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Review

Diet Diversification and Priming with *Kunu*: An Indigenous Probiotic Cereal-Based Non-Alcoholic Beverage in Nigeria

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Abstract: *Kunu* is a fermented non-alcoholic beverage consumed all over Nigeria. The drink is served as an alternative to alcohol due to its perceived extreme nourishing and therapeutic properties. Varieties of this beverage are determined mostly by the type of grain, the supplements, sensory additives used, and the process employed during its production. Dietary quality is paramount in nutritional well-being and a key factor in human overall health development. The nutritional quality of grains utilised for *Kunu* production makes the drink more appealing to a large growing population when compared to some other drinks. Some use *Kunu* drink as an infant weaning drink, thus serving as a priming beverage for infants due to its rich probiotic and nutritional properties. However, this beverage's short shelf-life has limited its production scale. This review therefore elaborates succinctly on the diverse therapeutic nutritional properties of the *Kunu* beverage and the effect of additives and fermentation on the microbial dynamics during *Kunu* production, as well as the prospect of *Kunu* in diet diversification and priming for weaning infants.

Keywords: *Kunu*; beverage; fermentation; diet priming; *Lactobacillus*; probiotic

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1. Introduction

Kunu, a fermented non-alcoholic beverage, is popular in the northern region of Nigeria. Furthermore, its refreshing nature increased the popularity of the beverage to non-alcoholic drink lovers [1] in many other parts of Nigeria. Varieties of this non-alcoholic beverage are determined mostly by the substrates (major grain used), supplements or sensory attributes employed during its production and primarily prepared to suit each individual's desire as porridge or free-flowing gruel [2,3]. Foods produced from single or mixed cereals can be taken by people of all ages and social classes, serving as breakfast for some adults, weaning foods for babies and beverages for people living in different local African communities [4,5]. These beverages have been produced from different grains such as *acha* (*Digitalis exilis*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), maize (*Zea mays*), millet (*Penisetum typhoides*) and wheat (*Triticum aestivum*). Beverages of African origin are produced from different raw materials including cereal grains, flowers, milk, plant juices, legumes and fruits [6]. They vary due to their origin, compositions and processing techniques particular to the cultural or ethnic groups that produced them [7,8]. Supplements used in producing these beverages improve their protein and amino acids content and their antioxidant properties [2,9].

The preparations of different *Kunu* beverages are usually artisanal and carried out in homes [10]. Their types are dependent on the raw materials, sources and techniques involved in processing them [7]. These characteristics also help to determine the cultural or ethnic groups, religious, socio-economic class and tribe of the consumers, which in turn affects their consumption by people living in urban areas [5]. Generally speaking, these foods are regarded as food for the poor since they are locally prepared and consumed by mostly by the poor or middle-class populations. In Nigerian rural communities, for instance, local beverages (both alcoholic and non-alcoholic), are served during social gatherings and festivities but served as a token of hospitality and produced during young girls' initiation into womanhood in Namibia [11,12]. Non-alcoholic beverages also have nutritional and therapeutic potentials besides social functions [13]. *Kunu* processing techniques involve malting, boiling, pasteurization, fermentation and distillation [8,14–16]. Several additives are also used to improve their quality, taste and shelf-life. These techniques improve their flavour, digest complex compounds, eliminate or transform poisons, degrade anti-nutrients and improve their overall quality, as stated by other investigators [5]. This review, therefore, highlights the diversity of *Kunu* drinks in Nigeria, its nutritional, therapeutic and additive effects. Additionally, the suitability as a weaning food for infants, the microbial dynamics and preservation of the beverage was explored.

2. Diversity of *Kunu* Drinks in Nigeria

Kunu generally refers to non-alcoholic beverages produced mainly from millet and sorghum in Nigeria. *Kunu* is of various types, and each type's name denotes the major or secondary ingredient used or the sensory attribute. Causes of nutritional variation among different *Kunu* types resulted from variances in raw materials used, methods of processing, and lack of standard methods and ingredients added [17]. Ginger, clove, fresh or dried red pepper and black pepper, as well as tamarind (*Dialium guineense* wild) fruit pulp, are the different spices that can be used either singly or in combination to produce different types of *Kunu* [18]. Depending on the major cereal employed in its production, thirteen [13] varieties have been reported in Nigeria at present [17]. They are *Kunu-zaki*, *Kunu-gyada*, *Kunu-tsamiya*, *Kunu-akamu*, *Kunu aya*, *Kunu-koko*, *Kunu-aduwa*, *Kunu-acha*, *Kunu-kanwa*, *Kunu-jiko*, *Kunu-banle*, *Kunu-gayamba* and *Kunu-amshau* (Table 1). However, five out of these thirteen varieties are amongst the most commonly consumed in various local communities in Africa because of the availability of the raw materials for their production [19]. These varieties are assessed and consumed by many ethnic groups in developing countries, even while on transit [20,21].

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

***Kunu* Type**	**Varieties**	**Used Grains**	**Sweetener/Additives**
Type I	*Kunu zaki*	Millet, maize or sorghum, or malted rice or sorghum	Ginger, clove, red pepper, sweet potatoes paste or extracts of *Cadaba farinosa* (dangarafa)
	Kunu baule	Sorghum or millet	Cadaba farinosa
	Kunu jiko	Sorghum, millet, malted cereal	Ginger and roots of certain plants.
Type II	*Kunu aya*	Tiger nut, Sorghum, millet, malted cereal	Ginger, clove, red pepper and roots of certain plants
	Kunu akamu	Maize or millet or sorghum	Ginger and sugar
	Kunu tsamiya	sorghum or rice	Tsamiya, red pepper and sugar
	Kunu bururu	Millet or sorghum	Fresh cow milk, tamari and sugar
	Kunu koko	Millet or sorghum	Ginger and pepper
	Kunu kanwa	Millet or sorghum	Potash, ginger and pepper
Type III	*Kunu aduwa*	sorghum, millet or maize	Aduwa (*Balanites aegyptica*) fruit pulp, tamarind and sugar
	Kunu acha	*Acha*	Tsamiya, milk and sugar
	Kunu gyada	Millet or sorghum or rice	Ground nut paste, tamarind fruit pulp extract and sugar
Others	*Kunu Gayamba*	Malted millet	Any available sweetener
	Kunu Amshau	Maize, sorghum or millet	Any available sweetener

2.1. Kunu-Zaki

Kunu-zaki is a locally produced, non-alcoholic beverage from Nigeria that is believed to have high nutrient value due to the ingredients used in its production. It is conceivably the most popular variety of *Kunu* available in Nigerian markets. Millet (*Pennisetum typoidum*), sorghum (*Sorghum bicolor*) or maize (*Zea mays*) can all be used for its preparation [22]. Several preparation techniques are used depending on a person's taste and culture. When making *Kunu-zaki*, it is important that it is well homogenised [23]. Sorghum grain is steeped, milled and sieved as part of the native processing of *Kunu-zaki*. However, modern technology makes use of millet and sorghum grain flour. With this processing approach, the time of processing is significantly reduced from 120 h to 10 to 12 h while also improving the microbiological, sensory and nutritional qualities at the same time [24]. The *Kunu* drink produced from sieved *Kunu-zaki* flour retains more nutrients than the one produced from non-sieved *Kunu-zaki* flour [24]. However, the laboratory-processed *Kunu* drink carbohydrate content does not significantly differ from the ones sold on the streets [1]. To improve the protein content of sorghum-based *Kunu-zaki* with enhanced organoleptic properties under hygienic conditions, starter cultures of *Lactobacillus* sp. were observed in samples of naturally fermented *Kunu-zaki* and used in a variety of combinations [25]. In a similar study, starter cultures of *Lactobacillus fermentum*, *L. plantarum* and *L. lactis* were used in controlled production of *Kunu-zaki* produced with millet alone or in combination with malted rice or wheat [26].

2.2. Kunu-Gyada

Kunu-gyada is a type of *Kunu* drink made with groundnuts and cereal [27]. 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. Maize, sorghum, rice, groundnuts and millet are the main staple crops used to make *Kunu-gyada*. The price and accessibility influence the choice of cereal in a particular location. When available, millet and sorghum are also commonly utilised cereals along with maize [27]. It has been suggested that extrusion technology could be adopted to produce instant *Kunu-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 [28]. In another study, extrusion cooking was used, and it increased the nutritional concentrations of cereals gruels and improved the product's quality [29]. 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 [17]. In the context of sensory analysis, the powder of *Kunu-gyada* felt slightly greasy to the touch. Based on consumer sensory evaluation using a 5-point rating scale, the product received a low overall acceptance rating [29]. Maltodextrin supplementation increased *Kunu-gyada*'s general acceptance and storage stability [30]. Groundnut is the major non-cereal ingredient that distinguishes *Kunu-gyada* from others [27].

2.3. Kunu-Tsamiya

Kunu-tsamiya is a *Kunu* made from the normal millet or sorghum cereals and supplemented with tamarind. Red pepper or ginger and sugar are added as spices and sweeteners, respectively [17].

2.4. Kunu-Akamu

Akamu or *Ogi* is a Nigerian beverage derived solely from maize, corn, millet and sorghum by fermentation. It often has a smooth texture and is consumed after being boiled into a porridge known as pap [31]. Fermented *akamu* has a distinctive scent that distinguishes it from starch and maize flour and a moderate to strong sour flavour that is similar to yoghurt. The appearance of *akamu* varies depending on the cereal; for white maize, it is somewhat cream, yellow or light brown, for sorghum and millet, it is greenish to grey [32]. Previous studies [33] characterised a set of unique yeasts and lactic acid bacteria that conferred some acidic (pH < 4), probiotic and antimicrobial attributes to experimental *akamu*.

2.5. Kunu-Aya

Kunu-aya is a locally prepared indigenous non-alcoholic beverage that is widely produced and consumed. *Kunu-aya'* is produced from tiger nut, an underutilised crop rich in fibre and fat. Another name for it is tiger nut milk. Although *Kunu-aya* is slightly more nutritious than *Kunu-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 [34,35]. *Kunu-aya* is produced by steeping cleaned and sorted cereal and/or tiger nut seeds in water for 48–72 h, and then wet milled together with desirable spices and filtered using muslin cloth. The slurry is left to ferment for another 24 h, thereafter it is bottled and chilled, ready for consumption.

3. Nutritional and Probiotic Properties of *Kunu* Drinks

The different *Kunu* drinks possess some nutritional and probiotic properties as a result from the breakdown of the complex molecules present in the cereals used for their production, and the microbial strains that carry out the fermentation process. These fermenting organisms often produce bioactive molecules (biogenics) (such as vitamins, organic or fatty acids) and peptides during the process [36]. Reports by Leblanc et al. [37] and Victor-Aduloju et al. [38] showed *Lactobacillus* sp. and *Bifidobacterium* sp. in fermented cereal foods produce compounds such as niacin, folate, cobalamin, lysine, menaquinone (vitamin K), riboflavin and thiamine. Another study [39] showed the possibility of isolation of probiotic *Lactobacillus* isolates from fortified *Kunu-zaki* which meet the common criteria for probiotic bacteria. According to some reports [40,41], some microorganisms showed potential probiotic properties by their ability to tolerate low pH and resist bile salts, and antimicrobial activities against some pathogenic organisms and cancer cells adherence. For instance, sour water of a naturally lactic fermented millet porridge koko, consumed in northern Ghana, has been used as a refreshing drink and remedy for stomach upsets [36]. These properties made traditionally from fermented African cereal-based foods are potential sources of novel probiotics and functional food components delivery vehicles [42].

The fermentation process also provides optimal pH for phytic acids', tannins' and other food inhibitors' reduction in cereal-based foods [43], and as a result, improves nutritional composition, shelf-life, flavour and digestibility. This helps to increase the number of potential probiotic bacteria [36]. Fermentation is also an economic and the most simple method of improving the nutritional, sensory and functional properties of cereal-based foods or beverages [9]. Supplementing the cereal with other carbohydrate and/or protein sources together with pre-treatment methods employed on these supplements could help to improve their nutritional composition, thus improving the dietary component of the final product. For instance, steeped tiger nut kernel contains a higher crude protein and fat content than fried or toasted ones, reducing their anti-nutritional properties [44]. The use of *Kunu* beverage with *Lactobacillus fermentum* enriched with cocoa powder has been proposed as a probiotic drink. Additionally, the studies by Adeniran et al. [45] showed antimicrobial properties against pathogenic *Escherichia coli* to promote consumers' health and also improve the shelf-life of the beverage. The fermentation by lactic acid bacteria increases the medium's acidity to inhibit the growth of other microbial strains that may not be desired in the food.

