Comparative Analysis of Microbial Load in Beske (Tofu) from Roadside Vendors in Two Selected Locations in Ibadan

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ABSTRACT

Background: *Beske (tofu) is a widely consumed, protein-rich food in Nigeria, commonly sold under varying hygienic conditions. While it is a popular street food, its display and handling raise concerns about microbial contamination and potential public health risks.*

Objective: *This study evaluated and compared the microbial load of beske (tofu) obtained from roadside vendors in two selected locations (Dugbe and Mokola) in Ibadan, using a laboratory-prepared sample as a control.*

Methodology: *A comparative laboratory study was conducted on beske samples collected from Dugbe (DUG) and Mokola (MKL) in Ibadan, alongside samples produced at the Nigerian Stored Products Research Institute (NSPRI). Microbiological analyses were performed to determine total viable bacteria count, coliform count, Escherichia coli count, and total fungal count using standard culture and plate count methods. Results were expressed as colony-forming units per gram (CFU/g).*

Results: *DUG and MKL samples recorded Total Viable Bacteria Count and Coliform Count values of* $>1.00 \times 10^{6}$ *CFU/g, indicating high microbial contamination, whereas the NSPRI sample recorded a Total Viable Bacteria Count of* 1.25×10^{4} *CFU/g and a Coliform Count of 0.00 CFU/g. Escherichia coli Count was 0.00 CFU/g in all samples. The highest Total Fungal Count was recorded in MKL* (3.03×10^{5} *CFU/g), while the NSPRI sample recorded the lowest Total Fungal Count* (2.50×10^{3} *CFU/g).*

Conclusion: *Roadside-vended beske from the study area harbours excessive microbial loads and poses potential health risks, whereas hygienically processed beske is safer. Improved sanitation practices and strengthened regulatory monitoring are recommended.*

Keywords: *Beske* (Tofu), Microbial load, Food safety, Street-vended foods, Hygienic processing

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INTRODUCTION

Soybean (*Glycine max* L.) has been cultivated for thousands of years and remains one of the world's most important food crops because of its rich nutritional value and versatility (1,2). Many foods are made from soy, such as soy milk, soy cheese, soy yogurt, and textured vegetable protein, and they are widely appreciated for providing good-quality protein, essential minerals, vitamins, and fibre while staying low in saturated fats (3). In Nigeria, one of the most popular soy-based foods is *beske* (Tofu). It is affordable, protein-dense, and commonly used as a substitute for meat. In addition to its affordability, *beske* is an important source of plant-derived nutrients that can support dietary protein intake and improve nutritional quality. Its nutritional value, however, depends not only on its composition but also on maintaining acceptable quality throughout processing and handling (3,4,5). Typically, *beske* is produced by curdling hot soymilk with an acidic coagulant, then pressing the curd into a semi-firm gel (4,5).

The final quality of *beske* depends strongly on how it is processed. Choices such as the type of coagulant used, the cleanliness of equipment, water quality, and general hygiene can influence both the texture and safety of the product (6,7). Because *beske* has high moisture and protein content, it spoils easily if proper hygiene is not maintained during preparation or handling. This is one of the reasons its shelf life is usually two to three days, especially when made at household or small-scale levels where sanitation may not be consistent (8,9).

In many Nigerian communities, *beske* is sold as a street food, often displayed in open environments and handled under varying hygienic conditions. While street foods serve millions of people every day, an estimated 2.5 billion globally (10), their safety largely depends on how they are prepared, stored, and sold. Exposure to dust, flies, contaminated water, dirty utensils, and poor handling practices can increase the chances of microbial contamination (11).

In developing countries such as Nigeria, these concerns are even more pronounced. Ready-to-eat foods are often prepared in environments where potable water is not readily available, and many food handlers have limited knowledge of personal and environmental hygiene (12). Studies have shown that street food vendors in places such as Benin City display inadequate understanding of food hygiene and safety requirements, and their actual hygiene practices fall short of recommended standards (13). Similar evaluations conducted in Lagos Mainland revealed varying levels of microbial contamination in commonly consumed snacks, highlighting ongoing public health risks associated with street-vended foods (14).

When contaminated foods are consumed, they may cause foodborne illnesses, which typically manifest as vomiting, diarrhea, stomach pain, or fever. In severe cases, these illnesses can be dangerous, especially for children, pregnant women, and the elderly (15).

