Microbiological Quality of Locally Prepared Kunu Sold in Selected Markets in Makurdi, Benue State, Nigeria

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ABSTRACT

Kunu is a popular traditional non-alcoholic beverage consumed widely in Nigeria, but its largely informal production and handling may expose the drink to microbial contamination. This study assessed the microbiological quality of locally prepared kunu sold in selected markets in Makurdi, Benue State, Nigeria. Six kunu samples were collected from vendors in Wurukum, Modern and International markets, with two samples obtained from each market. Samples were collected aseptically in sterile 250 mL containers, transported in coolers and analysed in the laboratory within two hours. Bacterial and fungal contaminants were isolated and identified using culture, morphological and biochemical techniques. The bacterial colony counts ranged from 1.14 × 10^5 to 1.82 × 10^5 CFU/g, with sample W2 recording the highest bacterial count. The bacterial isolates identified included Escherichia coli, Bacillus spp., Salmonella spp., Shigella spp., Streptococcus spp. and Staphylococcus spp. Escherichia coli was the most frequently reported bacterial isolate, accounting for 30.77% of the isolates, while Bacillus spp. and Salmonella spp. each accounted for 23.08%. Fungal contamination was also detected in all samples, with counts ranging from 6 × 10^3 to 1.2 × 10^4 CFU/g. Aspergillus spp. was the predominant fungal isolate, accounting for 62.5% of the fungal isolates, while Nucer spp. accounted for 37.5%. One-way analysis of variance showed a statistically significant difference in bacterial contamination among the samples (F = 19.34, P = 0.002), whereas the difference in fungal contamination was not statistically significant at the 5% level (F = 13.46, P = 0.06693). The findings demonstrate that locally prepared kunu sold in the sampled markets contained bacterial and fungal contaminants of public health importance. Improved hygiene, use of treated water, proper handling, refrigeration, routine microbiological monitoring and stronger quality-control measures are recommended to improve the safety of locally prepared kunu in Makurdi.

KEYWORDS

Kunu, microbiological quality, bacterial contamination, fungal contamination, food safety, Makurdi

I. INTRODUCTION

Kunu is a traditional non-alcoholic cereal-based beverage widely consumed in Nigeria. It is prepared mainly from cereals and is valued for its nutritional and refreshing properties. The beverage is commonly produced at household and small-scale commercial levels and is sold in markets and other public places.

The traditional preparation of kunu involves several processing stages, including soaking, milling, sieving, gelatinization, fermentation, sweetening and packaging. Because production is often carried out on a small scale, standardized hygienic practices may not always be consistently applied. The use of contaminated water, inadequately cleaned utensils, poor personal hygiene and improper packaging can introduce microorganisms into the beverage. Previous studies have reported a wide range of microorganisms associated with kunu. Ezekiel *et al.* (2019), for example, reported *Lactobacillus*, *Bacillus*, *Streptococcus*, *Staphylococcus*, *Escherichia coli*, *Aspergillus*, *Penicillium*, *Fusarium* and *Saccharomyces* among microorganisms associated with kunu drinks. Similarly, Adebayo-Tayo *et al.* (2016) reported bacterial organisms including *Staphylococcus*, *Streptococcus*, *Bacillus*, *Pseudomonas* and *E. coli*, as well as fungal organisms including *Fusarium*, *Aspergillus*, *Penicillium* and yeast in kunu drinks.

Microbial contamination is particularly important because some microorganisms can cause foodborne disease, while others contribute to spoilage and deterioration of beverage quality. The high moisture content of kunu can support microbial growth, especially when the beverage is stored for prolonged periods under ambient conditions. The thesis notes that kunu has a relatively short shelf life at ambient temperature and that refrigeration and appropriate processing can extend its storage life. *Escherichia coli* is of particular concern because its detection in food or beverages may indicate inadequate sanitary conditions or faecal contamination. The organism includes both harmless strains and pathogenic variants capable of causing disease. Fungal contamination also presents a food-safety concern. *Aspergillus* species are commonly associated with food deterioration, and some species can produce mycotoxins. The presence of such organisms in a beverage therefore warrants appropriate attention to processing and storage conditions.