4. Factors That Affect *Kunu* Production

There are different techniques in the production of *Kunu*. A six-step process in the production of local *Kunu* beverage has been reported [2]. The steps include (i) cereals softening by steeping in water and indigenous bacteria fermentation; (ii) wet milling; (iii) gelatinisation of part of the milled grains via boiling water introduction; (iv) addition of the milled grain residuum and a mix of milled additives to the gelatinised gruel; (v) fermentation of the mixture; and (vi) sieving of the fermented slurry. This process has been reported by many researchers [3,46–48]. An improved *Kunu-zaki* production using a malted soybean addition process has also been reported [45]. A flowchart illustrating the conventional production of *Kunu* varieties is presented in Figure 1. The final product is usually an unregulated artisanal drink among others (Figure 2) sold in the streets of Nigeria.

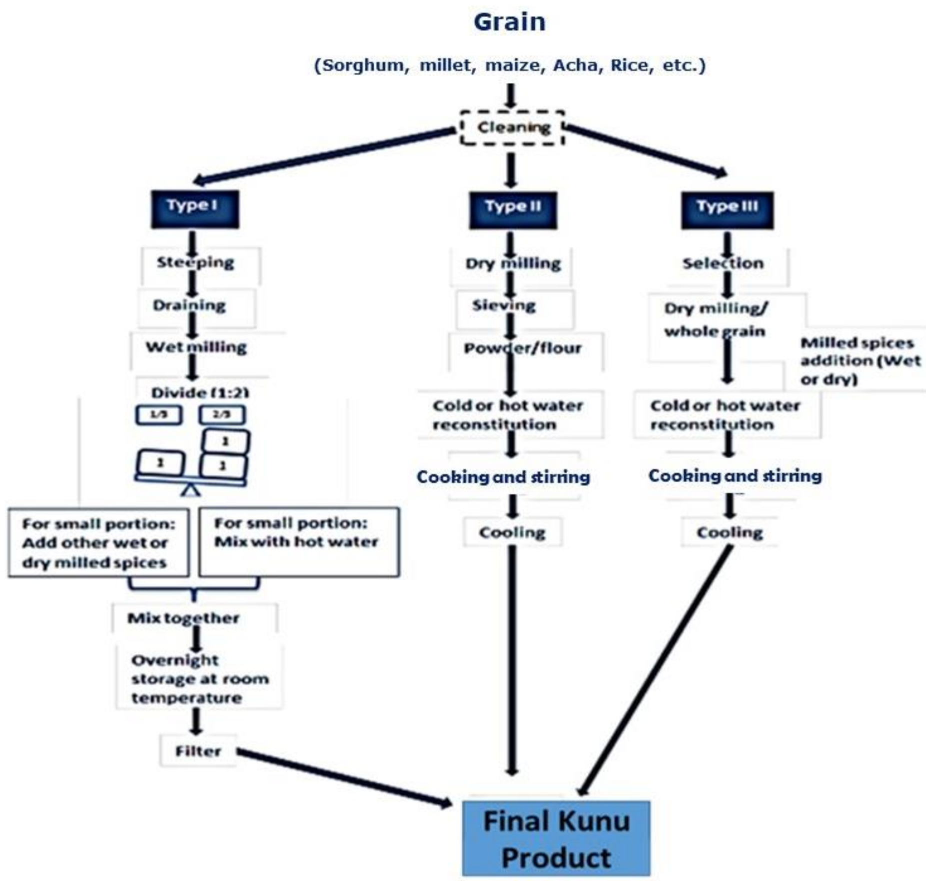

Figure 1. Flowchart of processes involved in the production of varieties of *Kunu* drinks.

Figure 2. Unregulated drinks sold in many streets in Nigeria. It includes *Kunu* (**A**) and Zobo (**B**). Source: Nwaiwu et al. [10].

4.1. Effects of pH on Kunu Production

Previous studies have reported that the pH of fermenting cereal grains often declines to a level that is adequate to hinder the growth of pathogenic microorganisms [35,49,50] Findings by others [35] revealed that acidic samples with 2.19–4.00 pH range could be one of the factors that inhibit the growth of several spoilage microorganisms. Low pH inhibition level hinges on the fermenting microbes, buffering potentials of the food and acids formed which penetrate the bacterial cell wall to delay the metabolic activities [51]. On the other hand, a report [52] found a decline in pH as the fermentation advanced (5.75–3.26), and this may be ascribed to the faster growth rate of lactic acid bacteria present in the sample. A study established [53] that the pH range of samples of Millet-based *Kunu-zaki* was steady for 2 days; however, it decreased on the 3rd day, which was due to the breakdown of complex sugars by the activities of micro-organisms and enzymes. This enabled the rise in the acidic level of millet-based *Kunu zaki* samples within 72 h of production. *Kunu-zaki* is acidic in nature, as a result of the fermentation process by lactic acid bacteria [54]. In addition, the metabolic activities of contamination could be averted by maintaining good hygienic conditions [35]. As opined previously [55], pH ranging from slight acidity to neutrality (6.83–7.13) might account for proliferation of spoilage and pathogenic organisms. *Kunu* drinks are often acidic owing to the presence of various bacteria that aid in acid fermentation of the products [56]. Several pH ranges have been reported: (1.02–1.14), (3.12–5.46), (2.95–4.15), (6.83–7.13) and (2.99–5.11) [23,53,54,57]. The prospective nutritional contribution at different processing stages and conditions is shown in Table 2.

Table 2. Nutritional contribution at different processing stages and conditions.

Processing Stages/Condition	Nutritional Contribution	References
Malting	Amino acids, digestible sugars, B-group vitamins, reduced dry matter, starch, anti-nutrients	[58,59]
Steeping	Improved flavour and taste	[60]
Fermentation	Soluble protein, nitrogen, probiotics	[20,61,62]
pH	Probiotics, phytic acids, tannins and other food inhibitors reduction	[33,42]

4.2. Effects of Flavonoids and Additives on Kunu Production

Homemade beverages are highly susceptible to contamination by food spoilage microbes which have led to unstable quality and short shelf-life due to the various process involved in their production. To mitigate this challenge of deterioration, researchers have delved into exploring various spices, which do not just only enhance the taste of the beverage but also serve as preservatives. It has been reported that organic spices increase the nutritive value of *Kunu* varieties; however, these could also possibly be employed as natural preservatives for improving the *Kunu-zaki* shelf-life [63]. Preservatives such as lemon, lime, Sodium benzoate, Phyllanthus and a combination of lime and lemon as mixed preservatives have been studied [64]. The result revealed improved taste, colour, flavour, texture and odour qualities with all the spices, especially the sample with the mixed preservatives, (lime and lemon). This mixture, however, resulted in a decrease in microbial count when compared with the specific preservatives. Diverse food spices, such as garlic, cinnamon and nutmeg have been reported as possible preservatives that could be used to prolong *Kunu-zaki* shelf-life [63]. Tiger nut milk serves as an enhancer of the nutritional qualities of *Kunu* and significantly elevates the sensory properties. Additives such as ginger concentrations in varying percentages (15, 20 and 25%) in *Kunu* samples boosts organoleptic qualities such as taste, aroma and colour, and the sensory panellist accepted its general satisfactoriness for 72 h [48]. Several authors have reported on the beneficial effects of using spices (ginger, garlic, cloves, sweet potato, tiger nut, rock salt, chili pepper, alligator pepper, etc.) as taste enhancers and preservatives in *Kunu* production [3,65]. Some of these organic extracts have been studied and proven safe, effective and desirable as preservatives in food products, they are also cheap and health-friendly. However, other investigators [66] opined that flavours could be introduced, as these additives could reduce the beany taste, improve the quality and also serve as a preservative to *Kunu-zaki*. Additionally, this drink should be kept in the refrigerator instead of storing at ambient temperature so as to extend the shelf-life.

Extract of West African black pepper (*Piper guineense*) has been prepared and used as organic preservative (anti-bacterial, anti-mould and anti-oxidant) by Orishagbemi et al. [67] to extend shelf–life of liquid *Kunu-zaki* under ambient storage (28 ± 2 °C) from 2 days to 28 days (4 weeks), which maintained the original qualities of fresh *Kunu* (i.e., nutritive, physical, sensory attributes). The acceptable limits of microbiological contents to guarantee safety of the consumer was achieved and this serves as a viable alternative to synthetic/chemical preservatives, which are associated with toxicity. It is worth noting that these spices are usually added in small quantities for the improvement of the beverage organoleptically, and furthermore, they have been reported to inhibit microbial growth [35].

Numerous reports show that synthetic/chemical preservatives are used to extend the shelf/storage life of foods, most especially food beverages/drinks, fruits/vegetables, etc. [67]. Artificial/synthetic preservatives are chemical substances that can trigger health challenges [68]. Food disorders are largely caused by the interaction between synthetic preservatives and the cellular components of the body [69]. Some of the examples of synthetic preservatives are nitrates, butylated hydroxy toluene (BHT), benzoates, sulphites, sorbates, parabens, formaldehyde, butylated hydroxy anisole (BHA) and sodium benzoate [70–73]. The reaction of preservatives can be very mild to life-threatening. These preservatives are used in the beverages/drinks which expose the consumers to health risks; their resultant negative aftermath effects associated with long term exposure which could lead to various ailments include stomach cancer, headache, palpitation, allergies, allergies, asthma, skin rashes, hypersensitivity, hyperactivity and neurological damage [57,74,75]. The use of chemical preservatives for *Kunu* commercialization must be carefully chosen after due consideration.

5. Microbial Dynamics and Preservation of *Kunu* Drink

The steps in the production of *Kunu* beverage can be categorised into three-critical steps (pre-fermentation, malting, and post-fermentation) based on the enzymatic and fermentative changes in the process of production. These three categories are impacted by the dynamics of microorganisms involved in each, and these might have a positive or negative effect on the shelf-life of the product.

5.1. Pre-Fermentation in Kunu Production

Wide varieties exist in the protocols of preparation, which impact the taste, cultural norms and habits around *Kunu* [47,76]. The pre-fermentation in *Kunu* production begins with cereal sorting, washing and steeping alone or in combination with additives and spices. The Steeping process can either be via the replacement of water at different time intervals or without water replacement [46,48,66]. Steeping is primarily employed to soften and increase grains' moisture content thereby easing milling. Certain physicochemical and biological changes (such as swelling of the grain, degradation of soluble carbohydrates and removal of some pigments, microorganisms and bitter substances) occur during steeping [77,78]. The product's characteristic organoleptic properties and nutrition components are due to the spontaneous fermentation mediated primarily by bacterial species during the steeping stage [51,79,80]. Furthermore, the highly fermentable solutes in the grains are transferred into the steeping water, while enhancing the release of sulphites, free reducing sugars and temperature level, which aids the rapid development of bacteria [78] needed during fermentation. Although the microbial community dynamics during the steeping and pre-fermentation stage and process are dependent on the type and variety of grains used [2,3], firmicutes dominate most of the steeping and souring stages during the processing of all millet varieties [81]. In a throughput metagenomic analysis of microbial dynamics during the steeping stage in *Ogi* production [81] an increase in the R and diversity (Shannon–Wiener index, H′) of ASVs at 48 h was observed when compared with 12 h of steeping; and that throughout the steeping stage, R and diversity (Shannon–Wiener index, H′) of ASVs were fluctuating among millet varieties [81]. They also reported the dominance of firmicutes during the steeping and souring stages of all three millet varieties. Additionally, another report [3] confirmed the prevalence of firmicutes in most of the processing stages, as proteobacteria dominated the rest of the stages. Furthermore, they observed the dominance of *Lactobacillus* at the genus level during most stages of processing and in the final product of the two *Kunu* formulations [3]. A similar observation of *Lactobacillus* spp. dominance in *Kunu-zaki* has been reported by others [82,83]. The genera *Lactobacillus*, *Lactococcus*, *Pediococcus and Burkholderia-Caballeronia-Paraburkholderia* were reported by Chibuzor-Onyema [81] to be present at most steeping and souring stages of all three millet varieties used. *Lactobacillus, Lactococcus* and *Saccharomyces* spp. have been implicated during the steeping stage [3]. However, Oyeyiola [84] reported the presence of bacteria (*Pediococcus pentosaceus* and *Lactobaclllus plantarum*), moulds (*Aspergillus versicolor*, *Penicillim nigricans* and *Rhizopus stolonifer*) and yeast (Saccharomyces cerevisiae) with the bacteria and yeast persisting to the end of the steeping period. Similar findings have shown that *Lactobacillus fermenturn*, L. *leichmannii*, *Bacillus subtilis*, *Enterobacter aerogenes* and *E. cloacae* dominated throughout the production process, with the latter disappearing during the post-fermentation stage [85]. Growth of *Saccharomyces cerevisiae* became apparent with increased acidity during the post-fermentation stage.

