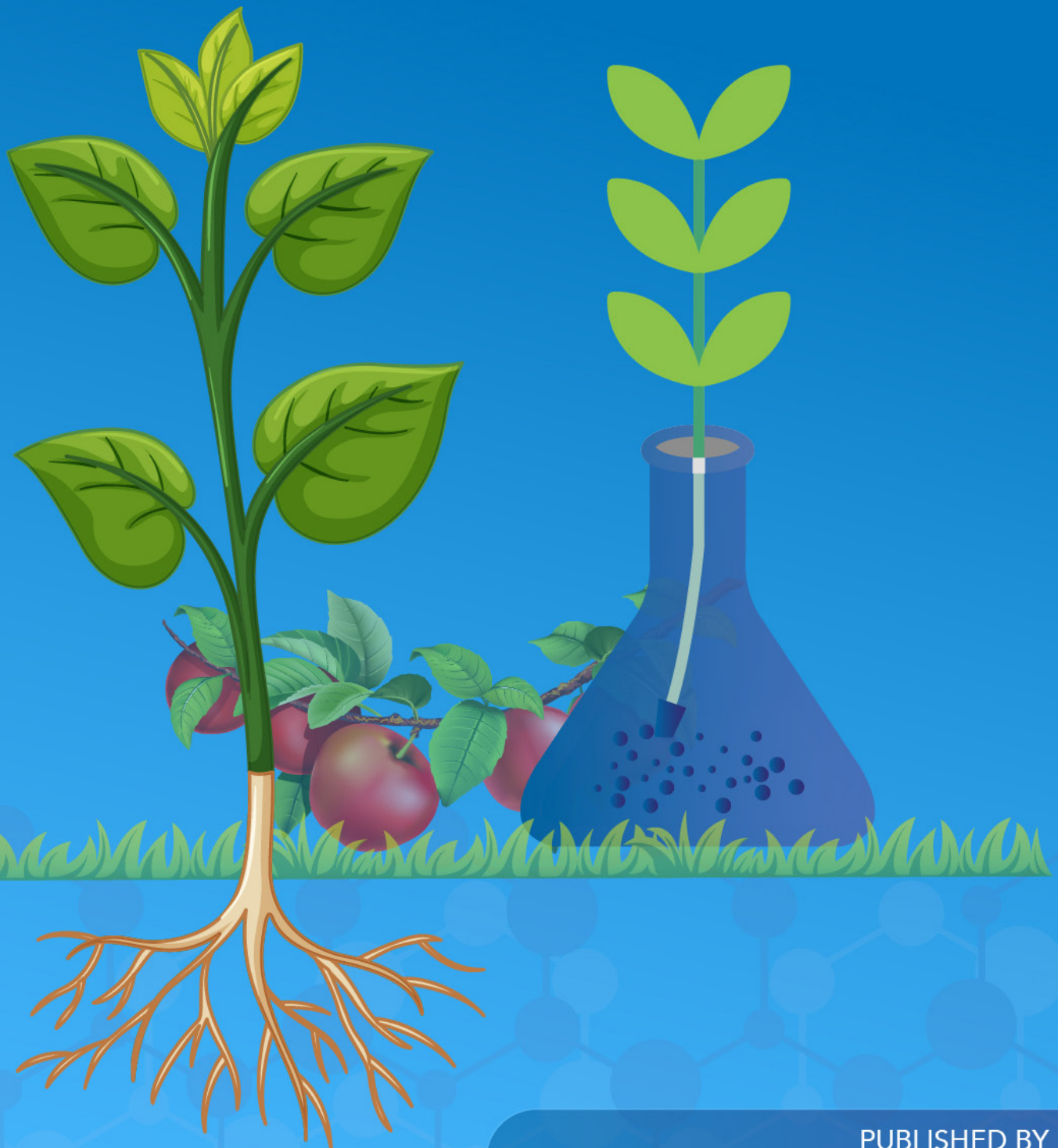




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## Antibiotic Susceptibility Pattern of Microorganisms Found in Fura De Nono Sold in Different Markets in Makurdi Benue State