Given the rising popularity of *beske* and the safety concerns surrounding street-vended foods, there is a clear need to assess how hygienic the product really is when sold in open markets. This study therefore compares the microbial load of *beske* purchased from roadside vendors in Ibadan with samples produced under sanitary conditions at the Nigerian Stored Products Research Institute (NSPRI). The findings aim to evaluate the sanitary quality of *beske* using microbial indices and underscore the importance of improving hygiene practices among local producers and vendors.

MATERIALS AND METHODS

Sample Collection

Three beske samples each were purchased randomly from two major vending locations in Ibadan, Oyo State: Dugbe and Mokola Roundabout. A laboratory-prepared beske sample was obtained from the Nigerian Stored Products Research Institute (NSPRI), Ibadan, where it was processed under hygienic conditions following standard protocols. All samples were collected aseptically using sterile polyethylene bags, labeled, and transported in insulated containers to the Microbiology Laboratory of NSPRI for immediate analysis (within 4 hours of collection).

Production of Beske

Beske was prepared following the method of (16) with minor modifications. Cleaned and dehulled soybeans (1.5 kg) were milled into a paste, mixed with water, and filtered to obtain soy milk. The milk was boiled for 20 minutes, coagulated with vinegar, and the resulting curds were drained, seasoned, pressed, and allowed to firm. The solidified curd was then cut into pieces and deep-fried in hot oil until golden brown.

Sample Preparation and Serial Dilution

The samples were blended aseptically with a sterile mortar and pestle. Ten grams (10 g) of each *beske* sample was aseptically homogenized in 90 mL of sterile 0.1% peptone water to obtain a 10^{-1} dilution. Serial dilutions were then prepared up to 10^{-6} by transferring 1 mL aliquots into successive test tubes containing 9 mL of sterile diluent.

For each dilution, 0.1 mL aliquots were plated in triplicate using the pour-plate technique on appropriate growth media. Plates were gently swirled to ensure even distribution of the inoculum.

Microbiological Analyses

Total viable bacteria were enumerated using Potato Dextrose Agar (PDA) and incubated at 37 °C for 24 h (17). Total coliform count was cultured on MacConkey Agar and incubated at 37 °C for 24 h (18). Presumptive *Escherichia coli* isolates were recovered on Eosin Methylene Blue (EMB) Agar and incubated at 37 °C for 24 h (19). Fungi were cultured on Sabouraud Dextrose Agar (SDA) and incubated at 25–28 °C for 48 h (20). Developed colonies of discrete organisms were observed and counted after incubation, as described by (8)

Enumeration of Microbial Load

After incubation, plates showing between 30 and 300 colonies were selected for enumeration. Colony counts were recorded, and the mean value from triplicate plates was used to calculate colony-forming units per gram (CFU/g) using the formula:

$$\mathrm{CFU/g} = \frac{number\ of\ colonies\ \times Dilution\ factor}{volume\ of\ culture} \times \frac{total\ number\ of\ intial\ supension\ in\ mL}{intial\ sample\ weight\ in\ grams}$$

Identification of Isolates

Distinct colonies were subcultured on fresh media to obtain pure isolates. Bacterial isolates were characterized based on colonial morphology, Gram reaction, and biochemical tests including catalase, oxidase, indole, methyl red, Voges-Proskauer, citrate utilization, and urease tests. Fungal isolates were identified microscopically using lactophenol cotton blue stain and compared with standard mycological keys (Plates 1 to 3).

RESULT

Total Microbial Counts

As shown in Table 1, Roadside samples from DUG and MKL exhibited extremely high Total Viable Bacteria Count and Coliform Count values of $>1.00 \times 10^6$ CFU/g, indicating substantial contamination likely resulting from poor handling and environmental exposure. In contrast, the NSPRI sample recorded a Total Viable Bacteria Count of 1.25×10^4 CFU/g and a Coliform Count of 0.00 CFU/g, reflecting proper sanitary control during preparation (Table 2). *Escherichia coli* Count was 0.00 CFU/g in all samples, suggesting the absence of faecal contamination. Total Fungal Count was considerably higher in the roadside samples, with 3.03×10^5 CFU/g for MKL and 1.01×10^5 CFU/g for DUG, compared with 2.50×10^3 CFU/g for the NSPRI sample. These findings indicate that roadside-vended beske from the study area may pose potential public health risks, whereas samples produced under controlled hygienic conditions exhibited lower microbial counts and are considered safer for consumption.