5.2. Post-Fermentation in Kunu Production

The dynamics of microbes during the post-fermentation stage of *Kunu* production are quite interesting as certain microbes observed in the pre-fermentation are eliminated during this stage. Moulds are eliminated prior to post fermentation and after steeping there was a unilateral in the ratio of Gram positive to Gram negative after the steeping stage [85]. Other reports [3] revealed that different bacterial succession patterns at different stages of fermentation of three different *Kunu* formulations. Some investigators [86] implicated *S. rouxii* and *S. cerevisiae* as being partly responsible for fermented maize organoleptic properties, [50] and highlighted *Penicillium* as the major organisms responsible for the fermentation and nutritional improvement of cereal-based fermented foods (*Ogi* and *Kunu-zaki*). However, overall the fermentation stages of *Kunu* production are driven by a cocktail of notable yeasts such as *Saccharomyces cerevisiae* [87] and predominantly lactic acid bacteria [88–90]. There is a relatively low OTU (operational taxonomic unit) diversity at the start of the post-fermentation in all the *Kunu* formulations due to hot water (100 °C) treatment prior to gelatinisation of the milled grains [3]. The bacteriostatic and/or bactericidal effect of such heat treatment on the indigenous microbiota might have contributed to the reduction in species diversity [91]. The total viable count of microbiota reduced sharply following heat treatment of fermented maize (*Ogi*) at 100 °C [92]. Generally, *Kunu* fermentation is seen as a lactic acid fermentation type, with slightly acidic pH of about 6.0 ab initio which reduces to an acidic pH of about 4.76 at the end of 12 h, and then decreases further to 3.0 in the final *Kunu* product [9,87]. Reduction in the pH gives a competitive advantage to certain microbial communities [93,94]. An increase in OTUs between the onset and first 6 h of fermentation might be due to the moderate pH and other favourable conditions (e.g., temperature, oxygen availability, absence of growth inhibition metabolites) during this period, which caused the recovery of microorganisms suppressed by the heat treatment in the gelatinisation stage [95]. However, as the selection pressure increases with further pH reduction toward the end of fermentation (at 12 h), only adapted species (mostly lactic acid bacteria) proliferate [87]. It is important to note again that different substrate types play critical roles not only in the balance of biochemical reactions and conditions (such as pH, oxygen availability, redox reactions, enzymatic activities and temperature), but also the genetic and functional diversity and dynamics of microbiota during fermentation [96–98]. From different research findings, Lactobacilli appears to be dominant during post-fermentation and it is responsible for the acidity in cereal fermentation [3,48,83,86,99–101]. *Lactobacillus* spp. includes several species with probiotic [102] and physiological capabilities for the digestion of complex polysaccharides in human and animal diets [103]. This may be the reason for some of the nutritional and health benefits generally associated with *Kunu* consumption [5]

Furthermore, the essential metabolites (such as pyruvate, amino acids and vitamins) provided by *S. cerevisiae* during post-fermentation work to excite the growth of *Lactobacilli*, as the yeast also utilises certain metabolites produced by *Lactobacilli* as their carbon sources [104]. Different yeast species have been reported to have pectinase activity which could engender the growth of other microorganisms during fermentation [3]. The antioxidant potential of fermented foods through an increase in the phenolic contents has been linked with the presence of yeasts [105,106]. More so, different studies have revealed cereal fermentation leads to phytase-dependent dephosphorylation of phytic acid. The phytic acid chelates many important nutritional minerals in food, hence its digestion results in essential minerals (such as iron, zinc, calcium and magnesium) accessibility [5]. The phytase activity within the cereal is induced during *Lactobacilli* acidification, thus engendering desirable biochemical changes such as aromatic compounds production, proteolytic and lipolytic activities [107–109].

5.3. Effects of Fermentation on Kunu Production

Fermentation is a procedure which aids the breakdown of complex organic molecules (carbohydrates, proteins, lipids) into simpler molecules via the activities of microorganisms [110]. Application of fermentation in production processes increases the security of food chain supply, hence, denotes a fundamental part of food culture development universally [111]. Furthermore, fermentation is beneficial in preservation of various food products, supplies diverse flavours, enhances taste, acidity, digestibility, texture and notably increases the nutritional potentials of the raw food [112]. Owing to the aforementioned vital characteristics associated with several fermented foods, fermented foods are produced and consumed worldwide [113,114]. Food preservation is of utmost importance, hence, fermentation is seemingly perceived as a tool for achieving the preservation of food throughout Africa and beyond, where current food preservation methods are still not yet fully established [112]. Food fermentation has been found to surge the macro-mineral and micro-mineral bioavailability by decreasing non-digestible material present in plants, including cellulose, hemicelluloses, glucuronic acid and polygalacturonic acids [115]. Fermented foods can be beneficial to consumers. The fermentation of much cereal-related food has overtime shown to have a direct therapeutic influence on the consumers [116], consequently, fermented food promotes consumers' wellbeing via boosting the number of accessible vitamins, including thiamine, folic acid, niacin and riboflavin [117]. Fermented foods, compared with simple foods regarding peptide production, antioxidants, organoleptic and probiotic properties as well as antimicrobial activity, have shown to be more acceptable, as they aid in the reduction of anti-nutrients and toxins [110]. Digestibility is an essential factor in food nutritional value, but other vital nutrients present could, however, be enriched through the fermentation process. This is obvious in regard to the variations in nutrient composition and their biochemical qualities relative to the initial constituents [110]. Fermentation has been proven to reduce the required energy for cooking and produce harmless products [118,119]. In addition, fermentation has been documented to enhance the iron utilisation by the breaking down of complex nutrients into inorganic iron and vitamin C [119]. According to Erkmen et al. [120], carbohydrates with non-digestible oligo- and polysaccharides' levels are largely reduced by natural fermentation and thereby, this boosts vitamin B group accessibility, improves amino acid synthesis and increases enzymatic degradation of phytates through providing ideal pH conditions existing in a composite form with polyvalent cations including iron, zinc, magnesium and calcium [119]. According to Singh et al. [121], cereals crops (namely: maize, millet, sorghum and other grains) promote the amount of protein as well as the levels of lysine when they undergo the fermentation process [122]. Hydrolytic enzymes have been reported to play a vital part in pre-fermentation [23]. Hydrolytic enzymes increase the nutritional and sensory quality of the *Kunu* product. Several researchers have used hydrolytic enzymes to produce *Kunu-zaki* which increased the nutritional and sensory quality of the product [123–125].

5.4. Malting in Kunu Production

Malting has been reported to primarily promote the synthesis of hydrolytic enzymes capable of solubilising large macro molecules into low molecular weight compounds [126,127]. Whereas fermentation favours the growth of microorganism of importance and prevents the growth of harmful microorganisms by increasing the acidity, thus preserving the food [128–130], malting enhances the bio-accessibility of minerals due to an increase in phytase enzyme activity which leads to phytate content reduction during grain sprouting [130,131]. During malting and fermentation, the microbial community implicated are yeasts and LAB, which raise the titratable acidity, reduce the pH and clog the development and proliferation of microbial contaminants such as coliforms and enterobacteriaceae, hence, extending the shelf-life of the cereal product [132]. During cereal drying and malting, reports [133] show that there is a reduction in the total microbial count due to the dried state of the cereal. However, it has been observed [131] that although the total plate count (TPC) decreased from 5.69 log Cfu/g in non-malted finger millet to 5 log Cfu/g in malted finger millet flour, LAB increased from 4.66 log Cfu/g to 6 log Cfu/g [133]. The reason for this increase might be due to the increase in the amount and availability of soluble sugars during malting as a result of extensive starch degradation [134]. The increase in the digestible and fermentable sugars after malting in *Kunu* production can impact the quality and amount of fermentative microbes necessary for the improved probiotic characteristics associated with the *Kunu* product. Probiotic bacteria alleviate digestive distress, reduce cholesterol levels, stall the ageing process and enhance energy and improve immunity [13,101]. Other authors [135] reported that LAB (*Lactobacillus fermentum*, *Lactobacillus salivarius*, *Pediococcus* and some species of *Leuconostoc*) are the primary microorganisms usually found in malted and fermented finger millet flour. LAB has been implicated in the induction of vitamin C and minerals synthesis and assimilation in the body [136]. Additionally, malting has been reported as a useful processing treatment which enhances the nutritional quality of the cereal product [6,58]. Grains within a range of time increase hydrolytic enzyme activities, thus improving the contents of certain essential amino acids, total sugars, and B-group vitamins, and reducing its dry matter, starch and anti-nutrients. Other investigators [58,59] opined that the partial hydrolysis during malting enhances the digestibility of storage proteins and starch. Furthermore, an improved taste of *Kunu-zaki* formulations due to malting of the pearl millet used has been reported [136]. Additionally, Akoma et al. [122] highlighted the influence of malting on the nutritional characteristics of *Kunu-zaki.* They observed that malted cereals improved the nutritional quality of the *Kunu-zaki* and elevated lymphocyte counts in the blood samples of animals fed with *Kunu-zaki*. The summary of microbiota in *Kunu* beverages based on processing stages is shown in Table 3.

Table 3. Summary of microbiota in *Kunu* beverages based on processing stages.

Process Stage	Microbiota	References
Malting	LAB (*Lactobacillus fermentum*, *Lactobacillus salivarius*, *Pediococcus* sp. *Leuconostoc* sp.	[130,136]
Pre-fermentation (steeping)	*Lactobacillus* sp., *Lactococcus* sp., *Pediococcus* sp., *Burkholderia-Caballeronia-Paraburkholderia* sp., *Saccharomyces* sp.	[3,81,85]
Post-fermentation	*Bacillus* sp., *Enferobacfer aerogenes* and *E. cloacae* *Saccharomyces* sp., lactic acid bacteria (LAB)	[3,88–90]

5.5. Effects of Malting on Kunu Production

Malting is a procedure usually employed mostly in West Africa towards formulating conventionally non-alcoholic beverages, beers and other varieties of food stuffs [137]. Malting as a process has been shown to increase the diastatic activities and protein content of samples [138]. Furthermore, malted cereal grains could bring about biochemical changes and yield malt alongside enhanced dietary value that could be utilised in diverse traditional recipes [139]. In line with the aforementioned report, [140] reported it has been demonstrated that malting significantly enhanced the in vitro starch (86% to 112%),protein (14% to 26%) and digestibility in pearl millet, and the enhancement by germination was expressively greater when compared with blanching [140]. An upsurge in tryptophan, lysine and non-protein nitrogen has also been detected [139]. Malting also had a significant effect with respect to the carbohydrate and fat contents of samples compared with non-malted samples [66].

It has been shown [141] that after the period of germination, steeping, debranning, and dry heating, protein digestibility is usually improved. This can, however, be ascribed to the decrease of anti-nutritional factors including tannins, polyphenols and phytic acid, which form complexes when interacting with protein. Malting, however, involves stages such as soaking, sprouting and drying, tailored to changing cereal grains into malt with significant enzymes and nutrient compositions [142]. Steeping involves soaking the grains in water or a different liquid to soften, cleanse, and extract some vital constituents in the grains [143]. The seed absorbs water during the steeping period, which results in swelling up of the seeds and thus brings about sprouting. However, this leads to a significant increase in vitamins content and a decrease in tannins and total phenols content. A study by [137] revealed a substantial difference in anti-nutrients, proximate, functional and mineral properties when steeped in lime and plantain peel ash solution before 24 h of sprouting of pearl millet at different steeping times. It has been found that the incorporation of ground-malted rice into millet in *Kunu-zaki* production was largely desired in both aroma and taste and was found to be remarkably discrete from the other products. Additionally, malted cereals enrich the nutritive value of the *Kunu-zaki*, and this has been reported to elevate the lymphocyte counts found in the blood samples of animals fed with it. This, however, reveals its therapeutic features, a notion generally preferred by several consumers [144]. Furthermore a laboratory trial [144] proved that addition of ground-malted rice and millet during the production of *Kunu-zaki* was more nourishing (crude protein; 0.74%; crude fat: 0.50%; iron: 50 ppm; calcium: 88 ppm) than the other products, and an albino rat used as a model gained more weight when compared with the control. Nonetheless, various minerals could vanish, and this occurrence may apparently be linked to solubilisation and leaching during steeping [137]. This nutritional content decrease could be likened to the loss of molecular weight of nitrogenous compounds during the process of steeping and rinsing of the millet grains and hydrolysis of lipid and oxidation of fatty acids during the time germination [145]. Variations are usually observed in the nutritional values of grains after germination, this could be ascribed to the usage by growing sprouts. Furthermore, dietary compositional variations resulting from sprouting are frequently concomitant with health benefits [146,147]. Based on laboratory trials, it has been revealed that the extraction and bioaccessibility of minerals including zinc, iron and calcium were enhanced in finger millet and pearl millet by germination; however, the anti-nutritional constituents such as phytic acid were deceased [148–150]

5.6. Preservation and Shelf-Life Extension

The shelf instability of *Kunu* is one of the bottlenecks to its large-scale production [151]. This lack of shelf stability could be also due to technology of production [152], such as poor hygienic environments and conditions; poor raw materials and ingredients handling [57]. Microbial invasion of *Kunu* during the processing activities (such as water, material handling and preservation additive) has also been highlighted by [151]. Currently, efforts are increasing in the modification of *Kunu* beverage processing with a view to enhancing its nutritive value, shelf-life and other possible therapeutic qualities. Most of the pathogens associated with food materials cause diarrhoea [153]. One of the fundamental reasons leading to the proliferation of these microbes in *Kunu* is the lack of public health regulatory agency to monitor the production processes of *Kunu* drinks despite the food-related poisoning associated with it [153]. A report [154] suggests that local drinks such as *Kunu* are possible mediators for zoonotic and food-borne infections such as *Staphylococcosis*, *Salmonellosis*, *Brucellosis*, *Tuberculosis*, *Shigellosis*, *Listeriosis*, etc. [154]. Additionally, microbes such as *Salmonella*, *Clostridium*, *Bacillus* and *Staphylococcus aureus*, *Pseudomona aeruginosa*, *Vibrio cholera* and *Escherichia coli* might contaminate food and cause physical and nutritional quality problems [155].

