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Quality Control and Safety Challenges in the Processing of Traditional Nigerian *Kunu* Beverages

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ABSTRACT

Native to Northern Nigeria, K*unu* is a fermented, non-alcoholic beverage that is widely consumed. *Kunu* serves as a drink, a side dish, and a thirst-quenching drink. The kind determines whether it should be served hot or cold. It looks like milky cream and is made with cereal, sugars, and other ingredients. There are currently thirteen types of *Kunu* in Nigeria. *Kunu* is rich in nutrients and has probiotic qualities. For inadvertent and / or false reasons, food can be sullied by microorganisms or hurtful substances and cause contaminations, such as food poisoning and toxin-infections Since *kunu* is typically manufactured in conditions with inadequate quality control, it may serve as a vector for zoonotic and food-borne illnesses such *listeriosis, salmonellosis, brucellosis, tuberculosis, shigellosis,* and others. It is advised that while preparing and selling *kunu*, manufacturers and hawkers receive training on proper hygienic practices and Hazard analysis of critical control points (HACCP) system ought to be used throughout the whole production process.

Keywords: Beverages, *Kunu*, Quality control, Food safety, HACCP, Contaminants.

INTRODUCTION

Drinks are important sources of minerals, phytonutrients, phenolic acids, and flavonoids, claim Ferruzzi *et al.,* (2020). They could be found in stimulants like coffee or tea, soft beverages like sodas and juices, water, or milk-based energy drinks. While *Nono* is a non-alcoholic milk base, other drinks such fermented palm wine, Pito, and Burukutu are alcoholic (Ani *et al.,* 2018). The general term *"kunu"* refers to any variety of cereal-based, non-alcoholic beverage; specifications are typically applied to indicate the underlying raw material used in processing (Nahemiah *et al.,* 2014). *Kunu* serves as a beverage, a side dish, and a thirst-quenching beverage (Mbachu *et al*., 2014). *Kunu* has the look of milky cream and is taken shortly after it is produced (Adeleke and Abiodun, 2010). Nigerians of indigenous descent, particularly those in the north, consume *kunu* (Amusa and Odunbaku, 2009).

Kunu can be made from a variety of stand-alone plants, such as *Acha* (*Digitalis exilis*), sorghum a(*Sorghum bicolor*), Millet (*Penisetum typhoides*), maize (*Zea mays*), rice (*Oryza sativa*), and Wheat (*Triticum aesstivum*). The ingredients needed to make *Kunu* are Ginger (*Zingiber officinales*), Black pepper (*Piper guinense*), Red pepper (*Capsicum species*), and Aligator pepper (*Afromonium melegueta*). Other ingredients, such as sugar and water, are also required (Adelekan *et al.,* 2014). Thirteen kinds have been reported in Nigeria as of right now, depending on the principal cereal used in its manufacturing. According to Gaffa *et al.,* (2002), these are *Kunun-zaki, Kunun-gyada,*

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Kunun-tsamiya, Kunun-akamu, Kunun aya, Kunun-koko, Kunun-aduwa, Kunun-acha, Kunun-kanwa, Kunun-jiko, Kunun-baule, Kunun-gayamba, and *Kunun-amshau.*The different *Kunu* drinks have specific nutritional and probiotic properties because of the fermentation process that is carried out by microbial strains and the dissolution of complex compounds found in the cereals used in their preparation (Snigdha *et al.,* 2019).

For inadvertent and / or false reasons, food can be sullied by microorganisms or hurtful substances and cause contaminations, such as food poisoning and toxin-infections (Tack *et al.,* 2019). Food defilement can happen at all stages of the food chain, from cultivation to table (Nerín *et al.,* 2016). Most pathogens found in food materials lead to Loose bowels and organisms such as *Staphylococcus aureus, Salmonella, Clostridium, Bacillus, Pseudomona aeruginosa, Vibrio cholera and Esherichai coli* may sully foods and lead to altering physical and wholesome quality (Bukar *et al.,* 2010). Concurring to Umaru *et al.,* (2014), refreshments / drinks such as *Kunu* might act as vehicles for zoonotic and food-borne diseases counting *Staphylococcosis*, *Salmonellosis, Brucellosis, Tuberculosis, Shigellosis, Listeriosis* etc. *Kunu* has high moisture content and total solid which may energize the development of strains of microorganisms to perilous levels during storage at surrounding temperature (Olasupo *et al.,* 2002). In expansion, a few cases of human infection arise due to metals such as Pb, Cd, Hg and As harmfulness has been detailed (Magomya *et al.,* 2015). There have been detailed cases of overwhelming metal defilement of local drinks made in Nigeria.