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### ABSTRACT

Fura de Nono, a traditional fermented dairy and millet product popular in Nigeria, is widely consumed for its nutritional value. However, its production, often under unsanitary conditions, raises concerns about microbial contamination and public health risks. This study investigates the microbial load in Fura de Nono samples collected from local markets in Makurdi, Nigeria, assessing the presence of pathogenic bacteria and fungi. Using standard microbiological techniques, including colony counting and biochemical tests, the study identified harmful microorganisms such as *Escherichia coli*, *Staphylococcus aureus*, *Proteus vulgaris*, and *Salmonella* species. Antibiotic susceptibility tests revealed resistance in certain isolates, posing additional risks to consumers. The findings underscore the urgent need for improved sanitation practices among vendors, routine microbiological testing, and better regulatory enforcement to ensure food safety. The study concludes with policy recommendations to enhance hygiene practices and establish a certification system for vendors to protect public health.

### INTRODUCTION

Milk is a liquid secreted by mammary glands of the female mammals. It serves as an important source of protein than most other foods. Milk is not 100 percent source of protein, since it is relatively poor in sulphureted amino acids such as methionine (essential) and cysteine (non-essential) as well as tryptophan and histidine. Curiously, children need less methionine and cysteine than adult. Because of this, cow milk meets the protein requirements of infancy quite well. According to Wodnerkos and Yitayal (2003), milk is primarily composed of water, protein in colloidal suspension, lactose and lipids in emulsion, inorganic salts in solution, vitamins, enzymes, gases, and other things. Along with being a great provider of calcium and phosphorus for healthy bones and teeth, milk also has notable levels of riboflavin, vitamin B1, vitamin B6, vitamin B12, and vitamin A (Yirsaw, 2004). Milk provides a range of essential nutrients, including carbohydrates, proteins, fats, vitamins, and minerals, all of which contribute to its high nutritional value. The specific composition of milk varies depending on the species, but cow's milk typically contains around 3.4% protein, 3.6% fat, and 4.6% lactose, providing about 68 kcal per 100 g (Goff & Douglas, 2010). The carbohydrate lactose is the primary sugar found in milk, contributing to its sweet flavor and providing a readily digestible energy source. Additionally, lactose aids in calcium absorption, promoting bone health (Muir *et al.*, 1992).

The protein content in milk is composed of two main types: casein and whey. Casein accounts for about 80% of the protein in milk and is responsible for its white color and ability to form curds, which is essential in cheese production (Goff, 2010). Whey proteins, although less

abundant, are water-soluble and offer a high biological value due to their complete amino acid profile, making them highly nutritious and easily digestible. Milk fat, meanwhile, varies depending on factors such as feed and environmental conditions but is rich in essential fatty acids and provides the characteristic texture and richness to dairy products (Goff, 2010).

In many African countries, including Nigeria, Nono—a fermented milk product made from locally sourced cow milk—plays a significant role in local diets. Nono is made from non-pasteurized cow milk collected in a container called calabash, and allowed to ferment naturally for 24 hours (Uzeh, 2006). It is categorized into two types, with the term “nono” commonly referring to the type known as kindirimu. Another notable product, Fura da Nono, combines this fermented milk with a cereal mix made from millet, creating a nutritious beverage enjoyed for its taste and health benefits. Milk if not given the right conditions because of its high-water activity and nutritional content, it serves as a wonderful medium for many different types of microorganisms to grow. (Mesfin *et al.*, 2017). If milk is not handled properly, it can become contaminated easily and deteriorate quickly.

Fura da Nono is fermented milk-cereal mix that is highly nutritious on a two in one beverage product. It consists of a cereal Fura and Nono which is a locally fermented milk with a consistency that is thick but not quite as thick as yoghurt. Traditionally Fura da Nono is usually prepared by mashing millet into powdery form and mixing the powdered millet with hot water in a bowl to make dough, allowing the dough to cool and solidify and finally mixing the mashed millet (fura) with fermented milk (nono) and served to customer (Abbas *et al.*, 2020).

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Fura is a porridge typically made from cereal grain millet (*Pennisetum glaucum*). There are a variety of millets that are specially used for Fura production. Millets 'gero' is one of the commonly used varieties.