However, shelf-life improvement and food-desirable properties enhancement (increased nutritional value, palatability) could be possible due to fermentation involved in the production of *Kunu* [156]. Muyanja and Namugumya [132] postulated that the microbial community implicated (yeasts and LAB) during malting and fermentation raises titratable acidity, thus, reducing the pH in *Kunu* beverage. This aids in the inhibition of the proliferation of microbial contaminants such as coliforms and enterobacteriaceae, and in extending the shelf-life of the cereal product. Lactic acid fermentation helps improve the shelf-life of fermented products via the production of different antimicrobial metabolites during fermentation [157]. LAB produce technologically important metabolites, such as ethanol, hydrogen peroxide, diacetyl, bacteriocins, aromatic compounds and exopolysaccharides. These in combination with weak acids can reduce the pH of the environment [158–163] making it unfavourable for the growth of undesirable and pathogenic microorganisms [156,164]. Other workers suggested that adding refrigeration and preservatives can improve the shelf stability of the *Kunu-zaki* product, which should be refrigerated rather than stored at ambient temperature to increase the shelf-life. Alternatively, Fapohunda et al. [64] postulated that the sensory and keeping quality of *Kunu-zaki* might be enhanced by the addition of ginger solution concentrated in a certain proportion aiding improvement in the shelf-life and storage optimisation. In another report, [48], it was noted that ginger extract concentrate (GEC) added into processed *Kunu-zaki* at different concentrations enhanced the shelf-life of the *Kunu* samples for 48–72 h.

The method of drying the beverage may also have an impact. Different researchers [165,166] have reported freeze-drying and tray-drying methods to enhance *kunu-zaki* storage without affecting its nutritional, sensory and physical properties throughout the period of storage. Although Chaven et al. [167] highlighted that drum-drying destroyed heat-sensitive nutrients (such as lysine) in *Kunu*, Cook [168] reported that dehydration of Kunu by drum- or tray-drying helped to prolong its shelf-life.

6. Prospects of *Kunu* Drinks

If the chemical contaminants concerns found in another traditional drink [169] are applicable and addressed for the *Kunu* drink, then the prospects of improving the profile of the drink is very high. Apart from the dietary benefits, there would be increased generation of waste which can be upcycled or valorised [170]. Dietary quality is paramount in nutritional well-being and a key factor in human overall health development [171]. The nutritional quality of grains such as maize, millet and sorghum utilised for *Kunu* drink production makes the drinks more appealing compared to some other drinks to a large growing population. For instance, *Kunu* has been revealed to be more nutritious than carbonated drinks and can serve as alternative to carbonated drinks especially during religious festivities in Nigeria [172]. The relative abundance of these cereals from which *Kunu* is produced makes *Kunu* drinks cheap and affordable to both the rich and poor population in Nigeria [172]. The minerals (magnesium, zinc and selenium) contained in the grains used for *Kunu* production are known as constituents of bones, teeth, blood, muscles, hair and nerve cells which makes them very important and essential ingredients of the diet required for normal metabolic activities of body tissues [172]. According to some authors, people in rural communities who cannot afford milk resort to *Kunu* drinks as alternatives because of the rich nutritional composition [173]. This could be the reason why some use *Kunu* drinks as a weaning drink for infants [66]. The spices usually added to the *Kunu* gruel also help improve the *Kunu* quality, with the production substrates determining the particular beverage type to be produced [2,174]. The addition of other components such as tiger nut milk extract or soybeans enriches the nutritional qualities of *Kunu* drinks to meet diverse dietary needs [66,173]. Tiger nuts have good nutritional quality with a fat composition similar to but superior to olive oil, and are rich in alpha tocopherol and other mineral components such as potassium, magnesium and phosphorus but low in sodium [173]. It is alluded that food rich in potassium and magnesium but low in sodium can lead to a reduction in blood pressure [173]. This makes *Kunu* drinks enriched with tiger nut milk a possible functional food for patients with high blood pressure. Enrichment with soymilk reportedly increased the protein and amino acid content and decreased carbohydrate content of *Kunu* drink because legumes are known to have a higher protein content than cereals [66]. The reduced carbohydrate content is an indication that *Kunu* drinks enriched with soymilk can serve as food for diabetic patients. Elsewhere, it was reported that *Kunu* drinks enriched with tiger nut milk extract (TME) had increased protein content as well as thiamine and riboflavin contents higher than the control (*Kunu* drink without TME) [47]. The fact is that these dietary nutrients originally sourced from costly foods such as egg, milk, meat, etc., can be obtained by consuming a cheap and available *Kunu* drink fortified with TME. More importantly, thiamine and riboflavin are vitamins considered crucial for infant health and development and should be adequately supplied to the infants through breast milk for at least the first 6 months of the infant's life [175]. In developing countries such as sub-Saharan Africa (Nigeria), *Kunu* drinks enriched with TME have the potential as a cost-effective alternative for thiamine and riboflavin, which can be consumed directly by infants or indirectly through their mothers' breast milk. In another report, *Kunu* drinks enriched with Orange Flesh Sweet Potato (OFSP) presented high β-carotene content [176], which presents the *Kunu* drinks as a good source of vitamin A and can be recommended for fighting vitamin A deficiency (VAD).

The plethora of microbial communities dominated by LAB identified in the process of *Kunu* production and the resultant decrease in pH of the product isolates *Kunu* fermentation to a lactic acid fermentation group [3]. These LAB confer probiotic properties on *Kunu* drinks and thus establish it as a functional food/drink. Probiotics are known to have the intrinsic capacity to impact positively on the health of the host by improving the intestinal microbiome, stimulating of the immune system, enhancing the bioavailability of nutrients and reduction of risk of lactose intolerance [177,178]. As highlighted, some of these probiotic properties include easing of digestive stress, lowering cholesterol level, slowing down the ageing process, boosting energy, improving immunity, and activating the synthesis and assimilation of vitamin C and minerals in the body. According to [179], the *Lactobacilli* sp. in *Kunu* drinks have been known to enhance the host's immune response. This presents *Kunu* drinks as a special diet for the elderly for the purpose of immunity enhancement since immunity declines with age. Additionally, some of the LAB spp. identified in *Kunu* drinks have been identified for cholesterol reduction in humans and animals [179]. The mechanisms of action were highlighted as cholesterol assimilation, bile salt deconjugation, binding of cholesterol to bacteria cell walls and reduced cholesterol biosynthesis [179].

Furthermore, the presence of LAB makes the *Kunu* drink a potential biotherapy against type-2 diabetes. This is because some LAB spp. such as Bifidobacteria and *Lactobacillus acidophilus* can modulate the gut micro flora and bring about suppression of insulin resistance in human subjects [180]. Some authors reported of a *Kunu* drink with hypoglycaemic effects, which present *Kunu* as alternative drinks for diabetic patients [44,181]. The hypoglycaemic effect of *Kunu* drinks is based on the effect of fructose, one of the simple sugars produced from digestion of carbohydrate content of *Kunu*. *Kunu* drink data found in literature are shown in Figure 3 and Table 4.

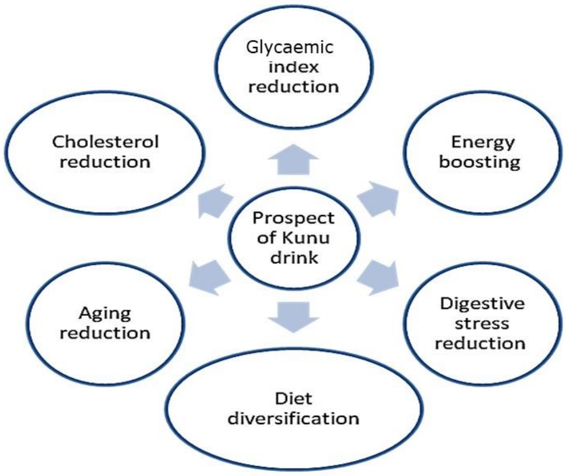

Figure 3. Prospects of *Kunu* drinks for human health benefit.

Table 4. Health and nutritional benefits associated with different varieties of *Kunu* beverages.

Kunu Type	Varieties	Health and Nutritional Benefits	References
Type I	General	Body tissues development and repair, gallstones prevention heart, breast cancer protective properties with other antioxidant protective properties as millet or sorghum is used	[182]
	Kunu-zaki	Bowels purging and relief of flatulent conditions, enhancement of lactation in nursing mothers.	[3,183]
	Kunu-baule	Purgative, anthelmintic, anti-syphilitic, emmenagogue, aperients, stimulant, antiscorbutic and antiphlogistic properties	[184–186]
Type II	*Kunu-jiko*	NA	NA
	Kunu-aya	Prevention of heart attacks, thrombosis and cancer; infants' teeth and bone development; reduction of body cholesterol and the risk of atherosclerosis	[187–189]
	Kunu-akamu	Prevention of rheumatism symptoms, functional improvement of thyroid gland and immune system due to maize fermentation	[190]
	Kunu-tsamiya	Rich in vitamin C and α-carotene; minerals (particularly P, K, Ca and Mg) with antioxidant, anti-inflammatory, anti-microbial and anti-fungal activity due to tsamiya additive.	[191]
	Kunu-bururu	NA	NA
Type III	*Kunu-koko*	Helps in reduction of persistent diarrhoea in young children	[13,192]
	Kunu-kanwa	Taste improvement and wound healing enhancement	[193]
	Kunu-aduwa	Good for children and people with haemorrhoids, stomach aches, jaundice, yellow fever, syphilis and epilepsy	[194–196]
	Kunu-acha	Aids digestion and cardiovascular function, good for diabetics, gluten-free diet, an excellent meal for weight loss	[197]
	Kunu-gyada	Sustainable alternative with acceptable nutritional profile that could provide mitigation on protein energy malnutrition; tends to improve blood lipid values in general.	[25]

NA: Not Available.

7. Conclusions

Kunu beverage is prepared in different ways by various regions in Africa. The beverage serves as an acceptable non-alcoholic drink and weaning food for infants in developing countries. The different varieties which result from the type of cereals used either singly or in combination with other carbohydrate and/or protein substrates can be used to prime different products. Overall, *Kunu* beverages are highly nutritive, and could be a good source of protein and energy. It is potentially a probiotic or functional food that can be beneficial to consumers. The technologies employed in the preparation of the beverage requires improvement and could take advantage of the low pH of the product to improve shelf-life. The short shelf-life associated with this beverage has limited the commercialisation of the beverage in a large scale, hence more successful studies on its preservation will have a big impact on the economic well-being of local entrepreneurs. To this end, the microbial dynamics and the chemical complexities before, during and after production needs further study. Increased regulation of the product and strict processing under good hygienic conditions will help in safeguarding public health.