Types of Nigerian *Kunu* beverages

According to Ndukwe *et al.,* (2023) there are thirteen varieties of Kunu beverages in Nigeria and are classified into three types: Type 1, type 2, Type 3 and Others as shown on table 1 below.

Table 1: *Kunu* beverage varieties and their different formulating ingredients.

Kunu type	Varieties	Grain use	Sweetener/additives
TYPE 1	*Kunun-zaki* *Kunun-baule* *Kunun- jiko* *Kunun-aya*	Millet, maize or sorghum, or malted rice or sorghum or millet	Spices, sweet potatoes exctract, *cadaba farinose* (*dangarafa*) and roots of certain plant.
TYPE 2	*Kunun-bururu, Kunun-akamu, Kunun-tsamiya* *Kunun- kanwa* *Kunun- aduwa*	Sorghum, millet, malted cereals	Fresh cow milk, tamarind, *aduwa (Balanites aegyptica)* Potash and sugar
TYPE 3	*Kunun acha* *Kunun gyada*	*Acha* or millet, sorghum and rice	Tamarind, milk, sugar**,** and ground nut paste.
OTHERS	*Kunun Gayamba* *Kunun Amshau*	Malted millet Maize, sorghum or millet	Any available sweetener Any available sweetener

Ndukwe *et al.,* (2023).

Hazard Analysis Critical Control Points (HACCP) System in *Kunu* processing

Food safety systems such as HACCP have been applied to prevent contamination of the food (Kim *et al.,* 2020), and its application in traditional foods processing caused significant improvement in their safety (Amoa-Awua *et al.,* 2007). HACCP system has been recognised as an effective and rational means of ensuring food safety from primary production to final consumption, using a "farm to table" methodology (El-Hofi *et al.,* 2010)

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The increasing demand for food safety is stimulating research regarding the benefits and risks associated with consumption of foodstuffs and drinks such as *kunu* (Magomya *et al.,* 2015).

Principles of the HACCP system

The HACCP system is designed, validated and implemented in accordance with the following seven principles:

Principle 1

Conduct a hazard analysis and identify control measures.

Principle 2

Determine the critical control points (CCPs).

Principle 3

Establish validated critical limits.

Principle 4

Establish a system to monitor control of CCPs.

Principle 5

Establish the corrective actions to be taken when monitoring indicates a deviation from a critical limit at a CCP has occurred.

Principle 6

Validate the HACCP plan and then establish procedures for verification to confirm that the HACCP system is working as intended.

Principle 7

Establish documentation concerning all procedures and records appropriate to these principles and their application (CXC 1-2022).

Tiger-Nut Milk Drink (*Kunun-aya*)

Kunun-aya is produced from tiger-nut, an under-utilized crop rich in fibre and fat. Although *Kunun-aya* is slightly more nutritious than *Kunun-zaki,* the beverage is lower in protein and other nutrients when compared. However, it is rich in fat and crude fibre, due to high fibre and fat content of tiger nut seeds (*Cyperus esculentus*) (Maduka *et al.,* 2017). In appearance, tiger-nut milk is a light brownish liquid. It has a low viscosity and sweet acidic taste (Kizzie-Hayford *et al.,* 2015). Addition of date palm (*Phoenix dactylifera L.*), coconut (*Cocos nucifera*), spices such as cloves (*Syzygium aromaticum*), ginger (*Zingiber officinale Roscoe*) etc during preparation of tiger-nut milk is a personal choice which influences the flavour of the product (Victor *et al.,* 2021). Health benefits associated with consumption of Tiger-nut tubers which include prevention of diabetes, colon cancer, obesity, and coronary heart diseases could also be derived by drinking tiger-nut milk (Bashir *et al.,* 2014).