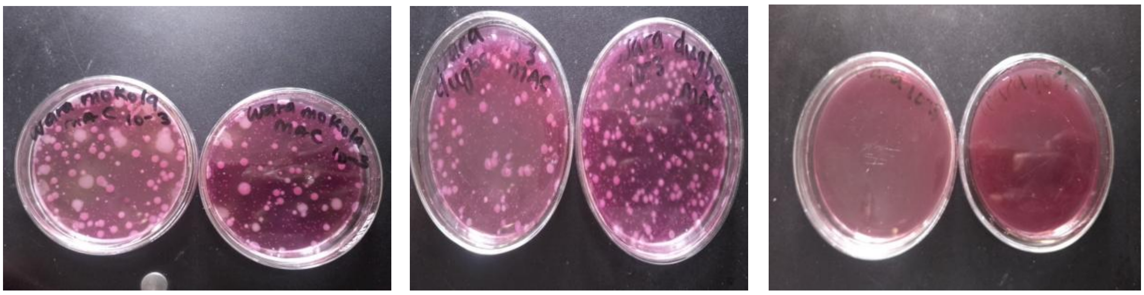

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Plate 1: A. Coliform Growth in *Beske* from Mokola on MacConkey Agar, B. Coliform Growth in *Beske* from Dugbe on MacConkey Agar, C. Coliform Growth in *Beske* Prepared in NSPRI on MacConkey Agar

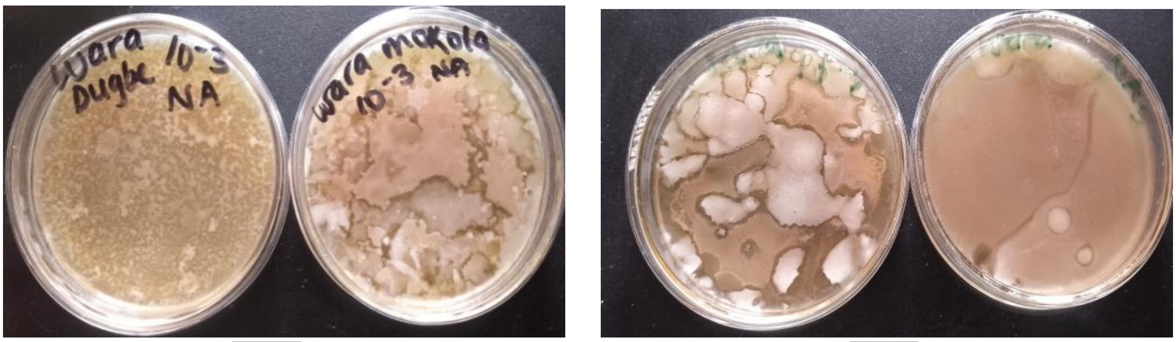

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Plate 2: A. Fungal Growth in *Beske* from Mokola and Dugbe on Sabouraud Dextrose Agar. B. Fungal Growth in *Beske* Prepared in NSPRI on Sabouraud Dextrose Agar

a b c

Plate 3: A. Bacterial Growth in *Beske* from Dugbe on Potato Dextrose Agar. B. Bacterial Growth in *Beske* from Mokola on Potato Dextrose Agar. C. Bacterial Growth in *Beske* Prepared in NSPRI on Potato Dextrose Agar

Table 1: Microbial Analysis of *beske* Samples from Different Sources

Sample Source	Total Bacterial Count	Coliform Count	*E. coli* Count	Total Fungal Count (CFU/g)
Dugbe (Roadside)	$>1.00 \times 10^6$	$>1.00 \times 10^6$	0.00	1.01×10^5
Mokola (Roadside)	$>1.00 \times 10^6$	$>1.00 \times 10^6$	0.00	3.03×10^5
NSPRI (Laboratory-prepared)	0.00	0.00	0.00	2.50×10^3

Table 2: Morphological Characteristics of Microbial Isolates from *beske* Samples

