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Local Cereal Fermented Foods with Probiotic Potentials

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ABSTRACT

Probiotics are microbial food supplements containing live microorganisms which exact beneficial effects on consumers' health. These live microorganisms may produce or release health promoting compounds in the substrate medium. Most probiotic foods are made of milk, although many locally fermented cereals are known to possess probiotic potentials. Examples of cereal fermented foods with probiotic potentials include pito, kunu-zaki, burukutu and obiolor. Cereal-based fermented food products have long been known to be beneficial to health. Cereal raw materials usually used for probiotic foods are sorghum, millet, and maize. Microorganisms involved in cereal probiotic foods are members of lactic acid bacteria and yeasts which mostly are part of the Lactobacillus, Lactococcus, Leuconostoc, Pediococcus and Bifidobacterium genera where as the yeasts are dominated by mostly Saccharomyces cerevisiae and Candida species. This review examines some locally fermented cereals with probiotic potentials.

Keywords: *Cereals, Fermented foods, Probiotic potentials, Lactic acid bacteria, Yeasts*

INTRODUCTION

Local cereal grains usually used as raw materials for probiotic foods are sorghum, millet, and maize. Nutritionally, they provide great sources of dietary protein, carbohydrates, B and E groups of vitamins, iron, trace minerals and fiber. According to Hamad and Fields, [1] majority of traditional cereal based foods consumed in Africa are processed by natural fermentation which increases their relative nutritive value and available lysine. The content and quality of cereal proteins may be improved by fermentation. Fermented foods with live cultures are often considered to be functional foods with probiotic benefits. Examples of cereal fermented foods with probiotic potentials include; pito, kunu-zaki, burukut and, obiolor. The fermentation processes of these cereal foods involve lactic acid fermentation which is carried out by a complex population of environmental microorganisms which confer souring taste and storage longevity. Microorganisms involved in cereal fermented foods belong mostly to the genera of Lactobacillus and Bifidobacterium species, which are indigenous to the human intestine and are predominantly selected for use although some other species have also been used [2]

Probiotics are viable, non pathogenic microorganisms (bacteria and yeasts) that when ingested are able to reach the intestines in sufficient number to confer health benefits to the host [3]. Viability of these bacteria upon ingestion and sufficient number of survival through gastro intestinal tract is critical to confer any health benefits to the host [4, 5, 6, 7].

According to FAO/WHO [8], probiotics were later termed as live microorganisms which when administered in adequate amounts confer a health benefit to the host. The amount required to gain any therapeutic benefit is a minimum of 106 viable probiotic cells per millilitre during storage until the expiry date [8, 9, 10].

It is widely recognized that probiotics have the possibility of exerting positive influence on the host through modulation of the endogenous ecosystem and stimulation of immune system also by maintaining a healthy intestinal microflora [11, 12, 13, 14, 15, 16]. However, research suggests that health benefits are mostly strain specific and changes per the amount ingested and duration of administration [8, 45, 57]. The viability of these cells after consumption has still been unknown as the bacteria are also subjected to unfavorable physiological conditions of the gastro intestinal (GI) tract such as extreme acid environment and bile secretions [17].

Probiotics were initially perceived to be derived from dairy-based products. Consumers generally link probiotic food products with yoghurt only because dairy products like fermented milk, yoghurt, and cheese, occupies the premier position in probiotic foods either due to more likness by people or much availability. However, scientific findings of recent had confirmed the probiotic potential of isolates in most traditional non-dairy-based fermented foods. This review therefore presents an overview of locally fermented cereal beverages and also discusses their probiotic potentials.

Cereal Fermented Foods With Probiotic Potential

Kunu-zaki

This is a traditional non-alcoholic fermented beverage consumed mostly in Northern Nigeria. It is however prepared using millet, by washing the millet thoroughly and steeping in water after which it is then wet milled with spices such as ginger, pepper and cloves. The resulting slurry is sieved using a sterile sieve until all the starch is extracted. The shafts are discarded and filtrate allowed to settle, the supernatant decanted and the sediment is divided into two parts ratio (3:2). The larger portion is cooked by the addition of water boiled for 5 min while cold water is added to the second part and then the slurry is thoroughly mixed and allowed to ferment for 6 h at ambient temperature (30±2oC) following which it is sieved and Kunu-zaki produced [18].(Fig 1).

