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Evaluation of Food Safety and Nutritional Quality of Indigenous Beverages Vended in Informal Market of Nasarawa State, North Central, Nigeria

Ikechukwu U. NWIYI[1] , Jasper Okoro Godwin ELECHI [2*]

[1]Department of Applied Microbiology and Brewing, Nnamdi Azikiwe University, Awka, Nigeria
[2]Department of Pharmacy, Health and Nutritional Sciences, University of Calabria, Arcavacata di Rende, 87036 Cosenza, Italy.

[*]Corresponding author: helloeljasper@gmail.com

[*]ORCID: 0000-0001-5623-4189

Abstract

Food security encompasses increased production, supply, and consumption of wholesome food, but poor food quality and safety jeopardizes the entire production, distribution, and ultimately consumption. Expanding the food chain to accommodate indigenous species is an important way to enhance overall human health and well-being, and improve food security as they form an important part of people's food intake all over local communities in the global south. However, due to poor food safety knowledge and practices, poverty, and illiteracy among consumers and vendors of indigenous foods, various unsafe and hazardous food safety practices abound that compromise the nutritional quality of the beverages and pose threat to public health, so their safety and quality require routine scrutiny. This study was carried out to evaluate the Food Safety and Nutritional Quality of Indigenous Beverages Vended in Informal Market of Nasarawa State, North Central, Nigeria. Fifty-five (55) samples of *Kunu Zaki, Zobo, Fura de Nono, Kunu Aya, Kunu Gyada* were obtained from street hawkers randomly from various open markets within the metropolis. The beverages were analyzed for proximate, physiochemical, micronutrient (Ca, Fe, Zn, Ca, and Mg), and microbial isolates using standard methods. The proximate quality of the beverage's samples was in the range of carbohydrate (3.55 to 23.28%), proteins (2.10 to 7.31%), fat (0.90 to 7.77%), crude fibre (0.15 to 2.15%), ash (0.83 to 1.99%), and moisture (66.13 to 85.38%). The physiochemical quality of the beverages was pH (4.22% to 5.53%), Titrable Acidity (0.025 to 5.85), Total soluble solid (0.485 to 10.36%), Total Solid (8.85 to 20.58%). The micronutrient result shows Ca (3.37 to 46.57mg/ml), Fe (0.47 to 45.67 mg/ml), Zn (0.35 to 34.87), Mg (1.84 to 23.34mg/ml). The microbial isolates include bacterial *Bacillus, Enterobacter, Lactobacillus, Micrococus, Salmonella, Staphylococcus, Streptococcus, Escherichia, Klebsiella, Lactobacillus and Pseudomonas.* The microbial safeties of most of the beverages were not more than the recommended standard.

Keywords: Food safety, Nutritional Quality, Indigenous Beverages, Nigeria, Informal Market, Food borne disease, Artisanal Beverages

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INTRODUCTION

Numerous conversations around food security focus on providing food for the projected nine billion people by 2050. Also, policies of several global food and health organisations focus on increased food production (Eke and Elechi, 2021). However, the issue of food security goes beyond simply increasing food production, supply, and consumption of food. The production and distribution efforts and capacities are at risk of being invalided by poor food safety and quality (Eke and Elechi, 2021). Unsafe foods reduce the quantity and quality of agricultural production, thereby reducing food availability and reducing food access for households whose incomes depend on their sale. Moreover, when contaminated food is eaten, there is an increased risk of malnutrition and illness. The Food and Agriculture Organization of the United Nations defines food security as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO 2002). Therefore, for people to be food secure, the safety and nutritional qualities of the food system must be constantly guaranteed, irrespective of how primitive, cultural, indigenous/traditional, modern, or technically advanced the food systems of the people may be. In nutritionally malnourished societies, food security and food choices are framed by the local context of food availability, accessibility, affordability, and attractiveness, and generally regarded as safe plant and animal-based food products. According to WHO (2019) as cited in Gizaw, (2019) "Unsafe food containing harmful bacteria, viruses, parasites, or chemical substances cause more than 200 diseases—ranging from diarrhoea to cancers. An estimated 600 million individuals worldwide took ill after eating contaminated food and 420,000 die every year, resulting in the loss of 33 million disability-adjusted life years (DALYs). Children under 5 years of age carry 40% of the food-borne disease burden, with 125,000 deaths every year. Diarrheal diseases are the most common illnesses resulting from the consumption of contaminated food, causing 550 million people to fall ill and 230,000 deaths every year". Despite the central role that Indigenous foods potentially play in meeting the food security of Nigerians, their safety and nutritional qualities are a source of concern because of the potential for foodborne illness outbreaks as a result of both risky food preparation and eating behaviour (Eke and Elechi, 2021).

