchased within Wukari and assessed for bacterial load and the presence of bacteria using standard microbiological methods. The result shows that the total viable bacteria count of the commercial ogi ranged from 1.2 x 10^7 cfu/g to 1.5 x 10^8 cfu/g. The coliform count ranged from 4.0 x 10^6 cfu/g to 4.0 x 10^7 cfu/g. Staphylococcal count ranged from no bacterial growth to 7.5 x 10^6 cfu/g. The lactic acid bacteria count ranged from 4.3 x 10^7 cfu/g to 1.5 x 10^8 cfu/g. The bacteria load in the laboratory prepared ogi showed a total count of 2.5 x 10^7 cfu/g, no coliform and staphylococcal growth, and lactic acid bacteria count of 1.0 x 10^8 cfu/g. The most frequently isolated bacteria species are *Staphylococcus* species, *Klebsiella* species, *Escherichia coli, Lactobacillus* species, *Leuconostoc* species, *Micrococcus* species *and Pediococcus* species. The occurrence of the organisms show that *Staphylococcus* sp. was present in samples B, C, E, G and I, *Klebsiella* sp. was present in samples B and D, *Escherichia coli* was present in samples A and H, *Lactobacillus* spp. was recovered from all the samples, *Lactococcus* sp. was present in samples B, D and H, *Micrococcus* spp was recovered from samples C, E, G and H, *Leuconostoc* sp. was present in sample F and the control while *Pediococcus* sp. was recovered from sample F, I and control. The presence of some potential pathogenic organisms in some of the commercially prepared sorghum-based ogi is of public health concern. Therefore, there is the need to incorporate good hygiene and sanitary measures in the production of this ogi so as to minimise bacteria contamination during processing and storage of the sorghum-based ogi.

1. Introduction

Sorghum (*Sorghum bicolor*) serves as an important food crop in arid and semi-arid

and can be used to solve one of the major concerns in Africa-Malnutrition [1, 2]. Sorghum is a dietary staple of more than 500 million people in more than 30 countries of the semi-arid tropics and Africa as serves majorly as weaning food for low income and high income countries [3-6]. It is used for food, fodder and production of alcoholic and non-alcoholic beverages, which is widely consumed by the young and old as it serves as a good source of energy, protein, minerals, antioxidant, vitamins, and gluten-free diet [7]. Sorghum grain contains phosphorus, potassium and magnesium in different amounts [6, 8].

The preparation of sorghum-based ogi is a fermentation function of numerous lactic acid bacteria which include *Leuconostoc, Lactobacillus, Streptococcus, Pediococcus,* and *Micrococcus* species [9]. Supplements can be added to the sorghum-based ogi to enhance its nutritional quality and composition [2]. Sorghum flour can also be produced by drying and milling sorghum-based ogi [10]. The wet fermented porridge from sorghum is prepared and consumed as ogi, akamu and akasan amongst the Yorubas, Ibos, and Hausas in the West, East and Northern Nigeria respectively [11]. Ogi are consumed by lactating mothers to stimulate the production of breast milk and is also prescribed as a semi-solid food for nursing the sick as it is light and easily digestible [12].

However, consumption of ogi can also serve as a medium for infection due to microbial contamination. Ogi can be contaminated during processing at the point of milling, storage or as a result of the hygiene of the producer. It can also be contaminated from materials used in the production process such as water and utensils [9, 13]. Maize porridge samples prepared for infants in Ghana were reported to be contaminated with *Aeromonas*, *Bacillus cereus*, *Salmonella*, *Staphylococcus aureus* and *Vibrio cholerae* [14]. Although the traditional fermentation processing of ogi wet paste gives the unique taste for which the product is loved, the wet storage methods of this prepared paste permit microbial growth including pathogens [15]. Therefore, the aim of this study is to compare the bacteriological qualities of commercially and laboratory prepared fermented ogi (akamu) prepared from sorghum.

2. Materials and Methods

2.1. Source of Materials

A total of nine (9) samples of commercially prepared fermented sorghum-based ogi were bought from Wapan-Nghaku area of Wukari, Taraba State, Nigeria. The samples were wrapped in polyethene bags to avoid further contamination, and were brought to the Microbiology laboratory, Federal University Wukari within an hour of purchase for analysis. *Sorghum bicolor* (red variety), were obtained from Wukari new market and used to prepare sorghum-based ogi in the laboratory as control.