The preparation process involves powdering millet together with other spices like pepper and ginger, and then shaping the mixture into tiny balls by compressing between the two palms after adding a little amount of hot water. Next the dough is then boiled for about 30 minutes in boiling water and and coated with the remaining dried flour (Jideani *et. al.*, 2010). The dough ball can be served by mashing them into fermented milk (nono) or water, sugar may be added to taste.

This local milk product in Nigeria is mainly carried out by Nomadic Fulani's from the Northern part of the country in villages where the producers are ignorant of the life and safety standard of the product but distribute it at will to consumers (Okonkwo, 2011). Fulani men milk the cows and thereafter, distribute the milk to the women in the encampment (Fulani farm stead) who later process the milk into various product like Fura da Nono, cheese and fermented milk (nono) etc. (Uzeh *et al.*, 2006).

The consumer's expectation of processed milk is that it should have the typical appearance of milk, be free from extraneous matter and should have a clean and slightly sweet taste, with no abnormal odors or taints. Apart from the microbial flora of raw milk being of great importance as regards to hygiene and food safety, raw milk should be unadulterated and free of taints contaminants. Since nono is produced by illiterate Fulani's in villages with poor knowledge of shelf-life and safety standards, handlers of these products may unknowingly introduce pathogenic microorganisms into the products during milking and also by using unsanitized milking equipment. since the products does not undergo further processing before being sold for consumption, it makes the food a potential source of health risk for consumers. Many dairy products, even those made from pasteurized milk have been associated with food borne diseases. In developing countries like Nigeria, it has been unusual to find microorganisms in Fura da Nono drinks. This is because milk is an excellent medium for microbial growth and also because of improper handling in Fura da Nono production. Raw milk and raw milk products can be contaminated with bacteria that can cause serious illness, hospitalization or death. These harmful bacteria include *Campylobacter jejuni*, *Bacillus cereus*, *Shiga toxin producing E. coli* (*E.coli* O157:H7), *Coxiella burnetii*, *Listeria monocytogenes*, *Mycobacterium tuberculosis*, *Mycobacterium bovis*, *Mycobacterium avium subspecies paratuberculosis*, *Salmonella spp*, *Yersinia enterocolitica*, and certain strains of *Staphylococcus aureus* which are capable of producing highly heat-stable toxins Brucella, streptococcus pyogenes (Anyanwu, 2019; Fagbemigun, 2021) Once the microbes get into the milk, they multiply rapidly because milk is an excellent medium for their growth (Okonkwo, 2011). The presence of coliform bacteria in Fura da Nono drinks could be due to the presence of dough. This is a source of concern in Nigeria because consumers have a strong

preference for this traditionally produced and processed milk and millet products. It is therefore suggested that the microbial analysis of Fura da Nono should be carried out periodically as quality assurance measures. The addition of growth-inhibiting ingredients, adjusting the storage conditions to hinder the growth of microorganisms, and proper sanitation at every stage of handling and processing will help reduce the microbial level of Fura da Nono contamination (Shehu *et al.*, 1990; Shehu *et al.*, 2000).

Relevant agencies like NAFDAC should put in place an irreducible minimum standard to producers and need to ensure and enforce strict compliance to this minimum standard all for production sectors in Nigeria. This research was aimed at evaluating the resistance or susceptibility pattern of microorganisms isolated from fura de nono using standard antibiotics kit.

## MATERIALS AND METHODS

### Sample Collection

A total of 20 samples of nono and fura were purchased from Fulani hawkers using random sampling method from two different locations: North Bank and Wadata markets within Makurdi metropolis. purchase samples were transported to the university microbiology laboratory in sterile corked plastic tubes packed in iced container where analysis was carried out within two hours of collection.