Indigenous beverages are local drinks made from animal milk, cereal-legumes, fruits and some vital herbs/spices using traditional knowhow and methods passed down by ancestral practices. Many of which could be classified as unregulated beverages and generally referred to as artisanal, illicit, or illegal drinks in more educated communities (Nwaiwu *et al*., 2020). However, being unregulated is not sufficient grounds to label indigenous beverages as illicit drinks. The origins and production of indigenous beverages is based on the cultural beliefs and practices that have served local communities in developing countries for generations and have come to be Generally Regarded as Safe (GRAS) by the indigenous people. Besides, food is "a defining characteristic of our identity and culture, and an important element, if not the centre, of many of our social activities" (Gkogka, 2019). Hence, indigenous foods and beverages represent the cultural identity of the people that should not be eroded by advances in food processing and packaging but rather complemented.

This is evidenced by the official recognition of the Mediterranean Diet as an Intangible Cultural Heritage of Humanity by UNESCO Intergovernmental Committee in 2010. Needless to say, that Africa whose food systems are characterised by indigenous cultural practices is an abode of several cultural foods and practices that could be accorded world cultural heritage recognition.

The safety issues that surround the production, distribution and consumption of indigenous beverages/foods in contemporary times is largely due to unhygienic processing and handling occasioned by poor infrastructural development and lack of social amenities provisions that has become the hallmark of developing communities across the globe. Accordingly, Nwaiwu *et al*., (2020) asserted that “a concern which may lead to the microbial contamination of unregulated artisanal local drinks in Nigeria is poor hygiene. Certain organisms have come to serve as indicators; which point to poor hygiene, this can occur at any point during the production or storage of finished products and sales. Around the world, it is an established fact that poor hygiene in developing countries contributes to the proliferation of food pathogens in several local beverages”. Therefore, the provisions and improvements in infrastructures in developing countries will lead to a drastic improvement in food safety practices in the production of safe foods irrespective of the origin and cultural practices associated with the production of the food items.

The food supply chains ranging from production, processing, distribution, marketing and consumption in Nigeria and other developing countries are largely based on indigenous knowledge and practices that were handed down from successive generational ancestors. In every culture across the world there remains viable traditional foods and food system that are deeply rooted in the culture and belief of the indigenous people. In most parts of the world, these traditional foods and food systems of the indigenous people have been commercialised to give urban migrants access to and taste of traditional delicacies of their ancestral homeland. In central and northern Nigeria, plant-based beverages are generally known as ‘*Kunu’.* Hence, there are different types of ‘*Kunus’* which are classified based on the derivative materials. These include *kunu zaki, kunu gyada, Kunu Aya, kunu akamu, kunu tsamiya, kunu baule, kunu jiko, ashamu* and *kunu gzakimba of which kunu jiko, Kunu Zaki, Zobo, Fura de Nono, Kunu Aya,* and *Kunu Gyada* are the most popular indigenous beverages in Nasarawa State, North Central Nigeria.