2.2. Preparation of Sorghum-Based Ogi in the Laboratory

The sorghum-based ogi was prepared according to the method of [2]. The sorghum grains were sorted and cleaned. Exactly 2 kg of the *Sorghum bicolor* was weighed and steeped in 5 litres of distilled water at room temperature for three (3) days. The steeped grain was regained by draining off the steeping water, and then wet milled using an electric milling machine. Excess water was then added to the milled sorghum, to make it slurry. This was allowed to settle, sour and form the ogi slurry. The surface water was decanted and the sediment (wet slurry) was collected in a bowl and allowed to stand for 10-12 h to sufficiently solidify [11]. The prepared ogi was then stored in a sterile plastic container in the refrigerator at 4°C for further use.

2.3. Bacteriological Analysis of Ogi Samples

The commercially and laboratory prepared ogi samples were analyzed bacteriologically to evaluate their sanitary state following a modification of the method described by Ogodo *et al.* (2015). Exactly 1g of each of the ogi samples dissolved in 9 ml of normal saline to obtain a ten-fold serial dilution. Exactly 0.2 ml aliquot was then removed and transferred to Nutrient Agar, MacConkey Agar, Mannitol Salt Agar, and de Man Rogosa and Sharpe Agar plates using the pour plate technique. Plates were incubated aerobically for 24 hours at 37°C while the MRS agar was incubated anaerobically. After 24 hours of incubation, plates were inspected for bacteria growth and then counted. Each cultured plate was examined for distinct colonies. These were then subcultured unto freshly prepared agar medium and incubated at 37°C for 24 h to obtain pure cultures. Pure cultures obtained were identified using the method of [16].

3. Results

The bacteria loads of the laboratory prepared ogi showed a total bacteria growth of 2.5 x 10^7 cfu/g, no coliform and staphylococcal growth, and lactic acid bacteria count of 1.0 x 10^8 cfu/g (Table 1).

Table 1. *Bacterial Load of Laboratory Prepared Sorghum Based Ogi.*

Media Used	Bacteria Count (CFU/g)
Nutrient agar	2.5×10^7
Mannitol salt agar	NBG
MacConkey agar	NBG
De Man Rogosa and Sharpe agar	1.0×10^8

Key: NBG = No bacteria growth

Table 2 presents the bacteria count for the commercially prepared sorghum-based ogi. The result showed that the total viable bacteria count ranged from 1.2 x 10^7 cfu/g to 1.5 x 10^8 cfu/g. The total coliform count ranged from 4.0 x 10^6 cfu/g to $4.0x10^7$ cfu/g. The staphylococcal count ranged from no bacteria growth in samples A, D and H to 7.5 x 10^6 cfu/g

(sample B). The lactic acid bacteria count ranged from 4.3 x 10^7 cfu/g to 1.4 x 10^8 cfu/g.

Table 2. *Bacterial Load of Commercially Prepared Sorghum-Based Ogi.*

Samples	MA (CFU/g)	MRS (CFU/g)	NA (CFU/g)	MSA(CFU/g)
A	4.0×10^6	1.2×10^8	1.2×10^7	NBG
B	1.0×10^7	4.3×10^7	3.5×10^7	7.5×10^6
C	1.5×10^7	6.0×10^7	2.9×10^7	1.5×10^6
D	2.7×10^7	1.0×10^8	3.7×10^7	NBG
E	1.2×10^7	1.2×10^8	5.0×10^7	1.2×10^6
F	1.9×10^7	7.0×10^7	1.0×10^8	1.0×10^6
G	4.0×10^7	1.4×10^8	1.5×10^8	3.0×10^6
H	4.0×10^7	7.5×10^7	6.0×10^7	NBG
I	2.5×10^7	8.5×10^7	7.5×10^7	2.0×10^6

Key: NBG = no bacterial growth, MA=MacConkey agar, MSA =Mannitol salt agar, MRS = de Man Rogosa and Sharpe agar, NA= nutrient agar, CFU/g; colony forming unit/gram

Table 3 presents the occurrence of the bacteria isolated from the various samples. The result showed that *Staphylococcus* species was isolated from samples B, C, E, G and I, respectively, *Lactobacillus* species was isolated from all the samples as well as the control sample *Micrococcus* species was isolated from sample C, E, F, G, and H respectively, *Pediococcus* species was isolated from sample F and I, *Lactococcus* species was isolated from sample B, D, and H, *Leuconostoc* species was isolated from sample F only, *Streptococcus* species from sample D and the control sample only, *Escherichia coli* was isolated from sample A and H respectively, with *Klebsiella* species isolated from sample B and D respectively.

