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Health Benefits and Antimicrobial Activities of Lactic Acid Bacteria in Probiotic-Rich Cereal Gruel, 'Ogi'

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ABSTRACT

Fermented foods have been found to have economic, organoleptic and health benefits in addition to the nutritional provision of energy and body maintenance. These health benefits are mediated by the activities of the beneficial, natural microflora of the raw material which usually dominate the fermentation process including Lactic acid bacteria (LAB). Lactic acid bacteria (LAB) are the primary microorganisms used to ferment foods processed from maize, sorghum or millet-based foods and for the production of ogi. LAB isolated from ogi has demonstrated probiotic properties, including hypolipidemic, hepatoprotective, and antibacterial effects. They have also proven effective as metal chelators in treating gastroenteritis. This review aims to highlight the health benefits and antimicrobial activities of LAB in probiotic- rich ogi, cereal gruel. A comprehensive literature search was conducted using databases such as PubMed and Google Scholar, employing keywords like "Nigerian fermented foods", "ogi from fermented cereals", "fermented beverages", "traditional fermented foods", "lactic acid bacteria from ogi", and fermented foods and beverages like ogi. Articles and books with information on the nutritional composition and health effects of LAB from ogi and its antimicrobial effects were included. Studies were assessed for the clarity of experimental design and relevance to the topic to ensure review quality. The need for fortification of ogi to improve nutritional benefits is discussed. The dominant activity of LAB in ogi and their metabolites as well as importance in the food, pharmaceutical and brewing industries make this review relevant.

Keywords: Antimicrobial activity, fermented cereal, fortification, health benefits, lactic acid bacteria (LAB), 'Ogi'.

Introduction

Ogi is a popular fermented cereal-bulky gruel consumed in Nigeria and most parts of West Africa; made from spontaneous fermentation of maize (*Zea mays*), sorghum (*Sorghum bicolor*), millet (*Pennisetum glaucum*) or a mixture of the grains (Omemu et al., 2018). Ogi is a traditionally health-sustaining food; affordable and available breakfast for all ages in many homes, suitable weaning food for babies and easily digestible food for the elderly, young children and convalescence (Jude-Ojei et al., 2017). Ogi has a moderate to strong sour flavour from the fermentation of the cereals, due to the presence of a unique set of yeasts and lactic acid bacteria that confer some acidic (pH<4), probiotic and antimicrobial attributes (Adebukunola et al., 2015; Ndukwe et al., 2023).

In addition to its low glycemic index, health benefits of ogi includes anti-diabetic, anti-diarrheal, anti-inflammatory, anti-ulcer, atherosclerogenic effects, antioxidant and antimicrobial properties (Adisa and Enujiugha, 2020). Ogi is slightly boiled in water to obtain a smooth porridge called pap (known as 'eko' or 'akamu' in Nigeria). The consistency of pap varies from thick to watery according to choice.

Pap can be sweetened with sugar and milk; it is then consumed with bean cake ('akara'), bean steamed pudding ('moin moin'), vegetables, groundnuts and other complementary foods. Ogi can also be subjected to extended cooking period to produce a solid, thick gel known as 'eko' or 'agidi' in Nigeria (Adebukunola et al., 2015).

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This paper however, concentrates on ogi consumed as pap. Ogi is produced by microbial fermentation, mostly under traditional and unconventional conditions using domestic equipment. It is usually stored in the wet form especially in homes, submerged in water at room temperature; the water is required to be changed from time to time to halt or slow down further fermentation which impact more sourness (Eke-Ejiofor and Beleya 2017).

Storage for commercial purposes involve dewatering and pressure applied, most times with weights on the ogi- paste to obtain ogi-cake with much less moisture for a more stable product; dished out in varying sizes for sale in leaves, polyethylene nylon etc. The ogi microflora and their metabolic activities are responsible for its unique characteristics; habouring a rich diversity of aerobic and lactic acid bacteria (LAB), yeasts and moulds. This review provides awareness on the cereal-based traditional ogi, its health benefits and the need for its fortification.

Production of Ogi

Fermentation procedure for the production of ogi involves microbial and enzymatic activities which confer distinct attributes, from the raw materials to the end product (Izah et al., 2016; Kiin-Kabari et al., 2018; Chaves-López et al., 2020).