Traditional or indigenous foods confer several health benefits; among others. They rely mostly on fermentation and do not require artificial additives and so are less harmful to people and the environment as a whole. Indigenous beverages give consumers; energy, and nourishment, and quench their thirst, especially in restaurants, homes, in different types of schools and institutions (Mohammed and Agha, 2016). They also form cheap sources of special delicacies to mark occasions for different religious folks, festivals, burial, marriage, and child naming ceremonies. Besides their food value, they serve as a source of income generation for the enormous number of both educated and uneducated youths and women. Therefore, expanding the food chain to accommodate indigenous species is an important way to enhance overall human health and well-being and improve food security as they form an important part of people’s food intake all over local communities in developing Nations. Beyond their contribution to local food availability, wild indigenous plants that serve as raw materials for the production of indigenous foods and beverages also help maintain cultural diversity (Agulanna, 2020). However, due to poor food safety knowledge and practices, poverty, and illiteracy among producers and vendors of indigenous foods, various unsafe and hazardous food safety practices abound that compromise the nutritional quality of the beverages and pose threat to public health. According to Delia *et al*., (2015) developing countries record well over 80% of food sold is done in informal markets which are largely unregulated and non-transparent, thus prone to activities that might compromise food safety. However, “informal markets are not necessarily dangerous and formal markets are not always safe. Although hazards are common in informal markets, they do not always translate to risk” (Delia *et al*., 2015).

Therefore, as a result of the growing concern related to food safety issues and open-air trading of food through the informal market systems, it is imperative to channel resources and research in the food chain to ascertain the impact and health implications of the consumption of roadside traded ready-to-drink beverages. This is particularly important in developing countries where informal markets and open-air trade of food are predominant and gastrointestinal diseases rank among the top five causes of illnesses, morbidity, and death. Unsafe food is one of the essential contributors to the burden of gastrointestinal diseases in the region (Nwaiwu, *et al.,* 2020).

Kunu-Zaki is a traditional non-alcoholic millet/sorghum-based fermented beverage indigenous to Northern Nigeria but consumed among the various ethnic groups in the country. The typical ingredients for *Kunu Zaki* production include millet or sorghum, malted rice, and spices such as ginger, pepper, and cloves (Abulude, *et al.,* 2006; Ashiru, *et al.,* 2003).

Zobo drink is a popular homemade beverage in Nigeria that is prepared from the *Hibiscus sabdariffa* plant. The beverage is made by extracting the juice from the rosella leaf which is a characteristically intense red colour using hot water. It is usually sweetened with sugar or fruit extracts such as pineapple and cloves before serving. It is loved and consumed by many people for its ability to quench thirst, stimulating effect, and nutritional value. In fact, it is considered a healthier alternative to some commercial carbonated soft drinks for health and nutrition-conscious Nigerians. Unfortunately, *Zobo* deteriorates quickly if prepared and not consumed immediately, due to varieties of factors such as processing method, contamination from the sorrel calyces, ingredients and poor-quality water used for production, and lack of personal hygiene from the home producers resulting in microbial contamination (Bristone *et al*., 2018).

Fura da nono (millet cereal and fermented milk) is a highly nutritious beverage consumed often in northern Nigeria. The nutritional values of the ingredients involved in mashed millet (*fura*) include carbohydrates essential for energy and that of milk or yoghurt (*nono*) includes proteins that are essential for growth and bodybuilding. Traditionally *fura da nono* is usually prepared by mashing millet into powdery form and mixing with spices and hot water to make dough, allowing the dough to cool and solidify and finally mixing the mashed millet (*fura*) with fermented milk (*nono*). The preparation of *fura da nono* from grain grinding to blending of *fura* with milk and other ingredients is by and large a traditional process passed on from one generation to another rather than a science-based procedure. Thus, the process is a simple process that typically employs traditionally-available utensils such as calabash, mortar, and pestle under limited hygiene practice or no hygiene precautions at all. In addition, environmental parameters such as temperature, relative humidity, and poor air quality could as well negatively affect the quality of *fura da nono*. Moreover, the poor hygienic conditions under which *fura da nono* is sold could make the product vulnerable to microbial contamination. Similar to the fermentation of most locally-produced fermented foods, the process of *fura da nono* fermentation is not only uncontrolled but unmonitored, particularly with respect to the duration and product quality. Thus, the production of undesirable fermentation by-products and contaminations is not checked (Yusuf *et al.*, 2020).

Kunun/Madaran aya (Tigernut Milk) is one of the most widely consumed Nigerian vegetable milk after soybean milk (*Madaran waken suya*), followed by cocoa nut milk extract (*Madararan koko*). The interest in tiger nut milk also known as *Kunun-Aya*, has increased over the years possibly because of its sensory, nutritional and probiotic prospects. *Kunun aya* beverages are made from the extract of tiger nuts.