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References

1. Amusa, N.A.; Odunbaku, O.A. Microbiological and nutritional quality of hawked *kunu*n (a sorghum based non-alcoholic beverage) widely consumed in Nigeria. *Pak. J. Nutr.* **2009**, *8*, 20–25. [CrossRef]
2. Gaffa, T.; Jideani, I.A.; Nkama, I. Traditional production, consumption and storage of *Kunu*—A non-alcoholic cereal beverage. *Plant Foods Hum. Nutr.* **2002**, *57*, 73–81. [CrossRef] [PubMed]
3. Ezekiel, C.N.; Ayeni, K.I.; Ezeokoli, O.T.; Sulyok, M.; van Wyk, D.A.B.; Oyedele, O.A.; Akinyemi, O.M.; Chibuzor-Onyema, I.E.; Adeleke, R.A.; Nwangburuka, C.C.; et al. High-throughput sequence analyses of bacterial communities and multi-mycotoxin profiling during processing of different formulations of *kunu*, a traditional fermented beverage. *Front. Microbiol.* **2019**, *9*, 3282. [CrossRef] [PubMed]
4. Izah, S.C.; Inyang, I.R.; Angaye, T.C.N.; Okowa, I.P. A review of heavy metal concentration and potential health implications of beverages consumed in Nigeria. *Toxics* **2017**, *5*, 1. [CrossRef]
5. Ezekiel, C.N.; Ayeni, K.I.; Misihairabgwi, J.M.; Somorin, Y.M.; Chibuzor-Onyema, I.E.; Oyedele, O.A.; Abia, W.A.; Sulyok, M.; Shephard, G.S.; Krska, R. Traditionally processed beverages in Africa: A review of the mycotoxin occurrence patterns and exposure assessment. *Comp. Rev. Food Sci. Food Saf.* **2017**, *17*, 334–351. [CrossRef]
6. Amadou, I.; Gbadamosi, O.S.; Le, G.W. Millet-based traditional processed foods and beverages—A review. *Cereal Foods World* **2011**, *56*, 115–121. [CrossRef]
7. Tafere, G. A review on traditional fermented beverages of Ethiopia. *J. Nat. Sci. Res.* **2015**, *5*, 94–102.
8. Kubo, R.; Funakawa, S.; Araki, S.; Kitabatake, N. Production of indigenous alcoholic beverages in a rural village of Cameroon. *J. Inst. Brew.* **2014**, *120*, 133–141. [CrossRef]
9. Blandino, A.; Al-Aseeri, M.C.; Pandiella, S.; Cantero, D.; Webb, C. Cereal-based fermented foods and beverages. *Food Res. Int.* **2003**, *36*, 527–543. [CrossRef]
10. Nwaiwu, O.; Aduba, C.C.; Igbokwe, V.C.; Sam, C.E.; Ukwuru, M.U. Traditional and artisanal beverages in Nigeria: Microbial diversity and safety issues. *Beverages* **2020**, *6*, 53. [CrossRef]
11. Ezekiel, C.N.; Abia, W.A.; Ogara, I.M.; Sulyok, M.; Warth, B.; Krska, R. Fate of mycotoxins in 2 popular traditional cereal-based beverages (*kunu*-zaki and pito) from rural Nigeria. *LWT Food Sci. Technol.* **2015**, *60*, 137–141. [CrossRef]
12. Mu Ashekele, H.; Embashu, W.; Cheikhyoussef, A. Indigenous knowledge system best practice from Namibia: The case of Oshikundu processing methods. *Trends Appl. Sci. Res.* **2012**, *7*, 913–921.
13. Aka, S.; Konan, G.; Fokou, G.; Dje Koffi, M.; Bonfoh, B. Review on African traditional cereal beverages. *Am. J. Res. Commun.* **2014**, *2*, 103–153.

14. Fadahunsi, I.F.; Ogunbanwo, S.T.; Fawole, A.O. Microbiological and nutritional assessment of burukutu and pito (indigenously fermented alcoholic beverages in West Africa) during storage. *Nat. Sci.* **2013**, *11*, 98–103.
15. Egwaikhide, I.A.; Malu, P.S.; Lawal, U.; Adelagun, R.O.; Andrew, C. Physico-chemical and microbiological analysis of fermented cow milk (nono) consumed within Kaduna Town, north-western Nigeria. *Food Sci. Qual. Manag.* **2014**, *29*, 44–48.
16. Onuoha, O.G.; Haruna, U.S.; Yelmi, B.M.; Samuel, E.; Uhiara, N.S.; Ngwu, P.C. Storage study on color retention in zobo concentrates by increasing concentration of ginger (*Zingiber officinale*). *Afr. J. Food Sci.* **2014**, *8*, 292–296. [CrossRef]
17. Gaffa, T.; Jideani, I.A.; Nkama, I. Nutritional composition of different types of *Kunu* produced in Bauchi and Gombe states of Nigeria. *Int. J. Food Prop.* **2002**, *5*, 351–357. [CrossRef]
18. Adeyemi, I.A.; Umar, S. Effect of methods of manufacture on the quality characteristics of *Kunu* zaki a millet based beverage. *Nig. Food J.* **1999**, *12*, 34–40.
19. Nduka, S.O.; Ezeokeke, T.C.; Onyeneke, E.N. Nutritional and microbiological quality of *kunu*n-zaki beverage produced in Owerri muncipal. *J. Agric. Food Sci.* **2018**, *16*, 49–64. [CrossRef]
20. Igwe, C.U.; Ibegbulem, C.O.; Nwaogu, L.A.; Ujowundu, C.O.; Okwu, G.N. Calcium, Zinc and Phytate Interrelationships in Four Lesser-Known African Seeds Processed into Food Condiments. *J. Adv. Chem.* **2013**, *4*, 288–294. [CrossRef]
21. Gaffa, T. Improving Traditional Kunu Production and its Storage Stability. Ph.D. Thesis, Biological Science Programme, Abubarkar Tafawa Balewa University of Bauchi, Bauchi, Nigeria, 2000.
22. Ofudje, E.; Okon, U.; Oduleye, O.; Williams, O. Proximate, mineral contents and microbial analysis of *kunu*-zaki (a non-alcoholic local beverage) in Ogun State, Nigeria. *J. Adv. Biol. Biotechnol.* **2016**, *7*, 26670. [CrossRef]
23. Amusa, N.A.; Ashaye, O.A. Effect of Processing on Nutritional, Microbiological and Sensory Properties of *Kunu*n-Zaki (A Sorghum Based Non-Alcoholic Beverage) Widely Consumed in Nigeria. *Pak. J. Nutr.* **2009**, *8*, 288–292. [CrossRef]
24. Onyimba, A.I.; Itelima, J.U.; Job, M.O.; Ogbonna, A.I.; Ode, C.O. Production of sorghum based *kunu*n zaki using selected starter cultures. *Int. J. Sci.* **2017**, *3*, 57–63. [CrossRef]
25. Agarry, O.O.; Nkama, I.; Akoma, O. Production of *Kunu*n-zaki (A Nigerian fermented cereal beverage) using starter culture. *Int. Res. J. Microbiol.* **2010**, *1*, 18–25.
26. Nkama, I.; Iliyas, A.; Jato, A. Studies on the preparation and nutrient composition of *kunu*n gyada, a traditional Nigerian groundnut-cereal-based weaning food. *Food Nutr. Bullet.* **1995**, *16*, 1–4. [CrossRef]
27. Yunusa, B.M.; Filli, K.B.; Jiddum, F.A. Application of RSM in modelling and numerical optimisation of proximate composition of instant extruded *kunu*n-gyada (porridge) from the blend of sorghum—Groundnut. *J. Food Sci. Technol.* **2022**, *7*, 431–441. [CrossRef]
28. Ularamu, J.J.; Maina, J.F.; Ta'awu, K.G.; Nwankwo, R.N. Production and nutritional evaluation of instantized *kunu*n gyada, a traditional Nigerian beverage from malted sorghum (*Sorghum bicolor*) and roasted groundnut (*Arachis hypogeae*) Paste by Extrusion Cooking. *IOSR J. Env. Sci. Toxicol. Food Technol.* **2017**, *11*, 32–37. [CrossRef]
29. Halilu, M.; Bello, Y.M.; Ghazali, H.M. Consumer Preference and Storage Stability Assessment of Drum Dried-Maltodextrin Added *Kunu*n-gyada Powder. *EAS J. Nutr. Food Sci.* **2022**, *4*, 1–7. [CrossRef]
30. Sanni, A.I.; Sefa-Dedeh, S.; Sakyi-Dawson, E.; Asiedu, M. Microbiological evaluation of Ghanaian maize dough co-fermented with cowpea. *Int. J. Food Sci. Nutr.* **2002**, *53*, 367–373. [CrossRef] [PubMed]
31. Teniola, O.D.; Odunfa, S.A. The effects of processing methods on the levels of lysine, methionine and the general acceptability of Ogi processed using starter cultures. *Int. J. Food Microbiol.* **2001**, *63*, 1–9. [CrossRef] [PubMed]
32. Obinna-Echem, C.P. Development of a Nigerian fermented maize food "Akamu" as a functional food. Ph.D. Thesis, University of Plymouth, Plymouth, UK, 2014.
33. Achi, O.K.; Asamudo, N.U. Cereal-Based Fermented Foods of Africa as Functional Foods. In *Bioactive Molecules in Food. Reference Series in Phytochemistry*; Mérillon, J.M., Ramawat, K.G., Eds.; Springer: Cham, Switzerland, 2019; pp. 1527–1558.
34. Belewu, M.A.; Abodunrin, O.A. Preparation of kunnu from unexploited rich food Source; Tiger-nut (*Cyperus esculentus*). *Pak. J. Nutr.* **2008**, *7*, 109–111. [CrossRef]
35. Musa, A.A.; Hamza, A. Comparative analysis of locally prepared '*kunu*n aya' (tiger-nut milk) consumed by students of Kaduna state university, Kaduna-Nigeria. *Sci. World J.* **2013**, *8*, 13–18.
36. Shortt, C. The probiotic century: Historical and current perspectives. *Trends Food Sci. Technol.* **1999**, *10*, 411–417. [CrossRef]
37. LeBlanc, J.G.; Laino, J.E.; del Valle, J.M.; Vannini, V.; van Sinderen, D.; Taranto, M.P.; de Valdez, F.G.; de Giori, S.G.; Sesma, F. B-group vitamin production by lactic acid bacteria—Current knowledge and potential applications. *J. Appl. Microbiol.* **2011**, *111*, 1297–1309. [CrossRef]
38. Victor-Aduloju, A.T.; Anyamene, C.; Ogbu, K.N.; Ishiwu, C.N. Isolation and identification of probiotic *Lactobacillus* species from traditional drink *kunu*n-zaki fortified with paddy rice and sweet potatoes. *Afr. J. Food Sci.* **2018**, *12*, 230–237. [CrossRef]
39. Jatmiko, Y.D.; Howarth, G.S.; Barton, M.D. Assessment of probiotic properties of lactic acid bacteria isolated from Indonesian naturally fermented milk. In Proceedings of the AIP Conference 1908, 8th International Conference on Global Resource Conservation (ICGRC 2017), Bydgoszcz, Poland, 9–11 May 2018; Paczkowski, T., Polasik, R., Eds.; AIP Publishing: Melville, NY, USA, 2018; pp. 050008-1–050008-14. [CrossRef]
40. Ayo, H.N.; Okorie, E.I. In vitro probiotics potential of autochthonos lactic acid bacteria and microbiology of *kunu* made from mixed grains. *Brit. Microbiol. Res. J.* **2016**, *14*, 25403.