### Microbiological Analysis

Tenfold serial dilution of Fura da Nono samples were made before being place on the media to count for colonies. Inoculation of Fura samples was done using spread plate techniques while that of nono was done using the pouring plate techniques. Aliquot of 0.1ml of dilutions of  $10^2$  and  $10^{10}$  of each Fura samples were pipette aseptically and dropped on a freshly prepared media and surface plated. The following media were used to isolate and count the organisms: Nutrient Agar (NA) (Biotech Lab. Ipswich, UK) for total aerobic and anaerobic microorganism counts, Eosine Methylene Blue Agar (EMBA) (Himedia Laboratories Pot Ltd, India) for *E. coli*, Desoxycholate Citrate Agar (DCA) for *Salmonella* and *Shigella* spp, Potato Dextrose Agar for Yeasts and mould counts, McConkey agar for total coliform counts, Man-Rogosa-Sharpe agar (MRS) for Lactic Acid Bacteria count, Mannitol Salt agar for staphylococcus aureus spp. All culture media were prepared according to manufacturer's instruction. Media were sterilized by autoclaving at 121°C for 15 min except DCA which involved only boiling over gauze. Using a digital illuminated colony counter (Gallen Kamp, Loughborough, Leicestershire, UK), plates containing 30-300 colonies were counted after incubation. The computed results were expressed as colony forming unit (cfu) per mL by multiplying the average number of colonies from the observed triplicates by the reciprocal of the dilution factor.

Number of organisms = number of colonies \* dilution factor/Volume of Inoculum.

### Identification of Isolates

Gram staining and microscopic identification: sub-cultured colonies on nutrient agar were gram stained. A small portion of 24 hours old colony was taken using a sterile wire loop and emulsified in a drop of distilled water on a clean glass slide and fixed by passing the smeared slide rapidly over a flame. The smear was covered with a crystal violet for about 30-60 seconds, rinsed with water and flooded with lugol's iodine for 30-60 seconds and then rinsed under a running tap, rapidly decolorized with acetone (75% alcohol reagent) for 30 seconds and then rinsed with water and then counter-stained with safranin (red) for 1 minute and rinse under a slow running tap then the slides were air dried. A drop of oil immersion was added to the sliding containing the specimen, it was observed under the microscope using x100 objective lens (Cheesbrough, 2003). Gram positive appeared purple while gram negative organisms appeared pink.

### Biochemical Identification of Isolates

The biochemical tests for the identification of the isolates were:

#### Motility Test

To determine whether an organism is motile or not.

#### Catalase Test

To determine the ability of an organism to produce catalase enzymes.

#### Oxidase Test

Use to identify bacteria that can produce cytochrome c oxidase, an enzyme of the bacteria electron chain.

#### Coagulase Test

To determine the ability of an organism to convert fibrinogen to fibrin in blood plasma.

#### Citrate Test

To determine if an organism is capable of utilizing citrates as its sole source of metabolism with resulting

alkalinization of the medium.

#### Indole Test

To detect the ability of an organism to break down tryptophan to pyruvate and indole.

#### Urease Test

To determine the ability of an organism to split urea in the presence of water to release ammonia and carbon(iv) oxide. The ammonia combines with CO<sub>2</sub> and H<sub>2</sub>O to form ammonium carbonate which turns the medium alkaline, turning the phenol red indicator from its original orange-yellow color to bright pink.

The biochemical test were carried out on isolates according to Cowan and Steel (1965) and Cheesbrough (2004) procedures.

#### Identification of fungi isolates

Fungi isolates were done using the method described by Benson, (1990). The fungal isolates underwent additional microscopy using acetone and lactophenol on cotton blue stain placed on a clean grease slide. Each isolate was confirmed using Microgen Identification. The cultural and morphological traits of the isolates, such as hyphae (septation), reproductive structure (sporangia/conidia) in chain or single, type of spore, etc., were observed and served as criteria used for identification.

#### Antibiotic Susceptibility Test

The isolated organisms were tested against routinely used commercially available antibiotics. The multi-susceptibility Optidisc (manufactured by Optun Laboratories, Nigeria Ltd, Aba) for gram positive and gram-negative organisms were used.