The consumers of this product believe that *Kunun aya* gives them ability to withstand extremely cold condition in the rain when farming and inside Cold River when fishing. Other benefits also include the smoothening of skin wrinkles usually caused by ageing or fatigue (Bristone *et al*., 2018).

Kunun gyada is one of the most important home-prepared and street-vended drinks. It is also taken as a complimentary breakfast cereal drink by all classes of children and adults. It is used extensively during fasting periods, ceremonies, school feeding, and the management of people with health problems. The mode of preparation may differ significantly depending on its intended uses, which also helps to create varieties of *Kunun gyada* (Bristone *et al*., 2018). Despite the wide acceptance these beverages have enjoyed and the concerns about the crude processing and post-processing procedures, not much is known about the food safety and nutritional qualities of the products in the study area as regards the informal marketing system.

MATERIALS AND METHOD

The Study Area

The research study was carried out within Lafia, an administrative and metropolitan capital of Nasarawa state, Nigeria. It is the major gateway that connects the Northern part of Nigeria with its Southern counterpart and hence a popular spot for road vended foods.

Sample Collection

Fifty-five (55) samples of *Kunu Zaki, Zobo, Fura de Nono, Kunu Aya, Kunu Gyada* were obtained from street hawkers randomly irrespective of their flavour, appearance, and hygiene from various open markets within the metropolis (Figure 1). The samples were collected in sterile sampling polythene bags and were immediately transported to the Animal Science laboratory, Faculty of Agriculture, Nasarawa State University Lafia campus, Nigeria.

Analyses

The beverages were analysed for proximate, physiochemical, and micronutrients (Ca, Fe, Zn, Ca, and Mg) using the methods described by AOAC (2010). Samples were analysed microbiologically using standard methods described by Cheesbrough (2005) and Sharma (2009). Isolates were characterized according to the methods of Sharma (2009).

Colony count was done using a digital colony counter for bacteria and a hand lens for fungi. The total colony was expressed as colony-forming units' in millilitres (Cfu/ml). Fungal colonies were identified colonially using characteristics such as pigmentation on the surface and reverse, sporulation, mycelia, and spore arrangement microscopically (Fawole and Oso, 2007). Bacteria and yeast were identified colonially, microscopically and in a few biochemical tests (Cheesbrough, 2005; Sharma, 2009). The resulting data were analysed using analysis of variance (ANOVA) to establish significant differences among samples.

Figure 1. Informal Market in Lafia-Nigeria: Open-air trading with food and beverages displayed on a dusty road.

RESULTS AND DISCUSSION

The result of the Food Safety and Nutritional Quality of Indigenous Beverages vended in Informal Market in Nasarawa State, Nigeria are presented in Table 1 -3. The proximate composition is presented in table 1. The proximate quality of the beverages samples was in the range of proteins (2.10 to 7.31%), ash (0.83 to 1.99%), carbohydrate (3.55 to 23.28%), moisture (66.13 to 85.38%), fat (0.90 to 7.77%). and crude fibre (0.15 to 2.15%) with samples FN having the highest protein content. Samples ZB, KZ, FN, and KA were generally high in moisture content. This is expected as the beverages are generally used for thirst quenching and refreshing purposes. More so, the study area is characterized by very hot weather and excessive loss of fluid (Gaffa *et al.,* 2002). As a result, Northern Nigeria is known for its preference for soft foods with higher moisture content as exemplified by their food choice and preparation in contrast to their Southern counterparts that have a preference for strong foods such as *eba, akpu*,. Similar studies conducted in southern Nigeria reported lower moisture content (Asuquo *et al*., 2017) proving local beverages in the region to be more viscous. Besides, higher moisture content signified adulteration for cheaper sales and profit maximization, especially among economically disadvantaged persons that are interested in thirst quenching and satisfying hunger rather than nutrition. The protein content of the beverages was observed to be high in KA (7.31%) followed by FN (6.34%) and lowest in ZB (2.10%). Low protein recorded in some of the beverages may be due to their source ingredients and processing methods that may lead to loss of protein especially in beverages that involved the use of cereal in which the protein and other essential nutrients are concentrated in their germs and tasta which are often sifted away during processing. Sample KA recorded the highest ash content (1.99%). These values agree with the finding of Ofudje *et al.,* (2016).