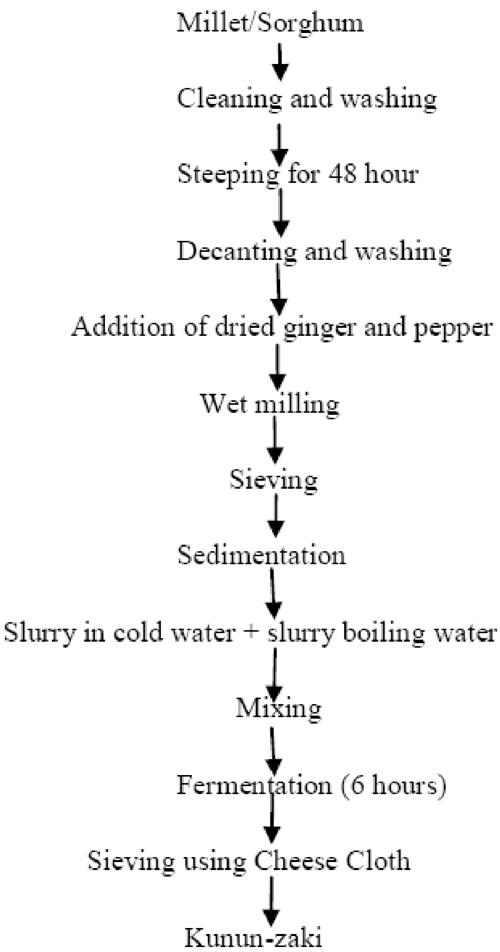

Fig1. *Flow chart for the production of kunu-zaki*

Pito

This is the traditional beverage drink of the Benin people in the Mid-Western and Middle Belt region of Nigeria. It is consumed because of its refreshing taste, satisfying textures and low cost. The preparation of pito involves saturating the cereal grains (maize, sorghum or blend of both) in water for 2 days, followed by malting and allowing them to sit for five to six days in basket lined with moistened banana or plantain leaves. The malted grains are sun dried before crushing. The malt flour is mixed with water and then boiled for 6-12 h, and the resulting wash cooled and later sifted through a fine mesh. The filtrate is again fermented overnight and this becomes slightly sour due to microbial action after which it is boiled for 12 h and again cooled. The starter (sediment) from a previous brew is added to the cooled distillate and then allowed to ferment for 12-24 h to obtain a dark brown liquid known as pito [20, 21]{Fig 2}

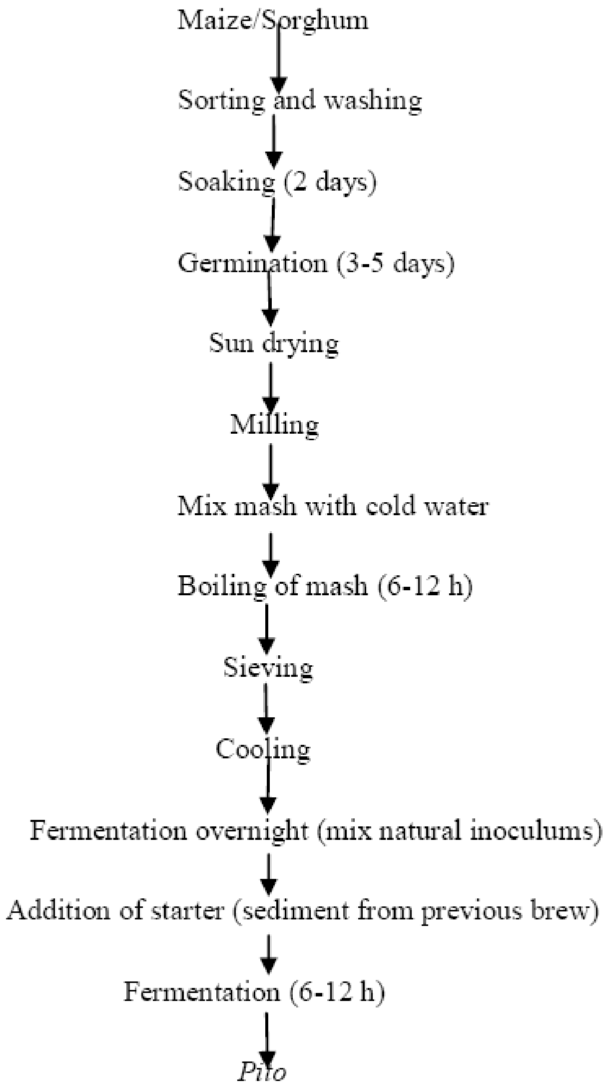

Fig2. *Flow chart for the production of pito [21, 22,23}*

Burukutu

This is a popular alcoholic beverage of vinegar-like flavor, somewhat bitter, sweetened sour beverage from Nigeria and Ghana made by fermentation of malted washed maize or sorghum. The preparation of burukutu involves steeping sorghum grains in water overnight followed by draining of excess water. The grains are spread out onto a tray covered with banana leaves and allowed to germinate. During germination progression, the grains are watered on alternate days and turned over at breaks. Germination continues for 4-5 days until the plumule attains a certain extent. The sprouted grains are sundried before grinding. Adjuncts are added in the form of garri to the mixture of the ground malt and then mixed with cold water and boiled for 6-12 h after which it is filtered through a fine mesh and cooled. The filtrate is again fermented overnight until it becomes slightly sour due to microbial action. It is then boiled for 12 h to concentrate it and again cooled. The starter (sediment) from a previous brew is added to the cooled concentrate and is allowed to ferment for 12-24 h to obtain burukutu [24, 25].{Fig3}.