### RESULTS AND DISCUSSION

Table 1 describes the cultural and morphological characteristics of various bacterial isolates. Each bacterial species displays distinct features on nutrient agar (NA) and MacConkey agar (MA). For example, *Escherichia coli* appears flat and creamy with an even edge on NA, while

**Table 1:** Cultural and Morphological Characteristics of the Bacterial Isolates

NA	MA	Suspected Organism
Flat and creamy with an even edge.	Reddish pink, smooth circular LF colonies	<i>Escherichia coli</i>
Creamy smooth raised and very mucoid colonies	Very mucoid, pink and smooth, LF	<i>Klebsiella sp</i>
Creamy flat smooth colonies	Deep pink dull colonies with rough edges	<i>Lactobacillus sp</i>
Light green with fruits smell	Pale NLF colonies	<i>Pseudomonas sp</i>
Golden yellow, smooth mucoid and raised	Pink smooth LF colonies	<i>Staphylococcus aureus</i>
Creamy, shiny with putrefactive odour	Pale smooth and discrete NLF colonies with irregular edges	<i>Proteus sp</i>
Creamy flat smooth	Pale rough, shiny NLF colonies	<i>Salmonella sp</i>
Creamy brown flat and glittering colonies	Pink flat and dull face LF colonies	<i>Streptococcus sp</i>
Flat, creamy small and slightly rough shiny	Deep pink dull and small colonies	<i>Staphylococcus epidermidis</i>
Creamy and swarmy colonies	Pale, mucoid and smooth NLF colonies	<i>Proteus vulgaris</i>

key: LF= lactose fermenting, NLF= non lactose fermenting, NGO= No growth observed, SP= Species

on MA, it forms reddish-pink smooth circular colonies, indicating lactose fermentation (LF). Other organisms like Klebsiella sp. and Staphylococcus aureus are also lactose fermenters, showing pink smooth colonies. In contrast, Pseudomonas sp. and Proteus sp. are non-lactose fermenters (NLF), presenting pale, smooth, and

discrete colonies on MA. The table effectively highlights the variability in colony morphology across different species, which aids in their identification.

### Microscopic and Biochemical Test

**Table 2:** Microscopic and Biochemical Characteristics of the Bacterial Isolates

Gram Reaction	MOT	CAT	COA G	CIT	IND	URE	OXI	Suspected Organism
-ve rods in chains	+ve	+ve	-ve	+ve	+ve	-ve	-ve	Escherichia coli
+ve cocci in clusters	+ve	+ve	-ve	-	+ve	-	+ve	Staphylococcus aureus
+ve cocci in clusters	+ve	+ve	-ve	-	+ve	-	-ve	Staphylococcus epidermidis
+ve rods in chains	+ve	+ve	-ve	+ve	+ve	+ve	-ve	Lactobacillus sp
-ve rods in clusters and chains	-ve	+ve	+ve	+ve	+ve	+ve	-ve	Proteus sp
-ve rods in pairs and short chains	-ve	+ve	-ve	+ve	-ve	+ve	-ve	Klebsiella sp
-ve rods appearing singly and scattered	-ve	+ve	+ve	+ve	+ve	-ve	-ve	Salmonella sp
-ve rods in clusters and chains	-ve	+ve	+ve	+ve	+ve	+ve	+ve	Proteus sp
-ve rods slightly curved	-ve	+ve	+ve	+ve	+ve	-ve	+ve	Pseudomonas sp
+ve cocci in chains	-ve	-ve	+ve	-	+ve	+ve	+ve	Streptococcus sp

KEY: CIT = Citrate, IND = Indole, UREA = Urease, OXI = Oxidase, CAT = Catalase, MOT = Motility, SP Species COAG = Coagulase, -ve = Negative, - = Not done, +ve = Positive

Table 2 details the microscopic and biochemical characteristics of various bacterial isolates, focusing on their Gram reactions, motility, and enzyme activities. The Gram stain distinguishes bacteria as either Gram-positive or Gram-negative, with the latter staining pink. The motility test identifies bacteria that can move, with different patterns observed. Enzymatic tests like the catalase test, which detects the production of the catalase enzyme, show bubbling in positive results. Similarly, the coagulase test indicates enzyme production by clumping of the organism. These initial tests provide foundational data for bacterial classification.

Further biochemical tests like the indole, urease, and oxidase tests offer more precise identification. The indole test detects tryptophan breakdown, with a bright pink layer indicating a positive result. The urease test identifies bacteria that produce urease, turning the medium pink when positive. Finally, the oxidase test reveals cytochrome c oxidase activity, with a blue-purple color change within 10 minutes signaling a positive result. These biochemical characteristics are key to distinguishing species and are critical in clinical diagnostics.