Despite the numerous health and nutritional benefits associated with tiger-nut milk, high level microbial contamination of the product especially homemade tiger-nut milk usually produced under unhygienic conditions could be a threat to public health (Ire *et al.,* 2020). It is listed among the beverages which constitute a hazard associated with foodborne diseases (Oduori *et al.,* 2022). Musa and Hamza (2013), reported the presence of bacterial genera which include *Staphylococcus sp., Proteus spp., Escherichia sp., Salmonella sp., Pseudomonas sp., Klebsiella sp., Bacillus sp., Streptococcus sp., Micrococcus sp., Enterobacter sp. and Corynebacterium sp.* In homemade commercially available tiger-nut milk while fungal genera encountered in the product include *Rhizopus sp., Penicillium sp., Saccharomyces sp., Aspergillus sp., Fusarium sp.* Majority of these microorganisms are associated with tiger-nut tubers and surfaces of equipment used in processing the tubers into tiger-nut milk (Pondei and Ariyo, 2021). It was concluded that there exists a rather high contamination level in home-made tiger nut beverages indicating the need to apply correct and strict hazard analysis and critical control point (HACCP) systems during manufacturing and storage.

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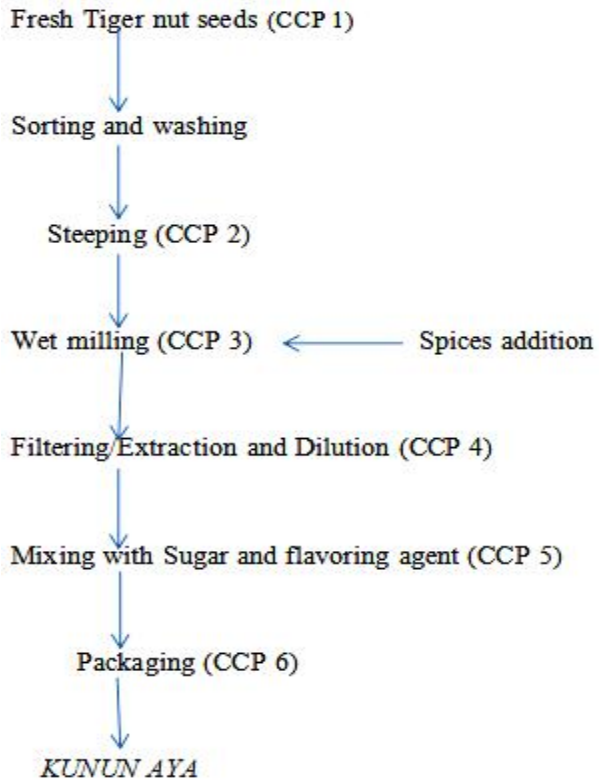

Figure 1: Flow chart for the production of *Kunun aya.*

Table 2: Critical control points, suspected hazards and their control measures during production of *Kunun Aya.*

Processing steps	Biological Hazards	Chemical Hazards	Physical Hazards	Control Measures
1. Raw tiger-nut (CCP 1)	Microorganisms Insects and animal waste	Myco-toxins, pesticides and Heavy metals	Impurities and foreign matters.	Visibly mouldy infected and/or damaged nuts should be discarded.
2. Steeping (CCP 2)	Microorganisms	Heavy metals		Use of potable water.
3. Wet milling and addition of spices. (CCP 3)	Microorganisms	Heavy metals	Impurities and foreign matters. Impurities and foreign matters.	Good hygienic practices, potable water and good quality spices.
4.Filteration /dilution (CCP4)	Microorganisms	Non	Non	Good hygienic practices and use of potable water and hand gloves.
5. Sugar addition and flavoring agents (CCP5)	Microorganisms		Impurities and foreign matters.	Use of Sugar-syrup
6. packaging (CCP 6)	Microorganisms	Non Non	Non	Use of sterile packaging containers and hand gloves

Codex (2009).