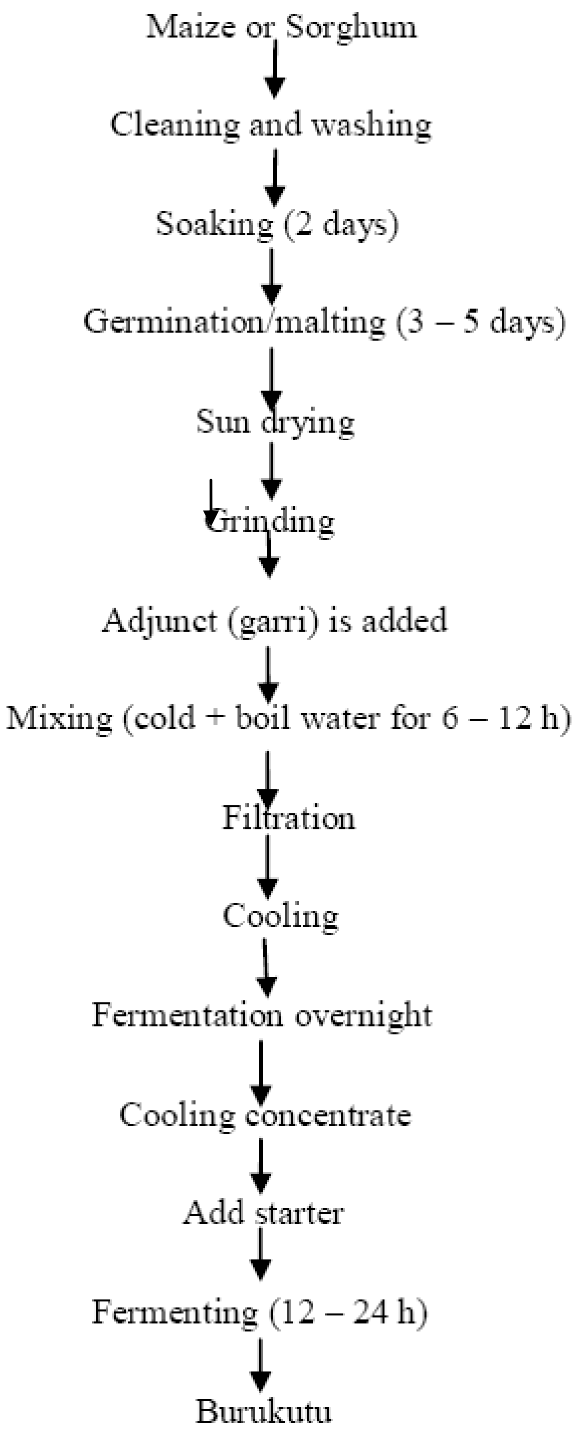

Fig3. *Flow chart for the production of burukutu [26, 27]*

Obiolo

This is a non-alcoholic beverage formed from fermented millet and sorghum malts in Nigeria. It is a th in gruel with sweet taste. The traditional preparation of obiolo is carried out by steeping millet and sorghum grains in water overnight after which the grains are enfolded in fresh banana or plantain leaves and allowed to germinate for 3 days. After germination period, the grains are wet milled and prepared into slurry. The slurry is mixed with boiling water in a ratio of (1:4 v/v) and the mash is cooled after which the cooled mash is sieved and then the deposit discarded, while the filtrate is concentrated by boiling for 30 min with constant stirring. The resultant gruel is cooled quickly and allowed to ferment for 24 h at ambient temperature (30±2oC), after which it is ready for consumption [25].{Fig 4}.