Despite the widespread consumption of kunu in Makurdi, information on the microbiological quality of locally prepared kunu sold in some of the city's major markets remains limited. This study therefore assessed the bacterial and fungal quality of kunu sold in Wurukum Market, International Market and Modern Market in Makurdi, Benue State. The study specifically sought to isolate and identify microbial contaminants, determine microbial loads and compare contamination levels among the sampled products. The selected markets were considered important commercial centres for traditional food and beverage sales in Makurdi.

The study aims to evaluate the microbiological quality of locally prepared kunu sold in some markets in Makurdi. The specific objectives are: to isolate and identify microbial contaminants present in kunu samples from selected markets, to compare the microbial load of kunu vendors in the study area, to assess the hygienic practices of kunu vendors in the study area.

II. MATERIALS AND METHODS

A. Study Area

The study was conducted in Makurdi, the capital of Benue State, North-Central Nigeria. Samples were collected from three major markets: Wurukum Market, International Market and Modern Market. These markets serve as important centres for the sale and distribution of traditional food and beverages.

B. Sample Collection

Six fresh kunu samples were purchased from selected vendors. Two samples were obtained from each market, giving a total of six samples. The samples were collected aseptically into sterile 250 mL containers, appropriately labelled and transported in coolers to the microbiology laboratory. Laboratory analysis was conducted within two hours of collection.

The samples were coded as follows:

- W1 and W2 – Wurukum Market
- INT1 and INT2 – International Market
- NB1 and NB2 – Modern Market

C. Microbiological Analysis

The materials used included sterile sampling bottles, coolers, Petri dishes, inoculating loops, pipettes, test tubes, incubators, autoclave, microscope and microbiological media including Nutrient Agar, MacConkey Agar, Eosin Methylene Blue Agar, Sabouraud Dextrose Agar and Mannitol Salt Agar. Biochemical test reagents included catalase, indole, citrate, and urease and coagulase test reagents. Serial dilutions of the samples were prepared and inoculated onto appropriate culture media. For *E. coli* and coliform assessment, serial dilutions were inoculated onto Violet Red Bile Agar and incubated at 37°C for 48 hours. Presumptive colonies were subsequently characterized using biochemical tests.

Bacterial isolates were characterized using cultural, morphological and biochemical characteristics. The biochemical tests included catalase, coagulase, citrate, urease and indole tests. Fungal isolates were cultured on Potato Dextrose Agar and identified based on colony colour, shape and other morphological characteristics

D. Statistical Analysis

The data were analysed using SPSS version 20. One-way analysis of variance (ANOVA) was used to compare the microbial contamination levels among samples. A probability value of $P < 0.05$ was considered statistically significant.

III. RESULTS

A. Bacterial Colony Counts and Identified Isolates

The bacterial colony counts varied among the six kunu samples. The total bacterial counts ranged from 1.14×10^5 to 1.82×10^5 CFU/g. Sample W2 recorded the highest bacterial count (1.82×10^5 CFU/g), while NB2 recorded the lowest (1.14×10^5 CFU/g).

Table 1. Bacterial colony counts and morphological characteristics of isolates from kunu samples

Sample	Total Colony Count (CFU/g)	Colony Characteristics	Suspected Organisms
W1	1.40×10^5	Creamy on NA; yellowish on MSA; green metallic sheen	*Bacillus* spp., *Staphylococcus* spp., *E. coli*
W2	1.82×10^5	Green metallic sheen on EMBA; blackish on DCA	*E. coli*, *Salmonella* spp.
INT1	1.40×10^5	Pinkish on MSA; blackish and pinkish/yellow colonies on DCA	*Streptococcus* spp., *Salmonella* spp., *Shigella* spp.
INT2	1.30×10^5	Creamy on NA; green metallic sheen on EMBA	*Bacillus* spp., *E. coli*
NB1	1.62×10^5	Blackish on DCA; green metallic sheen on EMBA	*Salmonella* spp., *E. coli*
NB2	1.14×10^5	Creamy on NA; yellow on MSA	*Bacillus* spp., *Staphylococcus* spp.

Source: Laboratory results from the study.

The results show that W2 had the highest bacterial load, followed by NB1, while NB2 had the lowest. The occurrence of green metallic sheen on EMBA in several samples was associated with presumptive *E. coli* colonies.