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Table 3: Proposed critical limits and corrective action of the CCPs during production of *Kunun Aya.*

Processing steps	Biological limit CFU/ml	Chemical limit (ppm)	Physical limit	Corrective action
1. Raw tiger-nut (CCP 1)	Aerobic Plate Count 10^5	Aflatoxins 10-15µg/kg Arsenic(As) 0.1-0.2,Cadmium (Cd) 0.1, Mercury (Hg) 0.5-1, Lead (Pb) 0.1	2% of physical contaminants	Tiger-nuts having high microbial and chemical contamination beyond limit should be discarded and change with a safer one
2. Steeping (CCP 2)	E. coli 20 ->10^2	As 0.01, Cd 0.003, Hg 0.001, Pb 0.01		Discard water with high E. coli count.
3. Wet milling and addition of spices. (CCP 3)	E. coli 20 - <10^2 Yeasts and moulds $5x10^2$	Alminium Al, 2mg/kg		Reject intermediate product and sanitize the processing equipment. Reject processing water with faecal contamination and/or high fungi count.
4.Filteration /dilution (CCP4)	E. coli 20 - <10^2 Yeasts and moulds $5x10^2$	As 3mg/kg, Pb 1mg/kg,		Reject and substitute sweetening and flavouring agents with high heavy metals.
5.Mixing with (sugar+flavouring agents)	Non Total bacteria Count 10^5-<10^7 E. coli			Reject any doubtful package and observe good manufacturing practices.
6. Packaging (CCP 6)	20 - <10^2			

(FAO/WHO, 2021; Codex, 2015 and CFS, 2014).

Kunun – zaki

Kunun zaki is a cereal-based beverage with low viscosity (Oboh and Okhai, 2012). The word *Kunun-zaki* is a Hausa word meaning sweet beverage (Sengev *et al.,* 2012). It can be used as weaning drinks for infants in some communities (Oboh and Okhai, 2012). Several preparation techniques are used depending on a person's taste and culture. When making *Kunu-zaki*, it is important that it is well homogenized. *Kunun-zaki* production involves sorting, cleaning, washing and steeping of whole grains for 10 to 24 hours, wet milling with spices and sweet potato, gelling of about three-quarters of the mixture in boiled water, addition of about one- quarter fresh ungelled part of the mixture and allowing for overnight fermentation. The *Kunun-zaki* is ready for consumption after filtration. However, modern technology makes use of millet and sorghum grain flour. With this processing approach, the time of processing is significantly reduced from 24h to 12 h while also improving the microbiological, sensory and nutritional qualities at the same time (Onyimba *et al.,* 2017).

The quality and the safety of the *kunun zaki* drinks therefore depend on the raw materials, the hygiene of the personnel, water, packaging materials and the production environment. Further-more the drink has short shelf-life. *Kunu-zaki* is prone to microbial spoilage if not adequately stored and could act as important medium for the transmission of pathogenic microorganisms (Ogbonna *et al.,* 2011). It has been reported that organic spices increase the nutritive value of *Kunu* varieties; however, these could also possibly be employed as

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natural preservatives for improving the *Kunu-zaki* shelf-life (Williana *et al.,* 2021). The use of chemical preservatives for *Kunu* commercialization must be carefully chosen after due consideration.