The percentage occurrences of the isolates shows that *Staphylococcus* species and *Micrococcus* species are the most common (19.23%), followed by *Lactobacillus species* (11.54%) while *Leuconostoc* species was the least (3.58%) (Table 4).

Table 3. *Occurrence of Bacterial Isolates in the Commercial and Laboratory Prepared Ogi Samples.*

Bacterial isolates	A	B	C	D	E	F	G	H	I	CONTROL
Staphylococcus species	-	+	+	-	+	-	+	-	+	-
Lactobacillus species	+	+	+	+	+	+	+	+	+	+
Micrococcus species	-	-	+	-	+	-	+	+	-	-
Pediococcus species	-	-	-	-	-	+	-	-	+	+
Lactococcus species	-	+	-	+	-	-	-	+	-	+
Leuconostoc species	-	-	-	-	-	+	-	-	-	+
Streptococcus species	-	-	-	+	-	-	-	-	-	+
Escherichia coli	+	-	-	-	-	-	-	+	-	-
Klebsiella species	-	+	-	+	-	-	-	-	-	-

Present: +, absent: -

Table 4. *The Percentage Occurrence of the Isolated Bacteria in the Various Samples.*

Isolate	Percentage (%)
Staphylococcus species	15.15
Lactobacillus species	30.30
Micrococcus species	1.21
Pediococcus species	9.09
Lactococcus species	9.09
Leuconostoc species	6.06
Streptococcus species	6.06
Escherichia coli	6.06
Klebsiella species	6.06

4. Discussion

The outbreak of infections and communicable diseases in tropical parts of the world is primarily as a result of food poisoning due to microbial contamination [17]. They are often responsible for acute gastroenteritis, abdominal discomfort, pain and diarrhea in infants and young adults [11].

The present study evaluated the bacteriological characteristics and qualities of ogi prepared from sorghum and marketed in Wukari metropolis using the laboratory prepared ogi as control. In the present study, the laboratory prepared ogi which served as the control showed minimal bacterial count with increased lactic acid bacteria count. Similar observations have been reported by other researchers [9, 18]. No coliform and staphylococcal growth was observed for the laboratory prepared ogi. This is an indication that the sample was prepared aseptically.

However, in the present study, the commercially prepared sorghum based ogi samples showed rather high bacteria counts with sample A having the lowest count of 1.2 x 10^7 CFU/g while sample G had the highest count of $1.5x10^8$CFU/g. These high bacteria counts can be due to the growth and multiplication of inherent microorganisms present in the raw material used in the production of the ogi [19]. Also, it could be attributed to bacteria contamination during storage, processing, handling [9, 20], especially from processing water since pipe borne potable water is lacking in the area of study.

Bacteria isolated from the various ogi samples include *Staphylococcus* species, *Lactobacillus* species, *Micrococcus* species, *Pediococcus* species, *Lactococcus* species, *Leuconostoc* species, *Streptococcus* species, *Escherichia coli, and Klebsiella* species. Similar observation has been reported by [9] who reported the presence of *Leuconostoc, Klebsiella, Escherichia coli*, *Lactobacillus* and *Micrococcus* species from ogi prepared with maize. This report is also in line with the work of [21] who studied the microbial quality of ogi prepared from cereals sold in Bauchi markets, and isolated *Klebsiella*, *Staphylococci*, *Lactobacillus* and *E. coli*. The presence of *Klebsiella, Escherichia coli* and *Micrococcus* species could be attributed to unhygienic preparation environment, contamination of water used, contamination due to exposure in the market from which the products were obtained as well as

storage conditions (Ogodo *et al.*, 2015). The bacteria isolated from the laboratory prepared ogi were mainly lactic acid bacteria. This report is consistent with the work of Olorunfemi (2005) who evaluated the microbial quality of laboratory prepared ogi and isolated mostly lactic acid bacteria.

5. Conclusion

This study has shown that the chances of contracting foodborne diseases from commercially prepared ogi (akamu) are very high. Therefore, there is need for sanitary measures to be taken in the production of fermented cereals so as to minimize the rate of contamination during processing and storage.

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