41. Franz, C.M.A.P.; Huch, M.; Mathara, J.M.; Abriouel, H.; Benomar, N.; Reid, G.; Galvez, A.; Holzapfel, W.H. African fermented foods and probiotics. *Int. J. Food Microbiol.* **2014**, *190*, 84–96. [CrossRef]
42. Giraud, E.; Brauman, A.; Kekele, S.; Lelong, B.; Raimbault, M. Isolation and physiological study of an amylolytic strain of *Lactobacillus plantarum*. *Appl. Microbiol. Biotechnol.* **1991**, *36*, 379–383. [CrossRef]
43. Umaru, H.A.; Umaru, I.J.; Aminu, A.; Umaru, K.I. Influence of different processing methods on proximate and anti-nutritional value of tigernuts (*Cyperus esculentus* L.). *GSC Biol. Pharm. Sci.* **2018**, *3*, 29–34. [CrossRef]
44. Oladele, K.A.; Osundahunsi, F.O.; Adebowale, A.Y. Influence of processing techniques on the nutrients and anti-nutrients of tiger nut (*Cyperus esculentus* L.). *World J. Dairy Food Sci.* **2009**, *4*, 88–93.
45. Adeniran, H.A.; Adeniyi, D.M.; Taiwo, K.A. Microbiological properties of probioticated *kunu*n zaki drink enriched with cocoa powder. *Eur. J. Agric. Food Sci.* **2020**, *2*, 1–9.
46. Sengev, I.A.; Akpapunam, M.A.; Ingbian, E.K. Physicochemical and sensory properties of instant *kunu*n-zaki flour blends from sorghum and mango mesocarp flours. *Nig. Inst. Food Sci. Tech.* **2012**, *30*, 8–16. [CrossRef]
47. Olaoye, O.A.; Ubbor, S.C.; Uduma, E.A. Determination of vitamins, minerals, and microbial loads of fortified nonalcoholic beverage (*kunu*n zaki) produced from millet. *Food Sci. Nutr.* **2016**, *4*, 96–102. [CrossRef]
48. Mohammed, S.F. Effect of different ratios of ginger solution concentrations on the quality of millet-based *Kunu*n-Zaki. *MOJ Food Process. Technol.* **2018**, *6*, 469–475.
49. Elmahmood, A.M.; Doughari, J.H. Microbial quality assessment of *kunu*n-zaki beverage sold in Girei town of Adamawa State, Nigeria. *Afr. J. Food Sci.* **2007**, *1*, 11–15.
50. Ekwem, O.H.; Okolo, B.N. Microorganisms isolated during fermentation of sorghum for production of Akamu (a Nigerian fermented gruel). *Microbiol. Res. J. Int.* **2017**, *21*, 1–5. [CrossRef]
51. Omemu, A.M.; Oyewole, O.B.; Bankole, M.O. Significance of yeasts in the fermentation of maize for ogi production. *Food Microbiol.* **2007**, *24*, 571–576. [CrossRef] [PubMed]
52. Nwachukwu, E.; Achi, O.K.; Ijeoma, I.O. Lactic acid bacteria in fermentation of cereals for the production of indigenous Nigerian foods. *Afr. J. Food Sci. Technol.* **2010**, *1*, 021–026.
53. Elihu, A.; Buba, Z.M.; Naphthali, N.P. Quality assessment of the '*Kunu*n-zaki'soft drink based on bacteria and fungi content. *Afr. Schol. J. Agric. Agric. Technol.* **2021**, *22*, 1–10.
54. Terna, G.; Ayo, J. Innovations in the traditional *kunu*n-zaki production process. *Pak. J. Nutr.* **2002**, *1*, 202–205.
55. Ekanem, J.O.; Mensah, B.J.; Marcus, N.S.; Ukpe, B.A. Microbial Quality and Proximate Composition of *Kunu* Drinks Produced and Sold in Ikot Ekpene Metropolis, Akwa Ibom State, Nigeria. *J. Appl. Sci. Environ. Manag.* **2018**, *22*, 1713–1718. [CrossRef]
56. Abiodun, O.A.; Dauda, A.O.; Adebisi, T.T.; Alonge, C.D. Physico-chemical, microbial and sensory properties of *kunu* zaki beverage sweetened with black velvet tamarind (*Dialium guineense*). *Croat. J. Food Sci. Technol.* **2017**, *9*, 46–56. [CrossRef]
57. Braide, W.; Adeleye, S.A.; Ukagwu, N.; Lugbe, P.B. Chemical properties and microbiological profile of *kunu* zaki, a non-alcoholic beverage. *Biomed. J. Sci. Tech. Res.* **2018**, *4*, 3731–3735.
58. Oluwajoba, S.O.; Akinyosoye, F.A.; Oyetayo, O.V. Comparative sensory and proximate evaluation of spontaneously fermenting kunu-zaki made from germinated and ungerminated composite cereal grains. *Food Sci. Nutr.* **2013**, *1*, 336–349. [CrossRef]
59. Akinhanmi, F.T.; Arogundade, A.L.; Tiamiyi, O.M.; Oloruntoba, E. Protein fractions of legumes and cereals consumed in Nigeria. *Int. J. Agric. Sci. Environ. Technol.* **2008**, *7*, 54–62.
60. Obadina, A.O.; Oyewole, O.B.; Awojobi, T.M. Effect of steeping time of milled grains on the quality of Kunnu-Zaki (A Nigerian beverage). *Afr. J. Food Sci. Res.* **2019**, *7*, 1–4.
61. Ojokoh, A.O.; Fayemi, O.E.; Ocloo, F.C.K.; Nwokolo, F.I. Effect of fermentation on proximate composition, physicochemical and microbial characteristics of pearl pearl millet (*Pennisetum glaucum* (L.) R. Br.) and Acha (*Digitaria exilis* (Kippist) Stapf) flour blends. *J. Agric. Biotechnol. Sustain. Dev.* **2015**, *7*, 1–8.
62. Afify, A.M.R.; El-Beltagi, H.S.; Abd El-Salam, S.M.; Omran, A.A. Bioavailability of Iron, Zinc, Phytate and Phytase Activity during Soaking and Germination of white Sorghum Varieties. *PLoS ONE* **2015**, *6*, e255512. [CrossRef]
63. Williana, N.M.; Babasola, A.O.; Cajethan, O.E.; Fapohunda, S.O. Role of organic spices in the preservation of traditionally fermented *kunu*n-zaki. *Microbiol. Biotechnol. Lett.* **2021**, *49*, 192–200. [CrossRef]
64. Fapohunda, S.O.; Adewale, A. Microbial Load and Keeping Quality of *Kunu* under Various Preservative Regimes. *J. Nutr. Food Sci.* **2012**, *2*, 141. [CrossRef]
65. Annunziata, A.; Vecchio, R. Functional foods development in the European market: A consumer perspective. *J. Funct. Foods* **2011**, *3*, 223–228. [CrossRef]
66. Adelekan, A.O.; Alamu, A.E.; Arisa, N.U.; Adebayo, Y.O.; Dosa, A.S. Nutritional, microbiological and sensory characteristics of malted soy *kunu* zaki: An improved traditional beverage. *Adv. Microbiol.* **2013**, *3*, 389–397. [CrossRef]
67. Orishagbemi, C.O.; Bushiratu, A.; Laisi, I.R.; Igbatigbi, J. Organic preservation and shelf–life evaluation of liquid *kunu* zaki food drink, with extract of West African black pepper (*Piper guineense*). *Int. J. Agric. Res. Food Prod.* **2020**, *5*, 1–18.
68. Dwivedi, S.; Prajapati, P.; Vyas, N.; Malviya, S.; Kharia, A. A review on food preservation: Methods, harmful effects and better alternatives. *Asian J. Pharm. Pharmacol.* **2017**, *3*, 193–199.
69. Mirza, S.K.; Asema, U.K.; Kasim, S.S. To study the harmful effects of food preservatives on human health. *J. Med. Chem. Drug Discov.* **2017**, *2*, 610–616.

70. Anand, S.P.; Sati, N. Artificial preservatives and their harmful effects: Looking toward nature for safer alternatives. *Int. J. Pharm. Sci. Res.* **2013**, *4*, 2496.
71. Benkeblia, N.; Lanzotti, V. Allium thiosulfinates: Chemistry, biological properties and their potential utilization in food preservation. *Foods* **2007**, *1*, 193–201.
72. Bruna, G.L.; Thais, A.C.; Lgia, A.C. Food additives and their health effects: A review on preservative sodium benzoate. *Afr. J. Biotechnol.* **2018**, *17*, 306–310. [CrossRef]
73. Sharif, Z.I.M.; Mustapha, F.A.; Jai, J.; Yusof, N.M.; Zaki, N.A.M. Review on methods for preservation and natural preservatives for extending the food longevity. *Chem. Eng. Res. Bullet.* **2017**, *19*, 145–153. [CrossRef]
74. Sharma, S. Food preservatives and their harmful effects. *Int. J. Scient. Res Pub.* **2015**, *5*, 1–2.
75. Anal, A.K.; Perpetuini, G.; Petchkongkaew, A.; Tan, R.; Avallone, S.; Tofalo, R.; Waché, Y. Food safety risks in traditional fermented food from South-East Asia. *Food Cont.* **2019**, *109*, 106922. [CrossRef]
76. Abulude, F.O.; Ogunkoya, M.O.; Oni, V.A. Mineral composition, shelf life, and sensory attributes of fortified '*Kunu*zaki' beverage. *Acta Sci. Pol. Technol. Aliment.* **2006**, *5*, 155–162.
77. Owuama, I.C. Brewing beer with sorghum. *J. Inst. Brew.* **1998**, *105*, 23–24. [CrossRef]
78. Ingbian, E.K.; Agwu, O. Effect of different steeping regimes on the microbiological, chemical and steep water characteristic of selected maize grain varieties. *J. Food Process. Preserv.* **2010**, *34*, 426–439. [CrossRef]
79. Osungbaro, T.O. Physical and nutritive properties of fermented cereal foods. *Afr. J. Food Sci.* **2009**, *3*, 23–27.
80. Teniola, O.D.; Holzapfel, W.H.; Odunfa, S.A. Comparative assessment of fermentation techniques useful in the processing of ogi. *World J. Microbiol. Biotechnol.* **2005**, *21*, 39–43. [CrossRef]
81. Chibuzor-Onyema, I.E.; Ezeokoli, O.T.; Sulyok, M.; Notununu, I.; Petchkongkaew, A.; Elliott, C.T.; Ezekiel, C.N. Metataxonomic analysis of bacterial communities and mycotoxin reduction during processing of three millet varieties into ogi, a fermented cereal beverage. *Food Res. Int.* **2021**, *143*, 110241. [CrossRef]
82. Inyang, C.U.; Dabot, Y.A. Storability and potability of pasteurized-sterilized "*kunu*n-zaki": A fermented sorghum beverage. *J. Food Process. Preserv.* **1997**, *21*, 1–7. [CrossRef]
83. Oguntoyinbo, F.A.; Narbad, A. Molecular characterization of lactic acid bacteria and in situ amylase expression during traditional fermentation of cereal foods. *Food Microbiol.* **2012**, *3*, 254–262. [CrossRef]
84. Oyeyiola, G.P. Fermentation of millet to produce kamu a Nigerian starch-cake food. *World J. Microbiol. Biotechnol.* **1991**, *7*, 196–201. [CrossRef]
85. Efiuvwevwere, B.J.O.; Akona, O. The microbiology of '*kunu*n-zaki', a cereal beverage from northern Nigeria, during the fermentation (production) process. *World J. Microbiol. Biotechnol.* **1995**, *11*, 491–493. [CrossRef] [PubMed]
86. Annan, N.; Poll, L.; Sefa-Dedeh, S.; Plahar, W.; Jakobsen, M. Volatile compounds produced by *Lactobacillus fermentum, Saccharomyces cerevisiae* and *Candida krusei* in single starter culture fermentations of Ghanaian maize dough. *J. Appl. Microbiol.* **2003**, *94*, 462–474. [CrossRef]
87. Gaffa, T.; Gaffa, A.T. Microbial succession during '*kunu*n-zaki' production with sorghum (*Sorghum biocolor*) grains. *World J. Microbiol. Biotechnol.* **2004**, *20*, 449–453. [CrossRef]
88. Osuntogun, B.; Aboaba, O.O. Microbiological and Physio-chemical Evaluation of some Non-alcoholic beverages. *Pak. J. Nutr.* **2004**, *3*, 188–192. [CrossRef]
89. Ikpoh, I.S.; Lennox, J.A.; Ekpo, L.A.; Agbo, B.E.; Henshaw, E.E.; Udoekong, N.S. Microbial quality assessment of *kunu* beverage locally prepared and hawked in Calabar, Cross river state, Nigeria. *Glob. J. Biodivers. Sci. Manag.* **2013**, *3*, 58–61.
90. Aboh, M.I.; Oladosu, P. Microbiological assessment of *kunu*-zaki marketed in Abuja municipal area council (AMAC) in the federal capital territory (FCT), Nigeria. *Afr. J. Microbiol. Res.* **2014**, *8*, 1633–1637. [CrossRef]
91. Russell, A.D. Lethal effects of heat on bacterial physiology and structure. *Sci. Prog.* **2003**, *86*, 115–137. [CrossRef]
92. Akharaiyi, F.C.; Omoya, F.O. Effect of processing methods on the microbiological quality of liquid pap ogi prepared from maize. *Trends Appl. Sci. Res.* **2008**, *3*, 330–334. [CrossRef]
93. Wolfe, B.E.; Dutton, R.J. Fermented foods as experimentally tractable microbial ecosystems. *Cell* **2015**, *161*, 49–55. [CrossRef]
94. Zabat, M.A.; Sano, W.H.; Wurster, J.I.; Cabral, D.J.; Belenky, P. Microbial community analysis of sauerkraut fermentation reveals a stable and rapidly established community. *Foods* **2018**, *7*, 77. [CrossRef]
95. Yang, L.; Yang, H.L.; Tu, Z.C.; Wang, X.L. High-throughput sequencing of microbial community diversity and dynamics during douche fermentation. *PLoS ONE* **2016**, *11*, e0168166. [CrossRef] [PubMed]
96. Giraffa, G. Studying the dynamics of microbial populations during food fermentation. *FEMS Microbiol. Rev.* **2004**, *28*, 251–260. [CrossRef] [PubMed]
97. Ijabadeniyi, A.O. Microorganisms associated with ogi traditionally produced from three varieties of maize. *Res. J. Microbiol.* **2007**, *2*, 247–253. [CrossRef]
98. Van der Meulen, R.; Scheirlinck, I.; Van Schoor, A.; Huys, G.; Vancanneyt, M.; Vandamme, P.; De Vuyst, L. Population dynamics and metabolite target analysis of lactic acid bacteria during laboratory fermentations of wheat and spelt sourdoughs. *Appl. Environ. Microbiol.* **2007**, *73*, 4741–4750. [CrossRef] [PubMed]
99. Sanni, A.I.; Adesulu, A.T. Microbiological and physicochemical changes during fermentation of maize for *masa* production. *Afr. J. Microbiol. Res.* **2013**, *7*, 4355–4362.