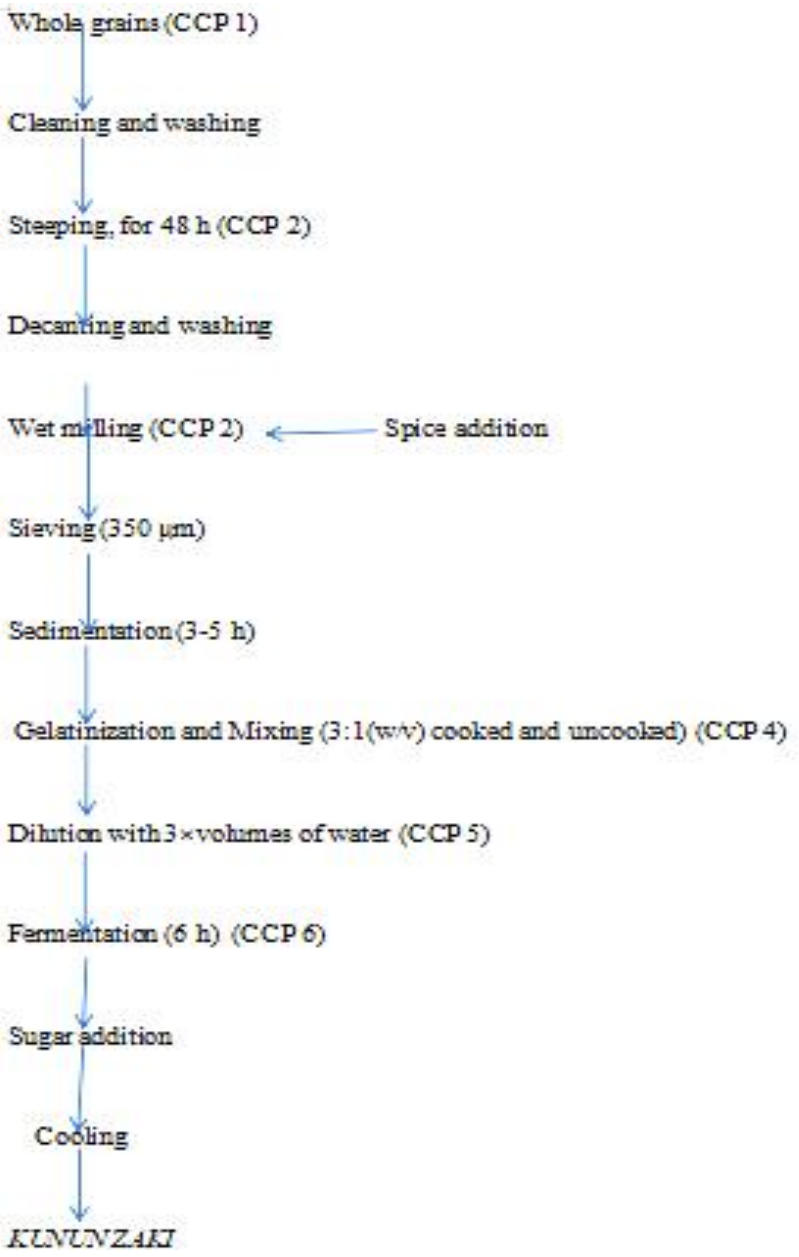

Figure 2: Flow chart for the production of *Kunun zaki* with the Critical control points (CCP)

Kunun-tsamiya.

Kunun-tsamiya is a traditional, non-fermented and carbohydrate-rich meal consumed in Northern Nigeria. It is produced mainly from pearl millet (*Pennisetum glaucum*) and a staple food especially consumed in Asian, South and Western African countries. It is known as a source of essential minerals, such as Calcium, Iron, Zinc, Copper and Manganese. During

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production process it is normally flavoured with Black pepper (*Piper guineense*), Ginger (*Zingiber officinale*) and Tamarind (*Tarmarindus indica*). These condiments enhance the taste, aroma, and also serve as purgative and cure for flatulent conditions (Bankole *et al.,* 1999).

Millet grains (*Pennisetum glaucum*) and spices (*Piper guineense, Dialium guineense* and *Zingiber officinale*) were cleaned of extraneous materials and dirts by washing, followed by drying and milling. After sieving (100µm mesh size), the "*Kunun-tsamiya*" was prepared by adding one volume of fermenting slurry and "*Tsamiya*' to 4 volumes of boiling water according to Bankole *et al.*, (1999) . The final product was obtained by adding *Tsamiya*" (*Tamarindus indica*) extract as a sweetener and boiling water to the fermented millet flour slurry.