### Percentage of Occurrences of Bacteria Isolates

**Table 3:** Percentage of Occurrences of Bacteria Isolates in Fura de Nono from Hawkers in North Bank Market

Isolates	Frequency of Bacterial Isolates (CFU/ml)	Percentage Occurrence (%)
Klebsiella sp	10	25.64
Proteus Vulgaris	12	30.76
Staphylococcus Epidermidis	2	5.12
E. Coli	4	10.25
Staphylococcus Aureus	2	5.12
Lactobacillus sp	7	17.94
Pseudomonas sp	2	5.12
<b>Total</b>	<b>39</b>	<b>100</b>

$X^2 = 28.00, DF = 16 (p < 0.05)$

The Table 3 above from the study presents the percentage of bacterial isolates found in “Fura de Nono” from hawkers at North Bank Market. It lists seven types of bacteria,

with Proteus vulgaris being the most prevalent at 30.76%, followed by Klebsiella sp at 25.64% and Lactobacillus sp at 17.94%. Other bacteria, such as E. coli, Staphylococcus

epidermidis, Staphylococcus aureus, and Pseudomonas sp, show much lower occurrences, all hovering around 5.12%. The total frequency of bacteria isolates was 39 CFU/ml,

and the statistical analysis yielded a Chi-square ( $X^2$ ) value of 28.00 with 16 degrees of freedom ( $p < 0.05$ ), indicating a significant distribution of these isolates.

**Table 4:** Percentage of Occurrences of Bacteria Isolates in Fura de Nono from Hawkers in Wadata Market

Isolates	Frequency of Bacterial Isolates (CFU/ml)	Percentage Occurrence (%)
Klebsiella sp	3	7.31
Proteus Vulgaris	3	7.31
Proteus sp	5	12.19
Streptococcus	3	7.31
<i>E. Coli</i>	8	19.51
Salmonella sp	3	7.31
Pseudomonas	2	4.87
Staphylococcus Aureus	4	9.75
Staphylococcus Epidermidis	3	7.31
Lactobacillus sp	4	9.75
<b>Total</b>	<b>41</b>	<b>100</b>

$X^2 = 40.00, DF = 16 (p < 0.05)$

The results from Table 4 provides data on the percentage occurrences of bacterial isolates in “Fura de Nono” sold by hawkers at Wadata Market. A total of 41 CFU/ml of bacterial isolates were recorded, with *E. coli* being the most prevalent at 19.51%. Other bacteria like *Proteus sp* accounted for 12.19%, while *Staphylococcus aureus* and *Lactobacillus sp* each made up 9.75% of the isolates. The

remaining bacteria, including *Klebsiella sp*, *Proteus vulgaris*, *Streptococcus sp*, and others, each had lower percentages around 7.31% or less. The Chi-square ( $X^2$ ) value of 40.00 with 16 degrees of freedom ( $p < 0.05$ ) suggests significant variation in the distribution of these isolates.

**Result of Susceptibility of the Bacterial Isolates**

**Table 5:** Antibiotic Resistance Pattern of the Bacteria Isolated from the Fura de Nono Sample

Antibiotics	Conc (mcg)	Klebsiella sp	Proteus vulgaris	Proteus sp	Streptococcus sp	E.coli sp	Salmonella sp	Pseudomonas	Staphylococcus aureus	Staph. epidermidis	Lactobacillus sp
Tarivid	10	20	21	24	8	16	25	10	23	25	35
Reflacine	10	25	20	16	26	30	5	12	30	28	18
Ciproflox	10	17	27	32	35	18	6	25	17	11	10
Augmentin	30	17	14	15	19	23	25	16	10	15	14
Gentamycin	10	14	21	17	12	13	14	20	15	23	21
Streptomycin	30	15	20	14	22	16	10	24	21	30	25
Ceporex	10	13	20	23	10	18	24	23	17	20	12
Nalidixic acid	30	15	24	14	20	10	12	11	29	22	15
Septtrin	30	20	29	21	10	16	13	12	26	15	16
Amplicin	30	12	15	11	10	25	16	15	11	17	15
Pefloxacin	10	39	29	32	20	35	22	27	28	12	13
Gentamycin	10	20	15	18	10	17	30	35	14	12	19
Ampliclox	30	15	10	13	16	20	30	25	26	28	11
Zinnace	20	21	22	27	10	15	12	35	38	25	27
Amoxicilin	30	8	15	12	11	39	21	25	17	35	20
Ciproflaxacin	25	37	31	30	25	15	13	39	16	23	24