B. Fungal Colony Counts and Isolates

Fungal contamination was detected in all six kunu samples. The fungal counts ranged from 6×10^3 to 1.2×10^4 CFU/g.

Table 2. Fungal colony counts and morphological characteristics of isolates from kunu samples

Sample	Fungal Colony Count (CFU/g)	Colony Characteristics	Suspected Organisms
W1	7×10^3	Greenish, blackish and whitish on PDA; circular	*Aspergillus* spp., *Nucer* spp.
W2	9×10^3	Greenish and blackish on PDA; circular and irregular	*Aspergillus* spp.
INT1	1.0×10^4	Greenish and blackish on PDA; circular	*Aspergillus* spp.
INT2	8×10^3	Whitish on PDA; circular and irregular	*Nucer* spp.

NB1	6×10^3	Greenish, blackish and whitish on PDA	*Aspergillus* spp., *Nucer* spp.
NB2	1.2×10^4	Greenish and blackish on PDA	*Aspergillus* spp.

Source: Laboratory results from the study.

The highest fungal count was recorded in NB2 (1.2×10^4 CFU/g), followed by INT1 (1.0×10^4 CFU/g), while the lowest count occurred in NB1 (6×10^3 CFU/g). *Aspergillus* spp. was the predominant fungal isolate and was detected in all six samples.

C. Biochemical Characteristics of Bacterial Isolates

The biochemical characteristics used to support the identification of the bacterial isolates are presented in Table 3.

Table 3. Biochemical characteristics of bacterial isolates

Organism	**Catalase**	**Coagulase**	**Citrate**	**Urease**	**Indole**	**Shape**
E. coli	+	−	−	−	+	Rod
Bacillus spp.	+	−	0	−	+	Rod
Salmonella spp.	+	−	+	−	−	Rod
Shigella spp.	+	−	−	−	−	Rod
Staphylococcus spp.	+	+	−	+	—	Cocci

Source: Laboratory biochemical tests.

The biochemical results supported the identification of the bacterial isolates. *E. coli* was catalase and indole positive but citrate and urease negative. *Salmonella* spp. was catalase and citrate positive but indole negative, while the *Staphylococcus* isolate was catalase and coagulase positive.

D. Frequency and Percentage of Bacterial Isolates

A total of 13 bacterial isolates were recorded

Table 4. Frequency and percentage occurrence of bacterial isolates

Bacterial isolate	**Number**	**Percentage (%)**
Bacillus spp.	3	23.08
E. coli	4	30.77
Salmonella spp.	3	23.08
Shigella spp.	1	7.69
Staphylococcus spp.	2	15.38
Total	13	100.00

Source: Study laboratory results.

E. coli had the highest frequency of occurrence (30.77%), followed by *Bacillus* spp. and *Salmonella* spp. at 23.08% each. *Shigella* spp. had the lowest frequency at 7.69%.

E. Frequency and Percentage of Fungal Isolates

Eight fungal isolates were reported from the six samples.

Table 5. Frequency and percentage occurrence of fungal isolates

Fungal isolate	Number	Percentage (%)
Aspergillus spp.	5	62.5
Nucer spp.	3	37.5
Total	8	100.0

Source**:** Study laboratory results.

Aspergillus spp. was the predominant fungal isolate, accounting for 62.5% of the isolates, while *Nucer* spp. accounted for 37.5%.

F. Analysis of Variance

Table 6. ANOVA for bacterial contamination

Source of variation	SS	df	MS	F	P-value
Between groups	756.9	1	756.9	19.34	0.002
Within groups	313.05	8	39.13		
Total	1069.95	9			

The ANOVA showed a statistically significant difference in bacterial contamination among the groups because P = 0.002 was less than 0.05.

Table 7. ANOVA for fungal contamination

Source of variation	SS	df	MS	F	P-value
Between groups	2116	1	2116	13.46	0.06693
Within groups	314.5	2	157.25		
Total	2430.5	3			

The difference in fungal contamination was not statistically significant at P < 0.05, because the reported P-value was 0.06693.