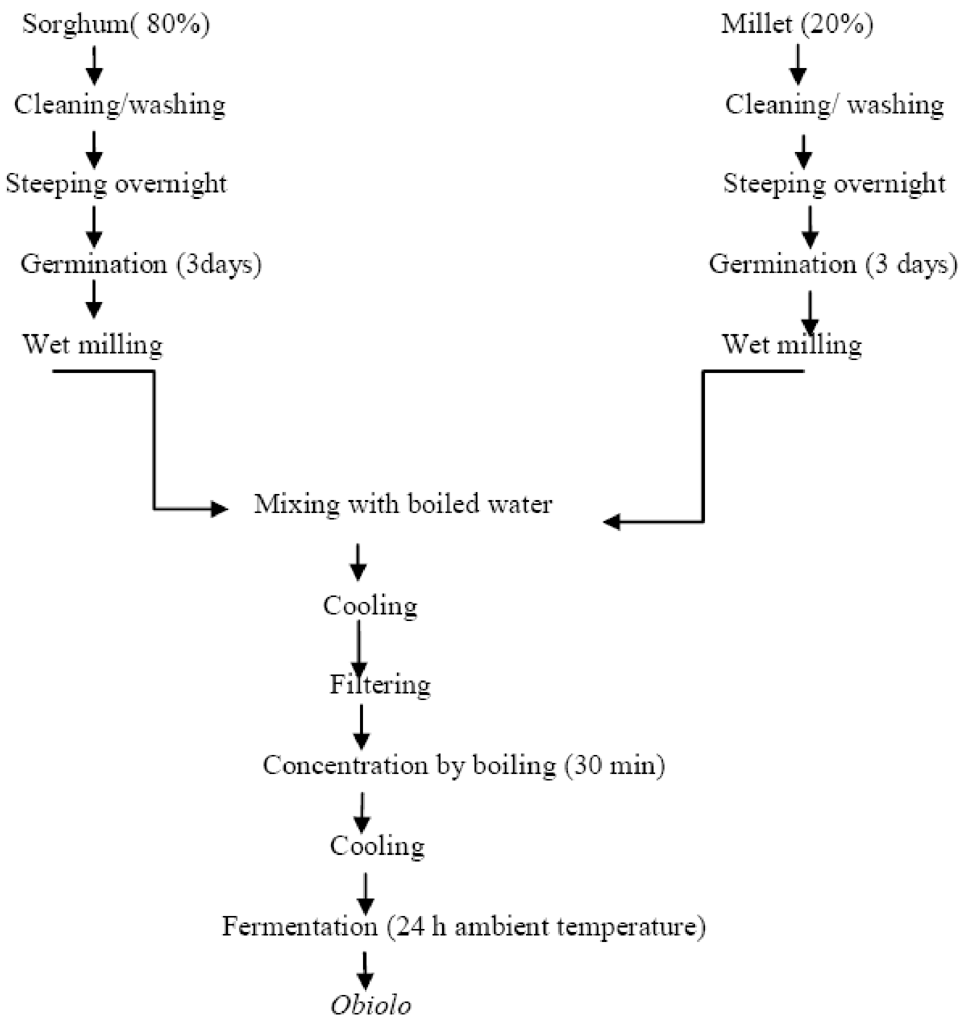

Fig4. *Flow chart for the production of obiolo [25, 28].*

Table1. *Probiotic organisims in cereal fermented products*

Product	Source	Microorganism (Lactic acid bacteria)	Yeast	Reference
Kunu-zaki	Millet or sorghum	*Lactobacillus plantarum, Lactobacillus pentosus, Lactobacillus celbiosus Leuconostocmesenteroides*	*Candidamycoderma, Saccharomycescerevisae*	[29, 30]
Pito	Sorghum	*Pediococcushalophylus Lactobacillus plantarum Lactobacillus casei*	*Saccharomycescerevisae Candidautilis Rhodotorulaglutinis Candida pelliculosa Cryptococcus albidus Geotrichumcandidum*	[20, 31]
Burukutu	Millet and sorghum	*Lactobacillus spp. Leuconostocmesenteroides Acetobacter species*	*Saccharomycescerevisae Rhodotorulaglutinis Cryptococcus aldidis Candida spp. Saccharomyceschavelieri*	[31, 32]
Obiolo	Millet and sorghum	*Lactobacillus fermentum Lactobacillus plantarum Lactobacillus acidophilus Lactobacillus brevis Lactobacillus rhamnosus Bifidobacterium longum Lactococcus lactic*		[25, 28]

ROLE OF PROBIOTIC MICROORGANISMS IN CEREAL FERMENTED FOODS

Cereal raw materials usually used for probiotic foods are sorghum, millet, and maize. Microorganisms involved in cereal probiotic foods are members of lactic acid bacteria (LAB) and yeasts which mostly belong to the genera Lactobacillus, Lactococcus, Leuconostoc, Pediococcus and Bifidobacterium while the yeasts are dominated by mostly Saccharomyces cerevisiae and Candida species [33, 34].{Table 1}.

The genus of lactic acid bacteria varies but Bifidobacterium and Lactobacillus are most important strains, and some of the species are Lactobacillus fermentum, Lactobacillus plantarum, Lactobacillus celibiosus, Lactobacillus acidophilus, Lactobacillus casei, Lactobacillus pentosus, Lactobacillus rhamnosus and Bifidobacterium longum [25, 35, 36]. The LAB are designated as gram positive, catalase negative, non-sporing rods and cocci which are usually non-motile when observed microscopically [30]. The activities of lactic acid bacteria contribute significantly to the production of many antimicrobial and inhibitory substances. It is carried out in a complex population of environmental microorganisms which confers its souring taste and storage longevity and also improves both food safety and digestibility [37].

In the fermented cereal foods, yeast contributes to flavor enhancement. These yeasst are dominated by mostly Saccharomyces cerevisae and Candida species which are capable of producing enzymes such as lipase, esterase and phytase. The lipolytic activity results in fatty acids which are precursors of flavor while esterase activity determine aroma and flavor. Phytase produced by these organisms helps in lowering phytic acid which can form complexes with minerals that in turn can negatively affect protein digestibility [22, 38].

LAB isolated from various fermented cereal foods are known to produce organic acids and a high diversity of antimicrobial agents, which are responsible for the increased quality and the high organoleptic properties of fermented cereal foods. Lactic acid food fermentation is a process whereby microorganisms and their enzymes are used to convert fermentable sugars in the food substance into mainly lactic acid and other limited products [35, 39].