Streptomycin	10	38	33	15	18	38	25	20	18	15	34
Septtrin	30	20	12	10	17	30	21	28	18	16	12
Erthromycin	10	20	14	12	11	15	17	30	19	17	35
Rocephin	25	35	16	20	23	14	27	25	36	13	14

KEY: CIT = Citrate, IND = Indole, UREA = Urease, OXI = Oxidase, CAT = Catalase, MOT = Motility, SP Species COAG = Coagulase, -ve = Negative, - = Not done, +ve = Positive

**Microscopic and Biochemical Test**

Antibiotic resistance profiles of isolates show that Klebsiella sp was highly sensitive to Pefloxacin (39 mm), streptomycin (38 mm), Ciproflaxacin (37mm) and Rocephin (37 mm). It was highly resistant to Amoxicillin (8mm).

Proteus sp were sensitive to streptomycin and resistant to most other antibiotic tested.

S. aureus was more sensitive to Reflacine (30mm). Nalixidic acid (29mm). Zinnacef (38mm).

Rocephin (36mm). The organism was resistant to Augmentin (10mm), Ampicilin (11mm)

Streptococcus sp was more sensitive to ciprofloxac (35mm). Reflacin (26mm), Ciproflaxacin.

(25mm). The organism was resistant to zinnacef (10mm),

Gentamicin (10mm), Ampicillin (10mm), Scepttrin (10mm), Tarivid (8mm).

E. coli was more sensitive to Reflacine (30mm), pefloxacin (35mm).

Amoxicillin (39mm), Streptomycin (38mm), Scepttrin (30mm). The organism was resistant to Nalixidic acid (10mm).

Salmonella sp was sensitive to Gentamicin (30mm), Ampiclox (36mm) and was resistant to Reflacine (5mm). Ciprofloxac (6mm).

Pseudomonas was sensitive to Gentamycin (35mm), Zennacel (35mm).

Ciproflaxacin (39mm), Erythromycin (30mm). The organism was resistant to Tarivid (10mm).

The result from Table 6 outlines the macro and micro

**Table 6:** Macro and Micro Characteristics of Fungal isolates on Potatoes Dextrose Agar

Colony Characteristics	Microscopic Appearance Suspected Fungal	Suspected Fungal
Gray, blackish-brown or black surface with gray periphery, black on reverse	Colorless, septet with chains of micro conidia	Alternaria
Bluish-green with Sulphur yellow areas on the surface	Septate hyphae with chains of radiate conidia on conidiophores	Aspergillus sp
Creamy and yellowish colonies which are pasty and glittering	Round conidia occurring singly and in small clusters with pseudo-hypae	Candida sp
White to dark gray mycelium with profuse cottony growth	Elliptical spores, colorless and non-septet hyphae with sporangiospores.	Mucor sp
Blue to green moldy and velvety appearance with milky- white on reverse.	Conidiophores bears sterigma with chains of conidia, parallel in arrangement.	Penicillium sp
White colony growth with black spots on the tip, some gray.	Non-septet colorless hyphae and mycelium with rhizoid and solon sporangiospores present	Rhizopus sp
Rapidly growing, flat, smooth, moist, dull and creamy colonies which are large and circular.	Unicellular multilateral and ellipsoid blastoconidia	Saccharomyces's

characteristics of fungal isolates on Potato Dextrose Agar, detailing both colony characteristics and microscopic appearances of various fungi. For instance, Alternaria presents with a grayish-black surface, while microscopically showing colorless septate with chains of micro conidia. Aspergillus sp is bluish-green with sulfur-

yellow areas and has septate hyphae with radiate conidia. Candida sp displays creamy yellow colonies, while Penicillium sp is blue-green with a velvety appearance. The table provides a clear comparison of colony morphology and microscopic traits, aiding in fungal identification based on both visual and microscopic features.