Sample Source	Microbial Type	Colony Count (CFU/g)	Colony Morphology
NSPRI (Laboratory-	Bacteria	1.25×10^4	Swarming colonies
Mokola (Roadside)	Bacteria	$>1.00 \times 10^6$	Creamy, swarming, and whitish colonies with flat, irregular shape
Dugbe (Roadside)	Bacteria	$>1.00 \times 10^6$	Creamy, swarming, and whitish colonies with flat, irregular shape
Mokola (Roadside)	Coliform	$>1.00 \times 10^6$	Large, flat, and mucoid colonies
Dugbe (Roadside)	Coliform	$>1.00 \times 10^6$	Large, elevated, mucoid, and pinkish colonies with regular edges
Mokola (Roadside)	Fungi (Yeast)	3.03×10^5	Creamy, raised colonies resembling yeast on PDA
Dugbe (Roadside)	Fungi (Yeast)	1.01×10^5	Creamy colonies resembling yeast on PDA
NSPRI (Laboratory-prepared)	Fungi (Yeast)	2.50×10^3	Small, smooth colonies resembling yeast on PDA

DISCUSSION

The microbial analyses revealed that the *beske* samples obtained from the two roadside sampling locations (DUG and MKL) were heavily contaminated with bacteria and fungi, whereas the NSPRI-processed sample showed a considerably lower Total Viable Bacteria Count (1.25×10^4 CFU/g) and a Coliform Count of 0.00 CFU/g (Table 1). The high Total Viable Bacteria Count and Coliform Count values ($>1.00 \times 10^6$ CFU/g) recorded for the DUG and MKL samples suggest that *beske* produced and sold in uncontrolled environments often exhibits high microbial loads due to poor hygiene and environmental exposure (21). (22) similarly reported that most commercial *beske* samples contained total viable count greater than 10^6 CFU/g and coliform levels exceeding 10^3 CFU/g, underscoring contamination risks associated with inadequate processing and handling.

Across Nigeria and other developing nations, the bacterial contamination trend has been repeatedly observed and attributed to similar causes. (23) linked the poor microbial quality of locally processed soy products to unhygienic preparation areas and exposure to dust and flies during sales, while (24) found in a meta-analysis that ready-to-eat foods in developing nations frequently exceed acceptable bacteriological limits due to insufficient hygiene and lack of temperature control. (25) emphasized that these challenges persist in urban markets where limited regulatory oversight and poor vendor practices continue to compromise food safety. The issue extends beyond Nigeria, as newer studies have provided regional evidence on soy-based street foods. (26) reported that commercial soy cheese (*beske*) skewers sold by vendors in Cameroon exhibited total mesophilic aerobic bacterial counts ranging from 4.87 to 7.79 log CFU/g (approximately 7.4×10^4 to 6.2×10^7 CFU/g). These studies affirm that inadequate sanitation, poor handling, and the absence of proper temperature management remain major contributors to bacterial contamination in soy-based foods. Similarly, (27) demonstrated that *beske* produced under controlled sanitary conditions and adequate heat treatment maintained microbial loads well within safe limits throughout storage, emphasizing the crucial role of production hygiene and temperature management in ensuring product safety.

Fungal contamination, particularly by yeasts and moulds, poses a serious threat to *beske* quality and safety due to the product's high moisture and nutrient content, which favor fungal proliferation and spoilage (28). The presence of these fungi is particularly concerning, as some species are capable of producing mycotoxins that can lead to food poisoning. (29,30).

Beske is a high-moisture product that is highly perishable and susceptible to post-processing contamination. (31) demonstrated that cold-tolerant and heat-resistant organisms such as *Bacillus* species can survive and proliferate in packed *beske* under poor storage conditions, suggesting that hygienic preparation alone is insufficient without proper storage and protection from dust, flies, and high temperatures during sale.

From a public health perspective, both the present findings and reviewed literature converge on similar risk-management priorities. Effective interventions include vendor hygiene training, the use of clean water, refrigeration or rapid product turnover to minimize ambient exposure, improved packaging and display to prevent contamination, and stronger regulatory oversight. These strategies are strongly supported by (32), who identified vendor hygiene, raw material quality, preparation and storage environments, packaging, and enforcement of food safety regulations as key determinants of street-vended food quality and safety in developing countries.

CONCLUSION

The findings indicate that the *beske* samples obtained from the two roadside sampling locations (DUG and MKL) had excessive microbial contamination compared with the NSPRI-processed sample. To ensure the safety of *beske* produced at these sampling locations, production should be carried out under strict sanitary conditions, and the product should be properly processed before sale. It is also important to educate vendors at these sampling locations on hygienic handling practices, appropriate storage temperatures, reduced time between preparation and marketing, and improved packaging methods. Implementing and enforcing these safety measures will enhance the microbiological quality of *beske* produced at these sampling locations and help minimize the incidence of foodborne illnesses among consumers.

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