Many probiotic organisms associated with cereal fermented foods synthesize antimicrobial bioactive molecules such as hydrogen peroxide, organic acids, bacteriocins that boost their biopreservative properties. There are many claims as to the functions of lactic acid bacteria in foods which are yet to be verified properly. Some of the applications of the various LAB associated with probiotic cereal foods include; Lactobacillus rhamnosus - helps in the reduction of dental caries risk, Lactobacillus casei alleviates type II diabetes and obesity; Bifidobacterium longum SPM 1207 and Lactobacillus species are used in lowering of cholesterol and low density lipoprotein [39, 41]. Lactobacillus species helps in inhibition of Listera monocytogenes and Clostridium species. Lactobacillus reuteri and Lactobacillus plantarum are applied as antifungal agents and drug delivery vehicles. Lactobacillus acidophilus, Lactobacillus salivarius, Lactobacills rhmnosus, Lactobacillus brevis and Lactobacillus casei are also applicable for immune system modulation and mental health. Lactobacillus species are used for the reduction of mycotoxins in fermented maize products [34, 39, 40, 41, 42].

Probiotic bacteria from the genus Lactobacillus are characteristically contemporary in fermented cereal foods and many diseases caused by pathogens attacking the gastrointestinal tract can be prevented by maintaining proper intestinal flora by consuming probiotics or fermented foods. Probiotic microorganisms have great potentials for refining nutrition, soothing duodenal disorders, optimizing gut ecology, improving the immune system and improving overall health because of their ability to compete with pathogens for adhesion sites, to antagonize pathogens or to modulate the host's immune response. A combination of Bifidobacterium species strictly anaerobic and prevent the large intestines from disease states. They also contribute in the breakdown of lactose, generation of lactate ions from lactic acid and vitamin synthesis [43, 44,4 45].

Functions of Probiotic Microorganisms

Fermented foods produced are associated with good bacteria referred to as probiotics. Probiotic microorganisms provide the characteristic sour taste of fermented foods such as in Pito, kunu-zaki, burukutu and obiolo beverages. It also helps in the production of valuable products including flavor and aroma compounds, proteins, minerals, lipids, carbohydrates, vitamins and other products of respiratory and biosynthetic processes such as lactic acid, ethanol, acetyaldehydes, pyruvic acid which helps in altering the pH of food to levels that do not favour growth of pathogenic microorganisms, hence increasing the shelf life of fermented cereal products [26, 46, 47].

Fermented foods containing live cultures called probiotics perform the following functions;

- It helps in enhancement of the diet through development of a variety of flavor, aroma, textures and other organoleptic properties in food substrates.
- It produces metabolites to the host.
- It helps in elimination of anti-nutrients.
- It helps to improve food quality through food digestibility and also increase essential amino acids, vitamins and protein.
- It also helps to lower the pH of food product through fermentation in form of food preservation to increase food shelf life.[26, 46}

Selection Criteria of Probiotics Potentials

Probiotic fermented cereal foods must satisfy the criteria for safety, production, administration and application endurance and colonization in the host. In vitro experiments are used to investigate whether the selected microbial strains accomplish these criteria and enable screening of microorganisms for their potentials as probiotic strains Table 2.

Table2. *Probiotics potential attributes*

Bile salt tolerance
Resistance to low pH
Bile salt hydrolase activity
Antimicrobial activity and safety
Adhesion to gut epithelia tissue
Rapid production of lactic acid
Resistance to antibiotics
Phenol tolerance
[48, 49, 50]

Resistance to Low Ph

Probiotic microorganisms with high tolerance for low pH demonstrate the capability to thrive in the stomach and intestine; they also compete successfully with other bacteria in this environment and colonize the gastro intestinal tract (GIT) of the host. Microorganisms with probiotic potentials should be resistant to low pH of 3.0 after treatment for 24 h [51]. In the study of Ikii by Charteris et al., [52] the pH was found to decrease to 3.9, the initial count of coliforms of 4.17 x 10-3 decreased and was not detected by the end of 24 h of the fermentation process. According to Oluwajoba et al., [53], Lactobacillus pentosus, Pediococcus damnosus, Lactobacillus paracesei spp paracasei isolated from the fermenting slurry of kunu-zaki showed the greatest resistance to exposure at pH 3.0 with their counts actually increasing after 3 h exposure. But Lactobacillus plantarum, Lactobacillus acidophilus and Lactobacillus fermentum followed closely though there was a decline in all their viable counts after 3 h counting in pH 3.0. In the assessment of traditional Bulgarian cereal-based fermented beverage by Gotcheva et al., [54], the behavior of four LAB and three yeast strains at low pH 2.0 – 3.0 varied. The initial absorbance (A) of LAB samples was within 0.04 – 0.09 for 4.5 h, growth of all the strains at pH 2.0 was strongly inhibited. The agar plating however, showed that the strains remained viable for this period. Significant changes in absorbance ($P<0.05$) were observed for strains B25, B28 and B29 at pH 2.5 and 3.0 absorbance of B3 samples at pH 2.0, 2.5 and 3.0 did not change significantly and only agar plates showed survival at the end of the experiment. Strain B28 showed best resistance followed by B25. Jacobsen et al., [55] observed survival of 29 out of 44 LAB strains (Lactobacillus spp) following 4 h of incubation at pH 2.5 but replication of the results was questionable. Yeast strains showed much lower tolerance to the test conditions as expected. After 4.5 h at repressing situations, parameter observed did not designate growth of any of the strains tested. However, agar plating at the end of the treatment showed endurance of the strains. The results indicated that the strains could survive in the acid stomach milieu and reach the areas of beneficial activity (small intestine and colon) when ingested.