**Table 7:** Mean Bacteria Count for Fura De Nono Samples Collected from Different Locations in Makurdi CFU/ml

Sample	S aureus	Lactic acid bacteria	Salmonella shigella	Total viable counts	Coliform counts	Escherichia coli	Total Fungal count
Nono	1.00 ± 0.63°	42.40 ± 9.77°	6.00 ± 3.84°	7.00 ± 3.53°	1.40 ± 0.67°	1.80 ± 0.96°	6.00 ± 1.14°
Fura	4.20 ± 1.74°	44.20 ± 29.89°	179.40 ± 150.42°	224.601 ± 66.08°	158.80 ± 72.50°	98.80 ± 14.77°	6.60 ± 1.88°

Nono 2	0.80± 0.80°	233.80± 108.86°	1480± 12.02°	288.80± 5.57°	53.40± 29.19°	111.40± 97.35°	7.40±0.74°
Fura 2	52.40± 26.49°	32.40± 110.18°	316.80± 88.42°	500.00± 0.00°	30.00± 180.41°	455.20± 85.12°	9.20±3.00°

\*\*values are Mean Standard error of mean (n 5)

Values for a given group in a column followed by same letter as superscript are not significantly different according to Duncan's multiple comparison procedure (at p 0.05).

The result from Table 7 compares the mean bacterial count of Fura De Nono samples collected from different locations in Makurdi, showing the presence of various bacteria such as *S. aureus*, lactic acid bacteria, *Salmonella shigella*, coliforms, *E. coli*, and total fungal counts. The bacterial counts vary significantly across samples. For instance, Nono 2 has the highest lactic acid bacteria count (233.80 CFU/ml), while Fura 2 exhibits the highest total viable counts (500.00 CFU/ml) and *E. coli* (455.20 CFU/ml). These variations highlight the microbial differences based on sample location and type, with some counts exceeding typical safety thresholds, suggesting potential contamination risks.

### CONCLUSION

The microbial analysis of Fura de Nono samples collected from various locations in Makurdi, Benue State, Nigeria, indicates significant bacterial contamination, posing a public health risk. High levels of bacteria such as *Escherichia coli*, *Staphylococcus aureus*, and *Proteus vulgaris* were found, with certain bacterial counts exceeding safe limits. These findings suggest inadequate hygiene practices during the preparation, storage, and sale of Fura de Nono by local vendors. The variability in bacterial counts across different samples highlights inconsistent sanitary measures and a lack of proper food safety protocols among vendors. This situation creates the potential for foodborne illnesses and underscores the need for immediate action to safeguard public health.

### Recommendations

To address the public health risks posed by contaminated Fura de Nono in Makurdi, several policy measures should be introduced. First, it is essential to improve sanitation practices among vendors. The Benue State government, in collaboration with health authorities, should develop and implement food safety training programs targeting Fura de Nono producers and sellers. These programs should cover proper handling, personal hygiene, and the use of clean, potable water during preparation. Additionally, the enforcement of hygiene standards must be strengthened through regular inspections and the application of penalties for non-compliance.

Second, the introduction of routine microbiological testing is necessary to ensure the safety of dairy products sold in local markets. Health authorities should conduct regular, random checks on Fura de Nono sold by vendors, testing for harmful bacteria such as *E. coli* and *Salmonella*.

These tests will help in identifying contamination early and preventing unsafe products from reaching consumers. Public health awareness campaigns should also be launched to inform both vendors and consumers about the risks associated with poor hygiene in dairy production. Consumers need to be educated on recognizing safe products and purchasing from reliable vendors, while vendors should be encouraged to adopt best practices to maintain the safety of their products.

Furthermore, a certification system should be established to regulate Fura de Nono vendors. Only vendors who meet the required food safety and hygiene standards should be granted a license to sell, ensuring that consumers can trust the quality of their purchases. This regulatory framework would not only improve food safety but also promote the economic well-being of certified vendors.

Finally, cold chain infrastructure must be implemented to maintain the quality and safety of Fura de Nono throughout its transportation and sale. Keeping the product at lower temperatures can significantly reduce bacterial growth, thereby minimizing the risk of contamination. The provision of adequate refrigeration and storage facilities for vendors, especially during transportation, would play a crucial role in ensuring food safety in Makurdi and beyond.

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