AJBAR Vol. 5(3), June 2026: 1-5, ISSN: 2811-2881

Arid Zone Journal of Basic and Applied Research
Faculty of Science, Kashim Ibrahim University
Maiduguri, Nigeria

Journal homepage: https://www.azjournalbar.com

Research Article

Mycological Quality and Aflatoxin Contamination of Commercially Available Fermented Maize Pap (Ogi/Akamu) Sold in Zaria Metropolis, Nigeria

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ARTICLE INFO:

Keywords:
Pap,
Ogi,
Aflatoxin B_1,
Nigeria,
Fungal contamination.

ABSTRACT

Fermented maize pap (commonly known as *ogi* or *akamu*) is widely consumed in Nigeria as a staple breakfast meal and as a complementary food for infants and young children. However, inadequate processing and poor storage conditions may predispose this product to fungal contamination and mycotoxin exposure. This study evaluated the proximate composition, mycological quality, and aflatoxin B_1 contamination of commercially available pap sold in Zaria metropolis. Ten pap samples were randomly collected from two locations, Samaru and Kwangila. Proximate composition was determined using standard AOAC methods, while fungal load and diversity were assessed using culture-based techniques. Aflatoxin B_1 levels were quantified using enzyme-linked immunosorbent assay (ELISA). Moisture content ranged from 73.14 ± 3.74% to 77.87 ± 2.88%. Fungal counts ranged from 2.0×10^4 to 2.0×10^5 cfu/mL, exceeding the permissible limit (1.0×10^4 cfu/mL) established by NAFDAC. Identified fungal species included *Aspergillus flavus*, *Aspergillus niger*, *Trichosporon*, and *Microsporum*. The average mean aflatoxin B_1 concentrations were 5.02 µg/kg and 7.93 µg/kg for Samaru and Kwangila samples respectively, with one sample exceeding the regulatory limit of 20 µg/kg established by the Standards Organisation of Nigeria. The results suggest that pap sold in Zaria may pose potential public health risks due to fungal contamination and aflatoxin exposure. Improved hygiene practices and regulatory monitoring are recommended to ensure food safety.

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INTRODUCTION

Fermented cereal foods play a major role in the diets of many African populations, particularly in Nigeria. One of the most widely consumed fermented cereal products is pap (also known as ogi or akamu), a semi-liquid gruel produced from fermented maize, millet, or sorghum (Parvin *et al.*, 2014). Pap is commonly

consumed as a breakfast meal by adults and is frequently used as a complementary food for infants and young children during the weaning period due to its soft texture and ease of digestion (Abdus-Salaam *et al*., 2015). Its high carbohydrate content provides quick energy, making it suitable for breakfast or as a light, easily digestible meal. Pap is often used to introduce infants to weaning at 5–6 months of age, typically when they weigh at least 4.5 kg (Parvin *et al*., 2014). Consequently, weaning food plays a pivotal role in mitigating malnutrition among infants.

Despite its nutritional importance, pap is susceptible to microbial contamination during processing, fermentation, and storage. Traditional pap production typically involves steeping maize grains in water for several days, wet milling, fermentation, sieving, and sedimentation. These processes are often carried out under unhygienic conditions, which may expose the product to contamination by bacteria, yeasts, and filamentous fungi (WHO, 1993; Tetteh *et al*., 2004).

Among microbial contaminants, toxigenic fungi represent a major food safety concern. Species such as *Aspergillus flavus* and *Aspergillus parasiticus* are well known for their ability to produce aflatoxins, toxic secondary metabolites commonly associated with maize and other cereal crops. Aflatoxin B_1, the most potent member of the aflatoxin group, has been classified as a Group 1 human carcinogen by the International Agency for Research on Cancer due to its strong association with hepatocellular carcinoma (Adetunji *et al*., 2017; Navale *et al*., 2021).

Although several studies have reported fungal contamination and aflatoxin occurrence in maize and other cereal products in Nigeria, data on the mycological quality and aflatoxin contamination of pap sold at the point of consumption remain limited in northern Nigeria. In this study two sampling sites (Samaru and Kwangila) were selected because they are major commercial centers with likely differences in environmental conditions and handling practices. Therefore, this study aimed to evaluate the proximate composition, fungal contamination, and aflatoxin B_1 levels of commercially available pap sold in Zaria metropolis.

MATERIALS AND METHODS

Study Area

The study was conducted in Zaria, Kaduna State, located in north-western Nigeria (11.1110° N, 7.7220° E).

Sample Collection

Ten (10) Vendors were randomly selected. The sampling was done on a single day where by prepared pap samples were purchased from each vendor in Samaru (n=5) and Kwangila (n=5). Samples were collected aseptically in sterile containers and transported to the microbiology laboratory for analysis.