IV. DISCUSSION

The present study demonstrated that all six locally prepared kunu samples examined contained bacterial and fungal contaminants. The bacterial counts ranged from 1.14×10^5 to 1.82×10^5 CFU/g. The variation in bacterial load among samples indicates that contamination was not uniform across the sampled products. The highest bacterial count was observed in W2 (1.82×10^5 CFU/g), while NB2 had the lowest count (1.14×10^5 CFU/g). Differences in microbial load may be associated with variations in processing, handling, sanitation, water quality, and packaging and storage conditions. The thesis similarly identifies preparation and storage conditions as possible contributors to the observed differences.

The isolation of *E. coli* from several samples is of particular importance. *E. coli* was the most frequently occurring bacterial isolate, representing 30.77% of all bacterial isolates. The presence of the organism may indicate inadequate sanitary conditions during preparation or handling. The green metallic sheen observed on EMBA in samples associated with *E. coli* further supported its presumptive identification. The detection of *Salmonella* spp. and *Shigella* spp. is also important because these organisms are associated with foodborne illness. Their presence in a ready-to-consume beverage suggests that inadequate hygienic conditions during production or handling could expose consumers to potential health risks.

The occurrence of *Bacillus* and *Staphylococcus* species further indicates environmental and handling-related contamination. Similar microbial diversity has been reported in earlier studies of kunu. Edward et al. (2019) reported *Bacillus*, *Staphylococcus*, *E. coli*, *Aspergillus*, *Penicillium* and *Fusarium* among microorganisms associated with kunu, while Adebayo-Tayo et al. (2016) also reported *Staphylococcus*, *Streptococcus*, *Bacillus* and *E. coli* in kunu drinks. Fungal contamination was also observed in all the samples. The counts ranged from 6×10^3 to 1.2×10^4 CFU/g. *Aspergillus* spp. was the dominant fungal isolate, accounting for 62.5% of the isolates. This agrees with the observation in the thesis that *Aspergillus* was widespread across the sampled kunu.

The presence of *Aspergillus* spp. may contribute to fungal spoilage. However, because this study did not directly test for mycotoxins, the presence of *Aspergillus* should not be interpreted as confirmation that aflatoxin was present in the samples. The statistical analysis showed that bacterial contamination differed significantly among the samples ($F = 19.34$, $P = 0.002$). This indicates substantial variation in bacterial contamination between the groups assessed. In contrast, fungal contamination did not differ significantly at the 5% level ($F = 13.46$, $P = 0.06693$). Thus, while fungal loads varied numerically, the available data do not provide sufficient statistical evidence to conclude that the groups differed significantly in fungal contamination.

The findings reinforce the importance of good hygiene during kunu preparation. The thesis recommends vendor hygiene training, use of clean water, proper storage, improved regulation and periodic microbiological monitoring.

V. CONCLUSION

The study demonstrated that locally prepared kunu sold in selected markets in Makurdi contained considerable bacterial and fungal contamination. Bacterial counts ranged from 1.14×10^5 to 1.82×10^5 CFU/g, with W2 recording the highest bacterial load. The bacterial isolates included *E. coli*, *Bacillus* spp., *Salmonella* spp., *Shigella* spp. and *Staphylococcus* spp. *E. coli* was the most prevalent bacterial isolate at 30.77%.

Fungal counts ranged from 6×10^3 to 1.2×10^4 CFU/g, with *Aspergillus* spp. being the predominant fungal isolate at 62.5%. The significant difference observed in bacterial contamination indicates variation in the microbiological quality of the sampled kunu products. Although fungal contamination varied between samples, the difference was not statistically significant at the 5% level.

Overall, the findings indicate that improved sanitation, safe water, hygienic packaging, appropriate storage and routine microbiological monitoring are necessary to improve the safety of locally prepared kunu in Makurdi.

RECOMMENDATION

- Kunu vendors should receive regular training on food hygiene and safe handling practices.
- Only clean and treated water should be used during kunu preparation.
- Production utensils and containers should be properly washed and sanitized before use.
- Kunu should be stored under appropriate refrigerated conditions where possible to reduce microbial proliferation.
- Vendors should avoid prolonged storage of kunu at ambient temperature.
- Relevant regulatory agencies should strengthen monitoring and quality-control measures for locally prepared beverages.
- Consumers should be encouraged to purchase kunu from vendors who maintain good personal and environmental hygiene.
- Further studies should involve a larger number of samples, more markets and repeated sampling over different seasons to provide a broader assessment of the microbiological quality of kunu in Makurdi.

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