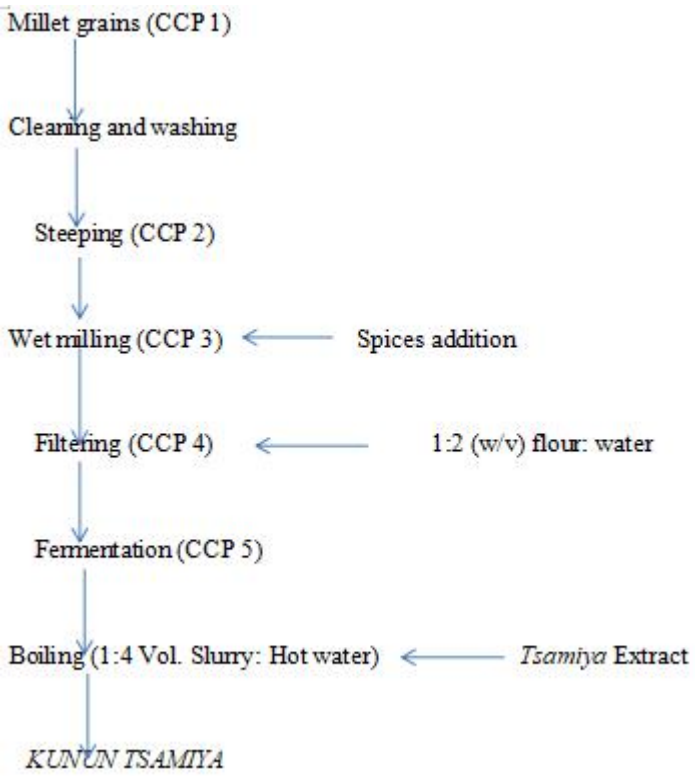

Figure 3: Flow chart for the production of *Kunun tsamiya* with the Critical control points (CCP).

Kunun-gyada

Kunun-gyada is a type of *Kunu* drink made with groundnuts and cereal (Yunusa *et al.,* 2022). It is among the most significant homemade weaning foods. Grain legumes can be included as a supplement to improve the protein content of diets based on cereal. To make *Kunun-gyada* a partially roasted groundnut and rice are soaked, cleaned, and wet milled to a smooth paste. After which is filtered and boiled on a medium heat until a desirable consistency is obtained. Tamarind or lemon juice as well as milk and sugar are added to improve the taste. It has been suggested that extrusion technology could be adopted to produce instant *Kunun-gyada* so as to satisfy the world bank's sustainable development goals (SDGs) because it may be used to prevent protein deficiency with a suitable nutritional composition (Ularamu *et*

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al., 2017). It was reported that the product can only be maintained for a maximum of four days and can readily go bad when kept at both refrigerated and unrefrigerated temperatures (Gaffa *et al.,* 2002).