Proximate Analysis

Proximate composition including moisture, ash, crude protein, crude fat, crude fibre, and carbohydrate content was determined according to standard methods of AOAC International (2019) using AOAC methods 925.10, 923.03, 984.13, 945.16, 962.09 and 986.25 respectively.

Isolation and Identification of Fungi

Ten millilitres (10mL) of each pap sample were homogenized in 90 mL sterile distilled water and serially diluted up to 10^{-6}. Aliquots were plated on Potato Dextrose Agar and incubated at 27 °C for 3–5 days. Fungal counts were performed in duplicate and the average were expressed as colony-forming units per millilitre (cfu/mL). Fungal isolates were identified based on colony morphology and microscopic characteristics using lactophenol cotton blue staining (Watanabe, 2010).

Aflatoxin Detection

A quantitative enzyme linked immunosorbent Assay (ELISA) Kit from Beacon manufacturers was used with a detection range around 0.0 µg/kg – 40.0 µg/kg and detection limit of 1.0 µg/kg. Aflatoxin B_1 was extracted using 70% methanol and quantified using ELISA. Absorbance was measured at 405 nm using a microplate reader, and toxin concentrations were calculated using a standard calibration curve.

Statistical Analysis

Data were analyzed using SPSS version 23. Results were expressed as mean ± standard deviation. Independent t-tests were used to compare means between locations, and statistical significance was set at $p < 0.05$.

RESULTS

The proximate composition of pap samples from Samaru and Kwangila is presented in Table 1

Samaru samples had higher mean carbohydrate (18.46±0.30%) and protein (0.59±0.02%) contents, while Kwangila samples had higher lipid (5.72±0.10%) and moisture (77.87±1.10%) contents. Ash content was slightly higher in Samaru (0.77± 0.05%) than Kwangila (0.60±0.04%). The fungal load of pap samples ranged from 2.0×10^4 to 2.0×10^5 cfu/ml in Samaru and 2.0×10^4 to 5.0×10^4 cfu/ml in Kwangila (Table 2). All samples exceeded the permissible limit of 1.0×10^4 cfu/ml as adopted by NAFDAC, 2023 indicating contamination and poor microbiological quality. The fungal isolates identified from pap samples included *Aspergillus flavus*, *A. fumigatus, A. niger, Microsporum spp.,* and *Trichosporon spp*. (Table 3). The percentage occurrence of fungal isolates showed *Microsporum* spp. had the highest frequency of occurrence of 4(33.3%), followed by *Aspergillus niger* 3(25.0%), *Aspergillus flavus*, and *A. fumigatus* with 2(16.7%) each and *Trichosporon* spp. 1(8.3%) as shown in Table 3. Table 4 shows the mean concentration level of aflatoxin. Samaru had the total mean of 5.02 µg/kg while Kwangila had 7.93 µg/kg. Sample 4 (PAP4) from Kwangila had the highest concentration (23.29 µg/kg) exceeded the regulatory limit and the least 1.02 µg/kg was recorded in sample 5 (PAP5) from Samaru.

Table 1: Proximate Composition of Pap (mean ± SD)

Parameter	**Samaru (n=5) Mean ± SD**	**Kwangila (n=5) Mean ± SD**	**p-value**
Lipid (%)	5.02 ± 0.08	5.72 ± 0.10	0.001
Carbohydrate (%)	18.46 ± 0.30	13.29 ± 0.25	0.000
Protein (%)	0.59 ± 0.02	0.42 ± 0.03	0.004
Moisture (%)	73.14 ± 1.20	77.87 ± 1.10	0.012
Ash (%)	0.77 ± 0.05	0.60 ± 0.04	0.021
Crude fibre	0.00±0.00	0.00±0.00	-

Key: n=5 sample size, SD= Standard Deviation

Table 2: Fungal Load (cfu/ml)

Sample	**Samaru (cfu/ml)**	**Kwangila (cfu/ml)**
PAP1	2.0×10^4	3.0×10^4
PAP2	2.0×10^5	3.0×10^4
PAP3	2.0×10^4	2.0×10^4
PAP4	3.0×10^4	5.0×10^4
PAP5	2.0×10^4	4.0×10^4

Acceptable limit: 1.0×10^4cfu/ml. NAFDAC, (2023)

Table 3: The Frequency of Occurrence of Fungi Isolated from Pap samples in Zaria Metropolis

Fungal Isolate	**Frequency**	**Occurrence (%)**
Aspergillus flavus	2	(16.7)
Aspergillus niger	3	(25.0)
Aspergillus fumigatus	2	(16.7)
Microsporum spp.	4	(33.3)
Trichosporon spp.	1	(8.3)
Total	**12**	**100**