Table 1. Proximate Composition of Indigenous Beverages vended in Informal Market of Nasarawa State, Nigeria (%)

	ZB	**KN**	**FN**	**KG**	**KA**
Moisture	85.38^{cd}±1.13	79.25^{b}±1.25	79.32^{b}±0.89	66.13^{a}±2.63	81.05^{c}±0.55
Crude protein	2.1^{a}±0.05	5.89^{c}±0.06	6.34^{c}±0.34	4.55^{b}±1.09	7.31^{d}±0.19
Crude Fat	0.89^{a}±0.02	0.99^{a}±0.14	7.77^{d}±0.09	2.78^{b}±0.18	5.08^{c}±0.11
Crude fibre	0.33^{a}±0.03	1.89^{c}±0.11	0.15^{a}±0.05	1.04^{b}±0.06	1.03^{b}±0.20
Ash	0.83^{a}±0.45	1.02^{a}±0.04	1.23^{b}±0.23	1.13^{b}±0.14	1.99^{c}±0.01
Carbohydrate	10.48^{c}±1.26	10.99^{c}±1.03	5.21^{b}±0.23	23.28^{d}±3.63	3.55^{a}±0.45

Results are the means of three replications. Mean values with same superscript in a column are not significantly different (p≥ 0.05).ZB = Zobo; KZ = Kunu Zaki; FN = Fura da nono; KG = Kunnu Gyada; KA = Kunnu Aya

Table 2 shows the physiochemical quality of the beverage samples. The PH values varied from 4.22% to 5.53% with KG recording the highest. Titrable Acidity range from 0.025 to 5.85 with KZ having the highest value. Total soluble solids were within the range of 0.485 to 10.36% with KA having the highest value. The Total Solid range had a range of 8.85 to 20.58% with FN being the highest. The pH of the beverage samples showed them to be acidic. This condition may account for the lower proliferation of spoilage and pathogenic organisms as they do not thrive easily in acidic mediums.

The pH values were lower than that reported by Braids *et al.*, (2018) and higher than the study of Onyemekara *et al.*, (2018) but similar to that reported by Ofudje *et al.*, (2016). The acidity value of KN was the highest (5.85%) among all the beverages. This could be attributed to the added species and also to the presence of some microorganisms such as *Lactobacillium, Acidophillus, Candida* species, and *Saccharomyces cerevisiae* which help in acid formation in indigenous beverages that employ uncontrolled wide fermentation and are essential to humans as reported by Ofudje *et al*., (2016). The value of the total solids was higher than that reported by Ofudje *et al*., (2016).

Table 2. Physiochemical Properties

Parameter	ZB	KZ	FN	KG	KA
pH	$5.17^{a}\pm0.63$	$4.48^{a}\pm0.19$	$4.94^{a}\pm0.07$	$5.530^{a}\pm0.100$	$4.22^{a}\pm0.25$
TTA	$2.06^{b}\pm0.08$	$5.85^{c}\pm0.15$	$1.74^{b}\pm1.18$	$0.025^{a}\pm0.005$	$0.953^{ab}\pm0.07$
TSS	$6.51^{b}\pm0.06$	$5.59^{b}\pm0.01$	$9.78^{c}\pm0.22$	$0.485^{a}\pm0.035$	$10.36^{c}\pm0.16$
TS	$8.85^{a}\pm0.09$	$10.01^{ab}\pm0.23$	$20.58^{c}\pm1.02$	$11.160^{ab}\pm0.18$	$19.54^{c}\pm1.00$

Results are the means of three replications. Mean values with same superscript in a column are not significantly different ($p\geq 0.05$).ZB = Zobo; KZ = Kunu Zaki; FN = Fura da nono; KG = Kunnu Gyada; KA = Kunnu Aya TTA = Titrable Acidity; TSS = Total Soluble Solid; TS = Total Solid