Bile Salt Tolerance

Probiotic potentials with high tolerance for bile salts can easily live in the stomach and intestine of their host. Organisms with probiotic potential should be resistant to bile salt of 0.3% (w/v) after treatment for 24 h [51]. In the study of Kunu-zaki by Oluwajoba et al. [53], there was a steady intensification in viable counts of all species afterwards culturing in bile salt but Lactobacillus paracasei spp paracasei I, Pediococcus damnosus, Lactococcus lactis spp Lactis and Lactobacillus rhamnosus could not maintain an appreciable level of survival after the 3rd h. These species experienced drop in their mean total viable counts between the 3rd and the 4th h of exposure to 0.3% concentration of bile. Charteris et al. [52] reported good bile tolerance (0.3% v/v) of 7 Lactobacillus and 7Bifidobacterium strains in an in vitro study. Jacobsen et al., [55] studied the survival of LAB strains tested for 4 h in 0.3% oxgall. Several Lactobacillus and Bifidobacterium strains were tested at bile levels of 1.0 and 1.5%. Some strains kept counts unaffected after 3 h of incubation at these bile levels. According to Gotcheva et al. [54] changes of absorbance for strains B3 and B25 were significant ($P<0.05$) at 0.2 and 0.3% bile concentration. Better results were observed for strains B28 and B29 where absorbance did not change significantly at the extreme 2.0% bile. Only plating indicated endurance of all LAB strains at the end of the test time. Changes of absorbance for Y27 were significant ($P<0.05$) to 0.2 and 0.3% bile, while for Y28 and Y30 absorbance at 0.02% were only significant, Y27 showed better tolerance, followed by Y30 and Y28 Yeast strains remained viable at all bile concentration throughout the test, indicated by agar plates. This above results showed that they could endure with bile toxicity driving their passage through the gastro- intestinal system.

Lactic Acid Production

Microorganisms involved in probiotics cereal fermented foods must belong to lactic acid bacteria (LAB).The activities of lactic acid bacteria contribute significantly to the production of many antimicrobial and inhibitory substances. In the study of *kunu-zaki* by Oluwajoba *et al.* [53] *Lactobacillus species* and *Pediococcus species* were identified.

Antimicrobial Activity and Safety

A typical probiotic strain is expected to show antimicrobial properties by manufacturing some of the several compounds such as organic acids, propionic acids, fatty acids, hydrogen peroxide, and diacetyl which cause pH reductions that hinder many microorganisms. Probiotics should advance safety to the host microorganism by inactivating pathogens but must not demonstrate any pathogenic or toxic activities to the host microorgaanism. In addition, it must have no transferable antibiotic resistance genes and must prevent the manufacture of biogenic amines from dietary proteins.

According to Kalu *et al*., [47] Lactabacilli isolates from *Ikii* showed antimicrobial effect against *Enterococcus faecalis*, *Staphylococcus aureus* and *Escherichia coli* all of which are food contaminants and pathogens. In the study of *Kunu-zaki* by Oluwajoba *et al.*, [53] all lactobacilli inhibited the growth of *Escherichia* coli, Staphylococcus aureus, Pseudomonas aeruginosa and Enterococcus faecalis except Pedicocus damnosus ,Lactococcus lactis spp *lactis* and *Lactobacillus fructivorans* that exhibited significantly ($P<0.05$) low antimicrobial result against *Enterococcus faecalis*. The strongest antimicrobial effect was shown by *Lactobacillus rhamnosus*, *Lactobacillus fermentum* and *Lactobacillus Pentosus* while antimicrobial effect of other Lactobacilli was similar against indicator bacteria. The antimicrobial action is reportedly due to the potential of LAB to manufacture both lactic acid and bacteriocins. A study by Koga *et al*. [56], showed no antimicrobial activity of the LAB tested towards pathogenic strains of *Salmonella enteridis* and *Escherichia coli*. Jacobsen *et al*. [55] studied LAB isolates from the fermented maize, strains with documented antimicrobial properties, human clinical isolates and dairy strains. Their activities varied too with many of the strains showing weak or no inhibition of the test pathogens. In the study, the inhibitory activity of the LAB and yeast strains towards pathogens was tested with eight clinical isolates, to obligatory pathogens *Salmonella enterides 1927* and *1968*, two strains causing opportunistic infections, *Pseudomonas aeruginosa 1806* and *1831*, one conditionally pathogen, *Enterococcus* and three strains of *E. coli* the entheropathogenic *E.coli 026* and entherotoxigenic *E.coli 06* and *027*. However, in the Gotcheva *et al*.[54] study, the antimicrobial activities of the LAB strains tested were variable. Strain *B25* had some activity towards *Salmonella*, *strain B29* showed no sign of inhibition, while *B28* had a plainly well-defined activity towards 6 of the test pathogens, especially *Salmonella*. Of the yeast strains, *Y27* had no antagonistic activity while *Y28* showed good inhibition of the *Salmonella* and *Pseudomonas aeruginosa 2. Y28* was active towards *E. coli 06* and *O26* as well strain *Y30* behaved in a similar way, actively inhibiting *Salmonella* and *Pseudomonas aeroginosa* and effective to *E.coli O26* and *O27*. Results showed the potential of strains *B28, Y28* and *Y30* to deliver an anti-pathogen barrier when applied in a food product such as fermented cereals.