Table 4: Average Aflatoxin Composition of Pap Samples

Sample	Samaru (µg/kg)	Kwangila (µg/kg)
PAP 1	1.42	5.17
PAP 2	17.87	1.29
PAP 3	2.99	8.87
PAP 4	2.08	23.29
PAP 5	1.02	1.73
Mean	5.02	7.93

Acceptable limit: ≤20 µg/kg. SON, 2015

DISCUSSION

This study provides preliminary insights into the mycological quality and aflatoxin contamination of pap sold in Zaria, Nigeria and highlights the potential public health risks associated with fungal contamination and aflatoxin exposure in widely consumed complementary foods. However, several limitations should be acknowledged. The relatively small sample size and limited geographic coverage may not fully represent the microbial quality of pap across the metropolis. Fungal identification was based solely on morphological characteristics, which may lead to misidentification; molecular techniques would provide more accurate species confirmation. Additionally, only aflatoxin B_1 was analyzed using ELISA, and other mycotoxins commonly associated with cereal products were not assessed. The cross-sectional design also limits the ability to evaluate seasonal variations in contamination levels. Future studies should incorporate larger sample sizes, molecular identification methods, multi-mycotoxin analysis, and detailed assessment of processing and storage practices to better understand contamination risks.

This study investigated the proximate composition, fungal load, and aflatoxin contamination of pap sold in Zaria metropolis. Proximate analysis showed there is statistically significant differences ($p < 0.05$) between Samaru and Kwangila samples this is might be due to environmental, storage and processing conditions. Samaru samples had slightly higher carbohydrate and protein contents, while Kwangila samples exhibited higher lipid and moisture levels. The high moisture content observed in pap samples likely contributed to the elevated fungal loads, as moisture is a critical determinant of fungal proliferation and mycotoxin biosynthesis. (Onyeke & Okorie, 2021). All pap samples exceeded the NAFDAC permissible limit of 1.0×10^4 cfu/ml, confirming microbial contamination and poor microbiological quality. The fungal loads ($2.0 \times 10^4 – 2.0 \times 10^5$ cfu/ml) indicate that pap sold in Zaria metropolis is unhygienically handled or poorly stored, consistent with other studies reporting high microbial contamination in pap (Okoli *et al*., 2023; Mbochi *et al*., 2024). The isolated fungi included *Aspergillus flavus*, *A. niger*, *A. fumigatus*, *Microsporum* spp., and *Trichosporon* spp. The percentage occurrence of fungal isolates showed *Trichosporon* spp. had the highest frequency of occurrence. The predominance of *Aspergillus* species, particularly *A. flavus*, is of concern due to their known aflatoxigenic potential. Measurable aflatoxin levels were detected in all pap samples. Although mean concentrations were not significantly different between Samaru (5.02 µg/kg) and Kwangila (7.93 µg/kg), one sample from Kwangila (23.29 µg/kg) exceeded the SON regulatory limit of 20 µg/kg. Although mean aflatoxin levels were within regulatory limits, the detection of a highly contaminated sample underscores the risk of chronic exposure, especially among infants and young children (Kamala *et al*., 2016; Ezekiel *et al*., 2020). Kwangila samples had higher mean aflatoxin levels despite having lower maximum fungal counts than Samaru this is might be due to environmental, storage and processing conditions. Exposure to aflatoxins is particularly concerning in developing countries where cereal-based foods constitute a major portion of the diet. Infants and young children are especially vulnerable because they consume

large quantities of cereal-based complementary foods relative to their body weight. Chronic exposure to aflatoxins has been linked to impaired growth, immune suppression, and increased susceptibility to infectious diseases (Dhakal *et al*., 2023; Gemede, 2025) as such the low-level aflatoxin exposure pap is required for infants and young children.

CONCLUSION AND RECOMMENDATIONS

This study evaluated the proximate composition, fungal contamination, and aflatoxin B_1 levels in commercially available pap sold in Zaria, Nigeria. The results revealed that while pap remains an important and widely consumed cereal-based food, its microbiological quality may be compromised by significant fungal contamination. The presence of potentially toxigenic fungi such as *Aspergillus flavus* and the detection of aflatoxin B_1 in all samples indicate a potential public health concern, particularly for infants and young children who frequently consume pap as a complementary food. Although most aflatoxin levels were within regulatory limits established by the Standards Organisation of Nigeria, the occurrence of one sample exceeding the permissible limit highlights the need for improved food safety monitoring. Strengthening hygienic processing practices, improving storage conditions, and implementing regular surveillance programs by regulatory agencies are essential to minimize fungal contamination and reduce aflatoxin exposure in fermented cereal foods and relatively increases sample size and large geographic coverage may fully represent the microbial quality of pap across the metropolis.

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