The micronutrient composition is shown in table 3. The micronutrient result show Ca (3.37 to 46.57mg/ml), Fe (0.47 to 45.67 mg/ml), Zn (0.35 to 34.87), and Mg (1.84 to 23.34mg/ml). Samples FN had the highest calcium (46.57mg/ml) and KZ had the highest Fe (45.67mg/ml), Zn (34.87mg/ml), and Mg (23.34mg/ml). The sample KZ's high mineral content could be attributed to the input materials of mixed herbs/species, malted cereals, and the fermentation processes employed in its production. Calcium, Magnesium, Iron, and Zinc are essential minerals required by the body in different quantities. Ca is crucial in promoting the deposition of hydroxyapatite in bone and serve the mechanical roles of strengthening bones and teeth, it supports the functions of excitable tissues, including nerves and heart muscles, as well as blood clotting (Aspray, 2017).

Fe is an essential nutrient supporting oxygen binding and transport, it is necessary for DNA synthesis and cellular proliferation. Due to these key roles, deficiency of Fe is manifested as anaemia, leading to reduced work capacity, impaired mental function, and lowered immunity. However, iron loading due to primary or secondary hemochromatosis can produce liver damage, leading to fibrosis, cirrhosis, and an increased risk of hepatic cancer (Wessling-Restick, 2017). Zn and Mg have been established as essential for health and nutrition especially in growth enhancement and enzyme-substrate interaction respectively. Therefore, the mineral values in this study showed the potential of indigenous beverages in resolving hidden hunger.

Table 3. Mineral Contents (mg/l)

Parameter	ZB	KZ	FN	KG	KA
Ca	$3.380^{a}\pm0.385$	$16.895^{d}\pm0.445$	$46.57^{e}\pm0.680$	$11.64^{c}\pm1.040$	$6.03^{b}\pm0.140$
Fe	$1.135^{ab}\pm0.005$	$45.665^{c}\pm1.345$	$2.155^{b}\pm0.605$	$0.465^{a}\pm0.025$	$0.755^{a}\pm0.055$
Zn	$2.325^{b}\pm0.075$	$34.865^{c}\pm0.885$	$0.630^{a}\pm0.060$	$0.355^{a}\pm0.190$	$0.670^{a}\pm0.010$
Mg	$7.625^{b}\pm0.375$	$23.340^{d}\pm0.78$	$5.075^{ab}\pm0.125$	$15.395^{c}\pm0.445$	$1.84^{a}\pm0.170$

Results are the means of three replications. Mean values with same superscript in a column are not significantly different ($p\geq 0.05$). ZB = Zobo; KZ = Kunu Zaki; FN = Fura da nono; KG = Kunnu Gyada; KA = Kunnu Aya

The microbial safety of the beverages is presented in Tables 4 and 5. The Microbial profile shows that the total plate count ranges from 3.33 x 10^5 cfu/g for sample KA, 7.88 x 10^3 cfu/g for sample ZB, 6.02 x 10^7 cfu/g for sample KZ, 7.13 x 10^5 cfu/g for sample FN, and 4.62 x 10^2 cfu/g for sample KA respectively. The fungi count ranges from 3.81×10^3 cfu/g for sample ZB, 5.04 x 10^6 cfu/g for sample KZ, 1.72 x 10^5 cfu/g for sample FN, 1.72 x 10^2 cfu/g for sample KG, 2.43 x 10^3 cfu/g for sample KA. The Coliform count ranges from 4.94 x 10^3 cfu/g for sample ZB, 6.84 x 10^8cfu/g for sample KZ, 7.08 x 10^6cfu/g for sample FN, 2.61 x 10^2cfu/g for sample KG, 4.60 x 10^4cfu/g for sample KA.

The microbial result of the beverages samples revealed varying degrees of microbial contamination with some samples (ZB, KG, and KA) showing an acceptable level of microbial load of < 10^4 cfu/g but the total coliform count exceeded the recommended safe level (< 100 coliform/g). The Total Viable Count is an indicator of quality, not safety, and cannot directly contribute towards a safety assessment of ready-to-eat food but can be used as part of a general quality assessment including that of extended shelf-life foods (Eke and Elechi, 2021). Microbial criteria regulation varies across countries.