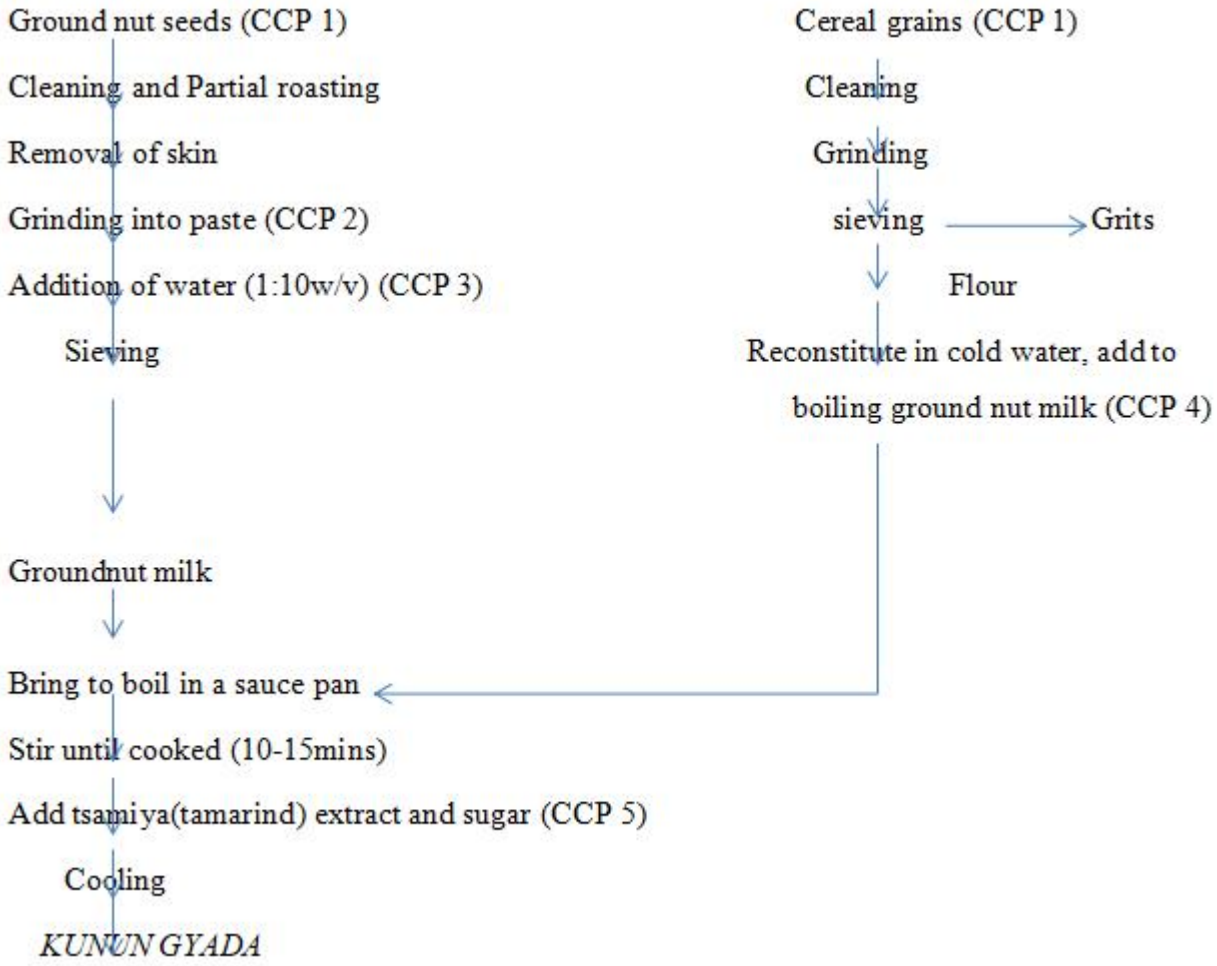

Figure 4: flow chart for the production of *Kunun gyada* with the Critical control points (CCP).

Food safety principles and practices in the processing of *Kunu* beverages

The inversion of microbes to *Kunu* drink resulting from the processing activities and materials such as water, handling and preservation techniques. Again, there is no regulatory agency of public health that monitors the production processes of *Kunu* drinks in spite of the associated harm that is allied to it. *Kunu* has high moisture content and total solid which may encourage the growth of strains of microorganisms to hazardous levels during storage at ambient temperature (Olasupo *et al.*, 2002). The World Health Organization (WHO) developed five crucial components for achieving safer food. The key features of these are: ensuring cleanliness, separating raw and cooked food, cooking thoroughly, keeping food at safe temperatures, and using safe water and raw materials (Fontannaz *et al.,* 2019). Base on this principles, It's mandatory on the producers and hawkers of *Kunu* to;

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1. Practice proper personal hygiene and keep all equipment and utensils used for the processing of the beverage clean and disinfected to avoid contamination.
2. Raw materials should be washed separately to avoid cross contamination.
3. The *Kunu* that is consumed cold should always be refrigeration to avoid multiplication of microbes.
4. Clean and boiled water should be utilize in the processing and reconstitution of *Kunu* to avoid contamination with coliform bacteria.
5. The serving cups, bowls or bottles for packaging *Kunu* should be sterilized after every usage.
6. The hawkers and producers of *Kunu* should always wear sanitary caps, wearing aprons, and use hand gloves while handling and preparing the beverage.
7. In case of a disease, avoid work while coughing/sore throat, avoid work while having diarrhea, avoid work while having skin infection
8. The environment where *Kunu* is processed should be clean and tidy before and after every processing. Sweep, mop and wash with detergent and also disinfectants to kill germs.
9. Decontaminate and discharge liquid waste (slurry) into drainage system properly (Lawan *et al.,* 2014).
10. Solid waste such as the bran and the sifted waste should be properly dumped into trash bins with closures.