Adhension to Gut Epithelial Tissue

Probiotic LAB isolates should demonstrate the capacity to adhere to gut epithelial tissue, to inhabit and to colonize the gastro intestinal tract (GIT). The relative importance of these features is emphasized by the fact that many of the probiotics available except *Lactobacillus rhamnosus*, do not colonize their targeted hosts and consequently do not remain in the gastro-intestinal tracts (GIT) for any significant period.

Antibiotics Resistance

An important safety aspect in assaying for probiotic potential is antibiotic resistance. This is because antibiotic genes, especially those encoded by potential strains need to be assayed for their antibiotic resistance to prevent the disagreeable transfer of resistance to other related and endogenous bacteria. The presence of an antibiotic may facilitate the growth of antibiotic mutants [15]. Application of antibiotics often disrupts the healthy balance of the residential microflora of the host, causing intestinal disorders. The administration of antibiotic-resistant strains can help in keeping the normal bacterial ratio in the intestines or its fast restoration if applied after the antibiotics treatment. According to Gotcheva *et al.*, [54] in the assessment of traditional Bulgarian cereal based fermented beverage, resistance of the three LAB strains to 9 antibiotics and chemotherapeutics was tested. *In vitro* resistance (R) and transitional sensitivity (I) which at *in vivo* environments turns into resistance were observed towards 21 of the test substances. All three strains were resistant to the inhibitors of the cell wall synthesis- penicillinase-resistant Oxacillin (1µg) and Methicillin (5µg) as well as to the cephalosporin generation II cefotoxine (30µg) and the glycopeptides, Vancomycin (30µg) and Teicoplanine (30µg). Vancomycin resistance is an intrinsic property of many LAB suggesting resistance of the tested LAB towards this antibiotic strain *B25 which* had imperfect resistance to cephalosporins generation III and a well-defined one to the inhibitions of neucleic acid synthesis – Nalidix acid and chynolons as well as to Tobramycin (10µg) and Kanamycin (30µg). Strain B showed full resistance to all inhibitions of neucleic acid synthesis - Nalidix acid and chynolons as well as to Trimethoprim sulfamethoxazote 1.25/23.75 mg which indicates good probiotic potential. Strain B29 was only partially resistant to inhibitions of the cell wall synthesis and exhibited good resistance to aminoglycosides and Trimethoprim – Sulfamethoxazole. Antibiotic resistance of the strains indicates their potential to be useful in therapeutic treatments.

Minimum Levels of Probiotics in Fermented Cereal Products

FAO/WHO guidelines [57] recommended attributes for the assessment of probiotics in food. The minimum concentration of probiotics required for beneficial effect is that at the point of consumption, probiotics should have a minimum concentration of >1x10^6 CFU/ML or gram. so that a total of some 10^8 to 10^9 probiotic organisms should be consumed daily if therapeutic effects are to be realized. The Swiss Food Regulation requires probiotic products to contain at least 10^6 Cfuml^{-1}.

These high bacterial cell counts of probiotic bacteria are proposed to allow for the possible reduction in numbers during passage through stomach and the intestines. Thus fermented cereal foods are to be investigated for their ability to reach the minimal levels of probiotic delivery according to FAO/WHO guidelines

Potential Benefits of Probiotics

Consumption of fermented cereal foods has a propensity to affect human health and mental wellbeing positively by stimulating the activities of the GUT microflora through the production of bioactive chemicals and neuropetides. Probiotic bacteria are beneficials in the following; Lowering serum cholesterol levels and reducing the incidence of coronary heart disease and reduction of risk factors for colon cancer by nutritional enrichment and metabolic effects. These can be done by:

- Enhancing the immune system, refining resistance to infection and improving well-being.
- Reduction of allergic inflammation by immune modulation.
- Prevention of type II diabetes and obesity.
- Prevention and treatment of dental caries
- Prevention or treatment of peptic ulcer disease.
- Colonization and maintenance of suitable intestinal microflora.
- Production of B-Vitamins.
- Protection of gastro-intestinal and general infections with mucosal entry.
- [17, 40, 45, 58]

The Mechanism of Action of Probiotic Bacteria

Probiotic bacteria exert beneficial properties through two basic mechanisms:

- Direct application of the live microbial cells known as the “probiotic effect”. Or

- Indirect effects during fermentation where these microbes act as cell factories for the generation of secondary metabolites with health-promoting properties.