ICMSF, (2006) considers TVC in the range of 0-10^3 cfu/g, 10^4-10^5 cfu/g, and >10^6 cfu/g as acceptable, marginally acceptable (tolerable), or unacceptable respectively. On the other hand, UK Health Protection Agency (2009) and FSANZ, (2001) are more stringent stating that RTE foods with TVC exceeding 10^5 cfu/g are of objectionable quality and therefore unfit for consumption. Based on the microbiological standards used, the indigenous beverages sold at the informal market of Nasarawa State – Nigeria were deemed acceptable for sale with the exception of KZ which recorded significantly above 10^5.

Some consumers of KZ (Kunnu Zaki) have reported cases of gastrointestinal disorders after consuming the beverages. This disorder could be attributed to the unhygienic processing and packaging of the products, especially with the tradition of the reuse of used pet bottles as packaging materials. Also, the characteristic flavour of Kunun Zaki as a result of the fermentation process makes a favourable substrate for houseflies' patching and contamination. This has made many consumers of these beverages patronise homemade Kunun Zaki by vendors with perceived good personal and food hygienic practices. The microbial counts were lower than that reported by Braids *et al.*, (2018) but higher than that reported by Onyemekara *et al.*, (2018).

Table 4. Microbial Profile CFU/l

Parameter	ZB	KZ	FN	KG	KA
Total Viable Count	$7.88 \times 10^3 \pm 120^b$	$6.02 \times 10^7 \pm 130^d$	$7.13 \times 10^5 \pm 150^d$	$4.62 \times 10^2 \pm 280^a$	$3.33 \times 10^5 \pm 900^c$
Total Coliform Count	$4.94 \times 10^3 \pm 600^b$	$6.84 \times 10^8 \pm 160^d$	$7.08 \times 10^6 \pm 290^c$	$2.61 \times 10^2 \pm 65^a$	$4.60 \times 10^4 \pm 200^{ab}$
Total Fungal Count	$3.81 \times 10^3 \pm 600^c$	$5.04 \times 10^6 \pm 259^e$	$1.66 \times 10^5 \pm 105^d$	$1.72 \times 10^2 \pm 26.5^a$	$2.43 \times 10^3 \pm 130^b$

Results are the means of three replications. Mean values with same superscript in a column are not significantly different ($p \geq 0.05$). ZB = Zobo; KZ = Kunu Zaki; FN = Fura da nono; KG = Kunnu Gyada; KA = Kunnu Aya

The microbial isolate from the beverages included *Staphylococcus aureus, Pseudomonas, Klebsiella species Bacillus species, Lactobacillus acidophilus, and Saccharomyces cerevisiae* some of which are of food spoilage and food poisoning significance as shown in table 5. This is not surprising as most of the isolates are secondary micro-flora of fermentable food products. Most of the indigenous beverages such as *Kunnu Zaki, Zobo,* and *nono* undergo fermentation within a short time (24-48 h) after production if kept at room temperature of between 40-45°C (Nwaiwu *et al.*, 2020).

Despite the acidic nature of the beverage samples, the survival of bacteria in the drinks is worrisome. The survival of both pathogenic and food spoilage microorganisms in spite of the low pH could be attributed to post-processing and marketing contamination as most of the vending points and vendors lack sanitary and hygienic practices. A comparison between freshly processed and street-hawked *kunu* (Amusa and Odunbaku, 2009; Nwaiwu *et al.*, 2020) showed that the fresh samples were free of coliforms whereas products found on the street were not. This shows that indigenous beverages due to their open-air trading systems are very susceptible to post-process contamination.