Food Safety Situation in Nigeria

Food vendors must have adequate knowledge of food safety, and the ability to apply that knowledge when handling food (Cunha *et al.,* 2018). But unfortunately as reported in several studies, foods are often prepared in unsanitary conditions, regular washing of hands is somewhat rare, and foods are often exposed to flies and other insects (Gali *et al.,* 2020). Among certain ethnic groups, keeping and preparing foods in advance for consumption is a common practice, while in some communities, food poisoning is often associated with evil spirits and ancestral curses.

Lawan *et al.,* (2014) stated food vendors operating in Kano generally knew about personal and food hygiene, but this was not reflected in their hygienic practices. It is the statutory responsibility of the environmental health officers to safeguard and implement food hygiene laws in Nigeria. But despite the available structure and personnel at the Local government area level, the laws are still inactive.

As in most developing countries, meeting the WHO's five key requirements for achieving safer food have been a struggle in Nigeria where basic amenities, particularly running water and robust sanitary units, are lacking (Fasoro *et al.,* 2016). These gaps in all aspects of the food chain—from the farm to the table—have amplified food safety issues in Nigeria. By the same token, other issues have contributed to poor food safety practices in Nigeria, including the rising population, the disparity in incomes, the extended food supply chains, the constantly evolving demographics, the dearth of education, the food consumption patterns, little or lack of food safety regulation, and other factors that are endemic in places with low levels of economic development (Fasoro *et al.,* 2016). Other key obstacles to food safety in Nigeria include the lack of a positive attitude towards risk management and an unwillingness to learn from accidents, near misses, and safety performance indicators (Chikaire *et al.,* 2020).

Solutions to Food Safety Challenges in Nigeria

There is a great need to employ adaptive strategies, such as establishing a food safety management program in Nigeria which would

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expound on the need to detect food hazards and promote food safety culture. A starting point may be for the government to show more regulatory oversight. There is a consensus that regulatory oversight and better relationships with food producers could improve the current food safety deficiencies in Nigeria (Nwaiwu, 2017). The government should constantly review food safety elements such as leadership, communication, risk perception, self-commitment, and management support. National Food Regulatory Agencies such as NAFDAC, Standard Organization, Consumer Protection Council, Ministry of Health and Agriculture should make food safety training mandatory using food safety guide published by FAO (2023) for all vendors participating in Safety Food practice (SFP). Madaki and Bavorova (2019) also reported a positive effect of age, literacy, and years of education on food safety knowledge of food vendors. The expansion and comprehensive coverage of radio, television, and internet service have led to its usage by all levels of government and non-governmental organizations to mobilize the public and raise awareness and preventive measures for the disease outbreak such as cholera and Lassa fever (Wogu *et al.,* 2019).

CONCLUSION

Kunu possesses both nutritional as well as probiotic properties. The production of *Kunu* is mostly carried out in environments where quality control and food safety practices are neglected therefore *kunu* could be considered as vehicle of transmitting food-borne infections.

Recommendations

Based on revealed literature, the followings are hereby recommended:

1. *Kunu* drinks are both nutritious and probiotic, they shouldn't be disregarded or viewed as inferior foods; instead, the technology used in their manufacturing should be improved.
2. Educate producers and hawkers of *Kunu* on good sanitary practice during the preparing and sale of the product.
3. Advocate on use of boiled water in processing and dilution of the processed drinks, also treated municipal water should be used in washing utensils to avoid contamination with entero-pathogenic bacteria. The processing environment should be hygienic and the packaging materials should be sterilized.
4. To minimize the presence and effects of microbes in the *kunu* beverage, the Good Hygiene Practices (GHP) and the Hazard analysis critical control points system should be applied throughout the production process.

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