Fermented cereal based probiotic bacteria are associated with the modulations of the host's defense which is most likely significant for the prevention and handling of infectious disease and for treatment of intestinal inflammation. Probiotics may influence the immune system by means of products such as metabolites cell wall component or DNA. These products can be recognized by the host cells sensitive because of the presence of a specific receptor. The main target cells are generally the gut epithelial and the gut associated immune cells. Also the interaction between probiotics and the host's immune cells by adhesion might be the triggering signaling cascade leading to immune modulation.Nutrients in fermented cereal with probiotic properties has positive significances for host well being regarding obesity and diabetes. Bacterial metabolism of nutrients in the gut is suggested to influence the release of bioactive compounds which interact with host cellular targets to control energy metabolism and immunity, resulting in less fat mass development, diabetes and low level of inflammation related with obesity.

The role of probiotic bacteria in the lessening of serum cholesterol which might cause cardiovascular diseases such as stroke and heart attack showed promising results where cholesterol precipitated out during *in vitro* studies with a possibility of the same being excreted under *in vivo* conditions. *Bifidobacterium longum SPM 1207*can reduce serum total cholesterol and low-density lipoproteins which are connected with bad cholesterol levels while to some extent increasing serum high-density lipoproteins which are associated with good cholesterol [8, 45]. This suggests that a combination of lactic acid bacteria (LAB) from the genus, *Bifidobacterium* and *Lactobacillus* could result in robust probiotics as the latter genera produce bacteriocins [15, 17, 44]. Bacteriocins from LAB are heterogeneous group of potent antimicrobial peptides primarily active against closely related micro organisms. They are mainly bactericidal with some being bacteriostatic, rendering them useful in the food and pharmaceutical divisions. Bacteriocins have been found to be very effective against gram-positive toxigenic pathogenic bacteria [15, 17, 44, 59].

Health Effects of Probiotics

According to Bruno and Shah, [60] probiotics are live microbial feed supplements that improve intestinal microbial balance and are intended for maintenance of health or prevention of disease. Probiotic bacteria are capable of suppressing potentially pathogenic microorganisms in the gastro-intestinal tract and improve the balance in favour of beneficial microorganisms [61]. The scientific evidence obtained through various studies on Lactobacilli and *Bifidobacterium spp*. has strengthened the positive effects of these microorganisms on human health. It is noted that no strain provides all the proposed health benefits and strains of the same species often exhibit distinct effects, therefore, the health properties of each strain need to be investigated independently [62]. Strain of *L. rhamnosus* GG (Valio) is the most extensively studied probiotic in human clinical trials [62], particularly involving in the management of rotavirus diarrhoea, and antibiotic-associated diarrhoea (*Clostridium difficile*). Strains of *L. acidophilus* NCFB 1748, B. lactis Bb 12, *L. plantarum* DSM9843 (299V), *L. reuteri* (BioGaia Biologics), *L. johnsonii* La-1 and *L. casei* Shirota (Yakault) are also well established for the clinical effects [63, 64].

Prospects of Ferment Cereals As Probiotic Foods

Probiotic foods are beneficial to human diet because of its massive health potentials. Although probiotic microorganisms have been used for centuries in food manufacture, worldwide research on their products applications should be encouraged. Hence, communities in rural and urban areas in developing countries should be encouraged to continue consuming their house hold fermented cereal foods and beverages as part of normal diet to exploit the probiotic benefit of these products. The use of fermented cereals with probiotic qualities offer an innovative approach for developing formulation applied as functional foods for management of diseases such as chronic inflammatory gastro-intestinal disorders. It also serves as drug delivery mechanisms and treatment of many lifestyle diseases. Because of increase in antibiotics resistance, probiotic lactic acid bacteria (LAB) and their products, such as bacteriocins promise to be good alternatives as antimicrobials.

Conclusion

In several African countries, cereal fermented beverages are produced. Cereal raw materials usually used for beverages are sorghum, millet and maize. Despite production technologies which are different between countries and regions where they are produced, their processing involves spontaneous fermentation steps: lactic acid fermentation and alcoholic fermentation. Fermented cereal beverages are rich sources of phenolic compounds, have antioxidants, anti-carcinogenic and antimicrobial properties and have also demonstrated potential preventive properties against cardio vascular diseases, hormonal related cancers and osteoporosis.

Probiotic microorganisms need to be consumed regularly and adequately (10^6 CFU/ml per serving) to maintain the intestinal population and to ensure that health benefits will be derived by the consumer. Microorganisms involved in cereal fermented probiotic foods belong mainly to lactic acid bacteria and yeasts. According to research, genus of lactic acid bacteria varies but *Lactobacillus* appears the predominant genus in the study of cereal fermented foods while *Lactobacillus fermentum*, *Lactobacillus brevis* and *Lactobacillus plantarum* are predominant species. Yeasts involved in majority of cereal fermented foods are dominated by *Saccharomyces cerevisae* strains.

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