The bacteria genera namely *Bacillus, Escherichia, Lactobacillus, Staphylococcus, and Streptococcus* were detected in all five beverages. It is worrisome that the three most prevalent bacteria are *Bacillus, Escherichia,* and *Staphylococcus.* These species are known hygiene indicators and suggest very poor hygienic conditions during the preparation and storage of beverages such as the use of unsafe water, cruel processing methods, and unhygienic display and vending environment. *Staphylococcus* is widely distributed in nature and is a part of normal flora among humans, animals, plants, and the environment; hence the possibility of food contamination with the genus is very high. *Lactobacillus* species is non-pathogenic and acid fermentation of *Kunnu* and *Nono.* Its production of lactic acid increases the acidity of the beverages thereby retarding the activities of pathogenic organisms for the microbial safety of the drinks (Onyemekara *et al.*, 2018). In particular, the roles of *Escherichia* and other *Enterobacteriaceae* as hygiene markers are well-reported (Buchanan and Oni, 2012) and high counts of these species mean that the food or drink did not follow normal food safety procedures. The concern is that the hygiene indicator organisms could also be pathogenic. However, there were no tests to confirm whether the *Bacillus* species observed were pathogenic *B. cereus or B. subtilis,* which could have probiotic potential. Additionally, a confirmation assay to determine if the *E. coli* strain found was the shiga toxin-producing E. coli O157:H7 or other E. coli serotypes with pathogenic potential was not carried out. It has been reported that the microorganisms associated with unhygienic processing conditions are mainly environmental contaminants with a few of faecal origin (Martin *et al.*, 2016). Hence, it can be concluded that most of the indicator organisms found in this study were due to process contamination and they may not be pathogenic strains.

Fungi are natural flora of the soil with their acid-tolerant spores easily spread by air, hence a common contaminant of cereal, legumes, and natural spices and herbs used as raw material in the production of indigenous beverages. Therefore, the fungi genera *Saccharomyces, Aspergillus, Candida, Penicillium, and Fusarium* were found in all the beverages. The presence of *Saccharomyces* is expected because it is known as a dominant organism in many beverage fermentations. There are no immediate concerns for adverse toxic metabolites from *Saccharomyces* fermentation but the risk could exist due to methanol production when the product is distilled into gin (Ohimain, 2016).

The occurrence of three fungal genera, namely *Aspergillus, Penicillium,* and *Fusarium,* which are responsible for producing the majority of the mycotoxins that are toxic to humans, animals, and plants (Ismaiel and Papenbrock, 2015) may mean that post-production tests of the beverages are required to assure food safety. The problem regarding the resources required to perform molecular characterizations contributed to the minimal investigation of the pathogenicity of microorganisms isolated in the beverage samples.

Table 5. Microbial Isolates

Parameter	**ZB**	**KZ**	**FN**	**KG**	**KA**
Bacterial	*Bacillus* *Enterobacter* *Lactobacillus* *Micrococus* *Salmonella* *Staphylococcus* *Streptococcus* *Pseudomonas*	*Bacillus* *Lactobacillus* *Staphylococcus* *Streptococcus* *Pseudomonas*	*Bacillus,* *Escherichia* *Enterobacter,* *Klebsiella,* *Staphylococcus* *Salmonella* *Streptococcus* *Pseudomonas*	*Bacillus,* *Escherichia* *Lactobacillus* *Salmonella* *Staphylococcus* *Streptococcus* *Pseudomonas*	*Bacillus,* *Escherichia* *Lactobacillus* *Salmonella* *Staphylococcus* *Streptococcus* *Pseudomonas*
Mould/fungi	*Aspergillus* *Penicillium* *Fusarium*	*Saccharomyces* *Penicillium*	*Aspergillus,* *Candida,* *Saccharomyce* *Penicillium*	*Aspergillus* *Penicillium*	*Aspergillus,* *Candida,* *Saccharomyce* *Penicillium*

ZB = Zobo, KZ = Kunu Zaki, FN = Fura da nono, KG = Kunnu Gyada, KA = Kunnu Aya

CONCLUSION

Despite the sector's contribution to the food and nutrition security of the country, ready-to-eat food traded in Nigeria's informal marketplaces is mostly uncontrolled. While the consumption of street meals that fall short of the minimum safety standard is harmful to health on an acute or ongoing basis, it has a beneficial influence on food security when they are healthy and nutritious. As a result, all of the samples of indigenous drinks were suitable for human consumption and nutritionally viable. Most of the beverage samples' microbial counts fell within acceptable ranges as per national and international norms and regulations.

The information provided here serves as a starting point for future quantitative risk assessments. The quality and safety of street food will be significantly increased, though, by providing basic facilities and educating the food vendors. Regulation, efficient monitoring, and execution of the current punitive measures are therefore advised to ensure the constant trading of safe and nutritious food for the general well-being of the indigenous people.

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