100. Adesulu-Dahunsi, A.T.; Sanni, A.I.; Jeyaram, K. Rapid differentiation among *Lactobacillus*, *Pediococcus* and *Weissella* species from some Nigerian indigenous fermented foods. *LWT- Food Sci. Technol.* **2017**, *77*, 39–44. [CrossRef]
101. Oguntoyinbo, F.A.; Tourlomousis, P.; Gasson, M.J.; Narbad, A. Analysis of bacterial communities of traditional fermented West African cereal foods using culture independent methods. *Int. J. Food Microbiol.* **2011**, *145*, 205–210. [CrossRef]
102. Oh, N.S.; Joung, J.Y.; Lee, J.Y.; Kim, Y. Probiotic and anti-inflammatory potential of *Lactobacillus rhamnosus* 4B15 and *Lactobacillus gasseri* 4M13 isolated from infant feces. *PLoS ONE* **2018**, *13*, e0192021. [CrossRef]
103. Barrangou, R.; Azcarate-Peril, M.A.; Duong, T.; Conners, S.B.; Kelly, R.M.; Klaenhammer, T.R. Global analysis of carbohydrate utilization by *Lactobacillus acidophilus* using cDNA microarrays. *Proc. Natl. Acad. Sci. USA* **2006**, *103*, 3816–3821. [CrossRef]
104. Akinrele, I.A. Fermentation studies on maize during the preparation of a traditional African starch cake food. *J. Sci. Food Agric.* **1970**, *21*, 619–625. [CrossRef]
105. Wang, L.; Luo, Y.; Wu, Y.; Liu, Y.; Wu, Z. Fermentation and complex enzyme hydrolysis for improving the total soluble phenolic contents, flavonoid aglycones contents and bio-activities of guava leaves tea. *Food Chem.* **2018**, *264*, 189–198. [CrossRef] [PubMed]
106. Zhao, Y.S.; Eweys, A.S.; Zhang, J.Y.; Zhu, Y.; Bai, J.; Darwesh, O.M.; Zhang, H.B.; Xiao, X. Fermentation affects the antioxidant activity of plant-based food material through the release and production of bioactive components. *Antioxidants* **2021**, *10*, 2004. [CrossRef] [PubMed]
107. Lioger, D.; Leenhardt, F.; Demigne, C.; Remesy, C. Sourdough fermentation of wheat fractions rich in fibres before their use in processed food. *J. Sci. Food Agric.* **2007**, *87*, 1368–1373. [CrossRef]
108. Moslehi-Jenabian, S.; Lindegaard, P.; Jespersen, L. Beneficial effects of probiotic and food borne yeasts on human health. *Nutrition* **2010**, *2*, 449–473. [CrossRef]
109. Reale, A.; Mannina, L.; Tremonte, P.; Sobolev, A.P.; Succi, M.; Sorrentino, E.; Coppola, R. Phytate degradation by lactic acid bacteria and yeast during the whole meal dough fermentation: A 31P NMR study. *J. Agric. Food Chem.* **2004**, *52*, 6300–6305. [CrossRef] [PubMed]
110. Sharma, R.; Garg, P.; Kumar, P.; Bhatia, S.K.; Kulshrestha, S. Microbial fermentation and its role in quality improvement of fermented foods. *Fermentation* **2020**, *6*, 106. [CrossRef]
111. Tsafrakidou, P.; Michaelidou, A.M.; Biliaderis, C. Fermented cereal-based products: Nutritional aspects, possible impact on gut microbiota and health implications. *Foods* **2020**, *9*, 734. [CrossRef] [PubMed]
112. Soro-Yao, A.A.; Brou, K.; Amani, G.; Thonart, P.; Djè, K.M. The use of lactic acid bacteria starter cultures during the processing of fermented cereal-based foods in West Africa: A review. *Trop. Life Sci. Res.* **2014**, *25*, 81.
113. Mugocha, P.T.; Taylor, J.R.N.; Bester, B.H. Fermentation of a composite finger millet-dairy beverage. *World J. Microbiol. Biotechnol.* **2000**, *16*, 341–344. [CrossRef]
114. Gotcheva, V.; Pandiella, S.S.; Angelov, A.; Roshkova, Z.; Webb, C. Monitoring the fermentation of the traditional Bulgarian beverage boza. *Int. J. Food Sci. Technol.* **2001**, *36*, 129–134. [CrossRef]
115. Gupta, R.K.; Gangoliya, S.S.; Singh, N.K. Reduction of phytic acid and enhancement of bioavailable micronutrients in food grains. *J. Food Sci. Technol.* **2015**, *52*, 676–684. [CrossRef]
116. Hill, D.; Sugrue, I.; Arendt, E.; Hill, C.; Stanton, C.; Ross, R.P. Recent advances in microbial fermentation for dairy and health. *F1000Research* **2017**, *6*, 1–9. [CrossRef] [PubMed]
117. Melini, F.; Melini, V.; Luziatelli, F.; Ficca, A.G.; Ruzzi, M. Health-promoting components in fermented foods: An up-to-date systematic review. *Nutrients* **2019**, *11*, 1189. [CrossRef]
118. Nkhata, S.G.; Ayua, E.; Kamau, E.H.; Shingiro, J.B. Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. *Food Sci. Nutr.* **2018**, *6*, 2446–2458. [CrossRef] [PubMed]
119. Xiang, H.; Sun-Waterhouse, D.; Waterhouse, G.I.; Cui, C.; Ruan, Z. Fermentation-enabled wellness foods: A fresh perspective. *Food Sci. Hum. Well.* **2019**, *8*, 203–243.
120. Erkmen, O.; Bozoğlu, T.F. Fermented cereal and grain products. In *Food Microbiology: Principles into Practice*; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2016.
121. Singh, A.K.; Rehal, J.; Kaur, A.; Jyot, G. Enhancement of attributes of cereals by germination and fermentation: A review. *Crit. Rev. Food Sci. Nutr.* **2015**, *55*, 1575–1589. [CrossRef]
122. Akoma, O.; Agarry, O.O.; Nkama, I. Influence of thermal enzymatic hydrolysis of cereal starch on the physico-chemical quality of *kunu*n-zaki (A fermented non-alcoholic cereal beverage). *Int. J. Appl. Biol. Pharmaceut. Technol.* **2010**, *3*, 821–829.
123. Okpara, A.N.; Okolo, B.N.; Ugwuanyi, J.O. Antimicrobial activities of lactic acid bacteria isolated from akamu and *kunu*n-zaki (cereal based non-alcoholic beverages) in Nigeria. *Afr. J. Biotechnol.* **2014**, *13*, 2977–2984. [CrossRef]
124. Aderinola, T.; Oluwamukomi, M. Effect of sodium benzoate on the quality and sensory properties of *kunu*n-zaki supplemented with groundnut. *J. Microbiol. Biotechnol. Food Sci.* **2014**, *3*, 426–431.
125. Amadou, I. Millet based fermented beverages processing. In *Fermented Beverages*; Grumezescu, A.M., Holban, A.M., Eds.; Woodhead Publishing: Sawston, UK, 2019; pp. 433–472.
126. Mohammed, A.M.; Emmanuel, O.A. Hydrolytic enzyme levels in malted cereals. *Adv. Biochem.* **2014**, *2*, 76–79.
127. Awodi, P.S.; Ella, A.B.; Asaar, G.B.; Tivkaa, T.J. Effect of malted cereals on the sugar content of sorghum gruel. *Int. J. Curr. Res. Biosci. Plant Biol.* **2018**, *5*, 43–48. [CrossRef]
128. Kohajdová, Z.; Karovičová, J. Fermentation of cereals for specific purpose. *J. Food Nutr. Res.* **2007**, *46*, 51–57.
129. Mani, A. Food Preservation by Fermentation and Fermented food products. *Int. J. Acad. Res. Dev.* **2018**, *1*, 51–57.

130. Kambabazi, M.R.; Hitayezu, E.; Mukandahiro, Y.; Vasanthakaalam, H. Assessment of microbiological changes during production of malted and fermented finger millet flour. *RWA J. Agric. Sci.* **2019**, *1*, 31–35.
131. Kalpana, P.; Sushima, W.; Krishnapura, S. Bio accessible Mineral Content of Malted Finger Millet (*Eleusine coracana*), Wheat (*Triticum aestivum*), and Barley (*Hordeum vulgare*). *J. Agric. Food Chem.* **2010**, *58*, 8100–8103.
132. Muyanja, C.; Namugumya, B.S. Traditional processing, microbiological, physiochemical and sensory characteristics of Kwete, a Ugandan fermented maize based beverage. *Afr. J. Food Agric. Nutr. Dev.* **2009**, *9*, 1046–1059. [CrossRef]
133. Livingstone, A.S.; Sandhu, J.; Malleshi, N. Microbiological evaluation of malted wheat, chickpea, and weaning food based on them. *J. Prop. Ped.* **1992**, *38*, 74–77. [CrossRef]
134. Badau, M.H. Microorganisms associated with pearl millet cultivars at various malting stages. *Int. J. Food Saf.* **2006**, *8*, 66–72.
135. Shankar, I.; Usha, A. Assessment of the microbiological quality of koozh, a fermented millet beverage. *Afr. J. Microbiol. Res.* **2014**, *8*, 308–312. [CrossRef]
136. Inyang, C.U.; Zakari, U.M. Effect of germination and fermentation of pearl millet on proximate, chemical and sensory properties of instant fura—A Nigerian cereal food. *Pak. J. Nutr.* **2008**, *7*, 9–12. [CrossRef]
137. Bello, F.A.; Inyang, U.E.; Umoh, A.P. Effect of alkaline steeping on the nutritional, antinutritional and functional properties of malted millet (*Pennisetum glaucum*) flour. *Int. J. Innov. Food Nutr. Sust. Agric.* **2017**, *5*, 17–23.
138. Uvere, P.O.; Amazikwu, U.C. Processing and evaluation of instant *kunu*n zaki from millet-cowpea malt and millet-soybean malt. *Afr. J. Food Sci.* **2011**, *5*, 761–768.
139. Ahmed, A.I.; Abdalla, A.A.; Tinay, A.E. Effect of traditional processing on chemical composition and mineral content of two cultivars of pearl millet (*Pennisetum glaucum*). *J. Appl. Sci.* **2009**, *5*, 2271–2276.
140. Sehgal, S.; Kawatra, A. In vitro protein and starch digestibility of pearl millet (*Pennisetum gluacum* L.) as affected by processing techniques. *Food/Nahr.* **2001**, *45*, 25–27.
141. Hassan, A.B.; Ahmed, I.A.M.; Osman, N.M.; Eltayeb, M.M.; Osman, G.A.; Babiker, E.E. Effect of processing treatments followed by fermentation on protein content and digestibil-ity of pearl millet (*Pennisetum typhoideum*) cultivars. *Pak. J. Nutr.* **2006**, *5*, 86–89.
142. Jaybhaye, R.V.; Pardeshi, I.L.; Vengaiah, P.C.; Srivastav, P.P. Processing and technology for millet based food products: A review. *J. Ready Eat Food* **2014**, *1*, 32–48.
143. Ikram, A.; Saeed, F.; Afzaal, M.; Imran, A.; Niaz, B.; Tufail, T.; Hussain, M.; Anjum, F.M. Nutritional and end-use perspectives of sprouted grains: A comprehensive review. *Food Sci. Nutr.* **2021**, *9*, 4617–4628. [CrossRef]
144. Akoma, O.; Jiya, E.A.; Akumka, D.D.; Mshelia, E. Influence of malting on the nutritional characteristics of *kunu*n-zaki. *Afr. J. Biotechnol.* **2006**, *5*, 996–1000.
145. Choudhury, M.; Das, P.; Baroova, B. Nutritional evaluation of popped and malted indigenous millet of Assam. *J. Food Sci. Technol.* **2011**, *48*, 706–711. [CrossRef]
146. Hooda, S.; Jood, S. Effect of soaking and germination on nutrient and antinutrient contents of fenugreek (*Trigonella foenum graecum* L.). *J. Food Biochem.* **2003**, *27*, 165–176. [CrossRef]
147. Lemmens, E.; Moroni, A.V.; Pagand, J.; Heirbaut, P.; Ritala, A.; Karlen, Y.; Lê, K.A.; van den Broeck, H.C.; Brouns, F.J.; De Brier, N.; et al. Impact of cereal seed sprouting on its nutritional and technological properties: A critical review. *Comp. Rev. Food Sci. Food Saf.* **2019**, *18*, 305–328. [CrossRef] [PubMed]
148. Abdelrahaman, S.M.; Elmaki, H.B.; Idris, W.H.; Hassan, A.B.; Babiker, E.E.; El Tinay, A.H. Antinutritional factor content and hydrochloric acid extractability of minerals in pearl millet cultivars as affected by germination. *Int. J. Food Sci. Nutr.* **2007**, *58*, 6–17. [CrossRef] [PubMed]
149. Nadeem, M.; Anjum, F.M.; Amir, R.M.; Khan, M.R.; Hussain, S.; Javed, M.S. An overview of anti-nutritional factors in cereal grains with special reference to wheat-A review. *Pak. J. Food Sci.* **2010**, *20*, 54–61.
150. Samtiya, M.; Aluko, R.E.; Dhewa, T. Plant food anti-nutritional factors and their reduction strategies: An overview. *Food Prod. Process. Nutr.* **2020**, *2*, 6. [CrossRef]
151. Badau, M.H. Sensory and microbial evaluation of pearl millet *kunu*-zaki saccharified with malt from some pearl millet and sorghum cultivars. *Agro Sci.* **2007**, *6*, 116–127. [CrossRef]
152. Mbachu, A.E.; Etok, C.A.; Agu, K.C.; Okafor, O.I.; Awah, N.S.; Chidi-Onuorah, L.C.; Ekwueme, V.C.; Okpala, J.; Ogbue, M.O.; Ikele, M.O. Microbial quality of *kunu* drink sold in Calabar, Cross River state, Nigeria. *J. Glob. Biosci.* **2014**, *3*, 511–515.
153. Adegoke, G.O.; Odeyemi, A.O.; Hussien, O. Ikheorah Control of Ochratoxin A (OTA) in *Kunu*zaki (a Non-alcoholic Beverage) using Daniellin (TM). *Afr. J. Agric.* **2007**, *2*, 200–202.
154. Orutugu, L.A.; Izah, S.C.; Aseibai, E.R. Microbiological quality of *kunu* drink sold in some major markets of Yenagoa metropolis, Nigeria. *Cont. J. Biomed. Sci.* **2015**, *9*, 9–16. [CrossRef]
155. Umaru, G.A.; Tukur, I.S.; Akensire, U.A.; Adamu, Z.; Bello, O.A.; Shawulu, A.H.B.; Audu, M. Microflora of *Kunu*n-Zaki and Sobo drinks in relation to public health in Jalingo Metropolis, North-Eastern Nigeria. *Int. J. Food Res.* **2014**, *1*, 16–21.
156. Bukar, A.; Uba, A.; Oyeyi, T.I. Occurrence of some entropathogenic bacteria in some minimally and fully processed read –to-eat foods in Kano metropolis. *Nig. Afr. J. Food Sci.* **2010**, *4*, 32–36.
157. Adesulu-Dahunsi, A.T.; Dahunsi, S.O.; Olayanju, A. Synergistic microbial interactions between lactic acid bacteria and yeasts during production of Nigerian indigenous fermented foods and beverages. *Food Cont.* **2019**, *110*, 106963. [CrossRef]
158. Halm, M.; Lillie, A.; Sorensen, A.K.; Jakobsen, M. Microbiological and aromatic characteristics of fermented maize doughs for kenkey production in Ghana. *Int. J. Food Microbiol. Biotechnol.* **1993**, *12*, 531–536.

159. Ananou, S.; Maqueda, M.; Martinez-Bueno, M.; Valdivia, E. Biopreservation, an ecological approach to improve the safety and shelf-life of foods. In *Communicating Current Research and Education Topics and Trends in Applied Microbiology*; Mendez-Vilas, A., Ed.; FORMATEX: Madrid, Spain, 2007.
160. Caplice, E.; Fitzgerald, G.F. Food fermentations: Role of microorganisms in food production and preservation. *Int. J. Food Microbiol.* **1999**, *50*, 131–149. [CrossRef]
161. Adesulu-Dahunsi, A.T.; Jeyaram, K.; Sanni, A.I. Probiotic and technological properties of exopolysaccharide producing Lactic acid bacteria isolated from some cereal-based Nigerian indigenous fermented food products. *Food Contr.* **2018**, *92*, 225–231. [CrossRef]
162. Adesulu-Dahunsi, A.T.; Jeyaram, K.; Sanni, A.I.; Banwo, K. Production of exopolysaccharide by strains of Lactobacillus plantarum YO175 and OF101 isolated from traditional fermented cereal beverage. *PeerJ* **2018**, *6*, e5326. [CrossRef] [PubMed]
163. Adesulu-Dahunsi, A.T.; Sanni, A.I.; Jeyaram, K. Production, characterization and In vitro antioxidant activities of exopolysaccharide from *Weissella cibaria* GA44. *LWT Food Sci. Technol.* **2018**, *87*, 432–442. [CrossRef]
164. Adesulu-Dahunsi, A.T.; Sanni, A.I.; Jeyaram, K.; Ojediran, J.O.; Ogunsakin, A.O.; Banwo, K. Extracellular polysaccharide from *Weissella confusa* OF126: Production, optimization, and characterization. *Int. J. Biol. Macromol.* **2018**, *111*, 514–525. [CrossRef]
165. Nkama, I.; Agarry, O.O.; Akoma, O. Sensory and nutritional quality characteristics of powdered 'Kunun-zaki': A Nigerian fermented cereal beverage. *Afr. J. Food Sci.* **2010**, *4*, 364–370.
166. Omowaye-Taiwo, O.A.; Oluwamukomi, M.O. Physical and nutritional composition of instant kunun-zaki powder obtained by three drying methods. *FUTA J. Res. Sci.* **2015**, *11*, 114–122.
167. Chaven, U.D.; Chaven, J.K.; Kadan, S.S. Effect of fermentation on soluble proteins and in vitro protein digestibility of sorghum, green gram and sorghum-green gram blends. *J. Food Sci.* **1988**, *53*, 1574. [CrossRef]
168. Cook, P.E. Fermented foods as biotechnological resourses. *Food Res. Int.* **1994**, *27*, 309. [CrossRef]
169. Nwaiwu, O.; Itumoh, M. Chemical Contaminants Associated with Palm Wine from Nigeria Are Potential Food Safety Hazards. *Beverages* **2017**, *3*, 16. [CrossRef]
170. Gedi, M.A.; di Bari, V.; Ibbett, R.; Darwish, R.; Nwaiwu, O.; Umar, Z.; Agarwal, D.; Worrall, R.; Gray, D.; Foster, T. Upcycling and valorisation of food waste. In *Routledge Handbook of Food Waste*; Reynolds, C., Soma, T., Spring, C., Lazell, J., Eds.; Routledge Taylor and Francis Publishers: Oxford, UK, 2020; 516p.
171. Nout, M.J.R. Rich nutrition from the poorest cereal fermentations in Africa and Asian. *Food Microbiol.* **2009**, *26*, 685–692. [CrossRef] [PubMed]
172. Abah, C.R.; Ishiwu, C.N.; Obiegbuna, J.E.; Oladejo, A.A. Nutritional Composition, Functional Properties and Food Applications of Millet Grains. *Asian Food Sci J.* **2020**, *14*, 9–19. [CrossRef]
173. Alejo, A.O.; Ilesanmi, F.F.; Ishola, D.T.; Afolabi, A.A.; Oyelakin, M.O. Sensory, Shelf-Life and Nutritional Evaluation of *Kunu* (Nigeria Non-Alcoholic Beverage) Produced from Different Grains. *Int. J. Res. Stud. Agric. Sci.* **2017**, *3*, 20–25.
174. Adaramola-Ajibola, K.M.; Osaloni, A.R.; Arijeniwa, O.C. Nutritional Composition, Microbiological Quality and Sensory Properties of *Kunu*-Zaki Produced from Millet and Tigernut Blend. *Asian Food Sci. J.* **2019**, *13*, 1–10. [CrossRef]
175. Kayode, R.M.; Joseph, J.K.; Adegunwa, M.O.; Dauda, A.O.; Akeem, S.A.; Kayode, B.I.; Babayeju, A.A.; Olabanji, S.O. Effects of addition of different spices on the quality attributes of tiger-nut milk (*kunu*n-aya) during storage. *J. Microbiol. Biotechnol. Food Sci.* **2017**, *7*, 1–6. [CrossRef]
176. Hampel, D.; Shahab-Ferdows, S.; Adair, L.S.; Bentley, M.E.; Flax, V.L.; Jamieson, D.J.; Ellington, S.R.; Tegha, G.; Chasela, C.S.; Kamwendo, D.; et al. Thiamin and Riboflavin in Human Milk: Effects of Lipid-Based Nutrient Supplementation and Stage of Lactation on Vitamer Secretion and Contributions to Total Vitamin Content. *PLoS ONE* **2016**, *11*, e0149479. [CrossRef]
177. Ofoeze, M.A.; Ukpabi, U.J.; Adiele, J.G.; Sanjeet, K. Quality Characteristic of Kunu Produced from Orange Fleshed Sweetpotato for Empowerment of Rural Women in Nigeria. *Nig. Agric. J.* **2021**, *52*, 325–330.
178. Bintsis, T. Lactic Acid Bacteria: Their Applications in Foods. *J. Bacteriol. Mycol.* **2018**, *5*, 1065.
179. Snigdha, M.M.; Mohanty, D.; Mohapatra, S. Applications of Probiotics as a Functional Ingredient in Food and Gut Health. *J. Food Nutr. Res.* **2019**, *7*, 213–223.
180. Nagpal, R.; Kumar, A.; Kumar, M.; Behare, P.V.; Jain, S.; Yadav, H. Probiotics, their health benefits and applications for developing healthier foods: A review. *FEMS Microbiol. Lett.* **2012**, *334*, 1–15. [CrossRef]
181. Oboh, H.; Obahiagbon, F.; Osagie, A.; Omotosho, A. Glycemic response of some local Nigerian drinks in healthy subjects. *Nig. J. Nutr. Sci.* **2011**, *32*, 1–5. [CrossRef]
182. Taiwo, A.A.; Adeoyegun, J.A.; Ijaola, T.A.; Lawal, O. Comparative study of nutritive composition andmicrobial level of *Kunu*n sold in three campuses in Abeokuta. *Sky J. Food Sci.* **2017**, *6*, 7–13.
183. Omakwu, J. The Preservation Effect of Spices in Kunnu-Samiya. Ph.D. Thesis, Ahmadu Bello University, Zaria, Nigeria, 1980.
184. Telrandhe, U.B.; Uplanchiwar, V. Phyto-Pharmacological Perspective of Cadaba farinosa forsk. *Am. J. Phytomed. Clin. Ther.* **2013**, *1*, 1011–1022.
185. Rahman, M.; Mossa, J.S.; Al-Said, M.S.; Al-Yahya, M.A. Medicinal plant diversity in the flora of Saudi Arabia 1: A report on seven plant families. *Fitoterapia* **2004**, *75*, 149–161. [CrossRef] [PubMed]
186. Alzahrani, D.A.; Albokhari, E.J.; Yaradua, S.S.; Abba, A. Comparative Analysis of Chloroplast Genomes of Four Medicinal Capparaceae Species: Genome Structures, Phylogenetic Relationships and Adaptive Evolution. *Plants* **2021**, *10*, 1229. [CrossRef] [PubMed]

187. Awonorin, S.O.; Udeozor, L.O. Chemical properties of tiger nut -soy milk extract. *IOSR J. Environ. Sci. Toxicol. Food Tech.* **2014**, *8*, 87–98.
188. Chevalier, A. *The Encyclopeadia of Medicinal Plants*; Dorling Kingsley Press: London, UK, 1998; pp. 48–51.
189. Gambo, A.; Da'u, A. Tiger nut (Cyperus esculentus): Composition, products, uses and health benefits-a review. *Bayero J. Pure Appl. Sci.* **2014**, *7*, 56–61. [CrossRef]
190. Rouf Shah, T.; Prasad, K.; Kumar, P. Maize-A potential source of human nutrition and health: A review. *Cogent Food Agric.* **2016**, *2*, 1166995. [CrossRef]
191. De Caluwé, E.; Halamová, K.; Van Damme, P. *Tamarindus indica* L.—A review of traditional uses, phytochemistry and pharmacology. *Afr. Focus* **2010**, *23*, 53–83. [CrossRef]
192. Bristone, C.; Ariahu, C.C.; Ikya, J.K.; Eke, M.O. Potentials of Nigerian indigenous food products for addressing nutritional needs of persons in internally displaced persons' camps (I. D. P. Camps). *Acad. J. Food Res.* **2018**, *6*, 41–50. [CrossRef]
193. Kankara, S.S.; Ibrahim, M.H.; Mustafa, M.; Go, R. Ethnobotanical survey of medicinal plants used for traditional maternal healthcare in Katsina state, Nigeria. *S. Afr. J. Bot.* **2015**, *97*, 165–175. [CrossRef]
194. Ojo, O.O.; Nadro, M.S.; Tell, I.O. Protection of rats by extracts of some common Nigerian trees against acetaminophen-induced hepatotoxicity. *Afr. J. Biotechnol.* **2006**, *5*, 755–760.
195. Iwu Maurice, M. *Handbook of African Medicinal Plants*; CRC Press: Boca Raton, FL, USA, 1993; p. 129.
196. Murthy, H.N.; Yadav, G.G.; Dewir, Y.H.; Ibrahim, A. Phytochemicals and Biological Activity of Desert Date (*Balanites aegyptiaca* (L.) Delile). *Plants* **2020**, *10*, 32. [CrossRef] [PubMed]
197. Istifanus, M.F.; Agbo, E.B. Nutritional and Health Benefits of Acha (*Digitaria exilis*) in the Human Diet—A Review. *Niger. Food J.* **2016**, *34*, 72–78.