Consequently, different cereal substrates individually or in different combinations and under different fermentation conditions confer variations in colour, taste, flavour, sourness, aroma, and overall acceptability (Mathew et al., 2018; Ozabor et al., 2020). However, production procedure is similar, and follows the same steps irrespective of the fermentation substrate (Kiin-Kabari et al., 2018). Production of ogi is still mostly achieved under traditional and unconventional conditions using domestic equipment, and efforts are ongoing towards the development of large-scale factory production and commercialization. Therefore, production procedure is empirical with several modifications and lacking standard. Substantial nutrient losses have also been reported to occur at different stages of the production (Bolaji et al., 2017). Generally, the procedure comprises six steps which involves grain cleaning, steeping, milling, sieving, sedimentation and fermentation and a final step of pressing.

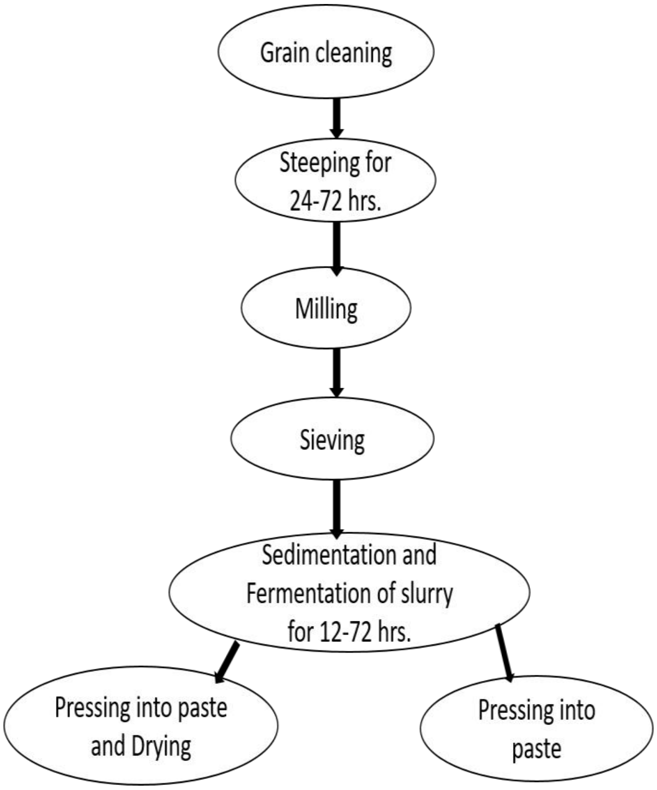

Fig. 1: Flowchat for Ogi production (Adisa & Enujiugha, 2020, with modifications)

Grain cleaning

The grain is sorted and cleaned in order to remove damaged ones, husks and hulls which may be present. Cleaning could be performed by hand-picking or winnowing using appropriate utensils or by washing in excess water to allow extraneous materials such as dirt particles float and be separated from the grains. Maize can also be coarsely sieved mechanically, to separate contaminants such as stones, cobs, foreign grain material, fine materials and dust particles. The cleaning stage is necessary in order to remove extraneous materials that may affect the quality and taste of the ogi (Otitoju, 2020; Anyanwu et al., 2021; Ukwuru & Muritala, 2023).

Steeping

The steeping stage involves cold steeping procedure in which the maize grains are directly put in water at ambient temperature and soaked for 24 to 72 hours, with a daily change of the steeping liquid, sometimes referred to as corn steep liquor (CSL).

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A second procedure involves pouring hot water onto the grains, and then steeping for 24 h. In the third procedure, the maize grains are placed in boiling water on fire, and then cooked for 10 min before steeping off-fire for 12–48 h (Bolaji et al., 2017 & Sanya et al., 2023). Soaking softens the cotyledon and enhances the milling process; it also facilitates the development of sour taste or some aromatic substances, when maize or millet respectively is used (Ukwuru & Muritala, 2023). Steeping is associated with microbial succession and the variations in steeping procedures can lead to differences in the ogi microbiota, which is followed by fermentation of the starch grain (Okeke et al., 2015; Anumudu et al., 2018 & Sanya et al., 2023). Studies have shown that the length of steeping period affects the characteristics of the ogi. Characteristics such as pasting properties decreases with increase in soaking period, while the swelling index, emulsion capacity, stability and the viscosities are increased. Conversely, extended steeping periods (up to 120 h) is reported to be detrimental on total carotenoid of biofortified orange maize with higher provitamin A carotenoid. Steeping methods and differences in the varieties have also been shown to influence the physicochemical characteristics and consumers' preference of ogi (Mathew et al., 2018; Sanya et al., 2023; Apotiola, 2013 & Ortiz et al., 2019). Fermentation in steeping stage is carried out by lactic acid bacteria (LAB) including *Lactobacillus* and *Pediococcus* species; aerobic bacteria, e.g. *Corynebacterium* spp. and *Streptococcus* spp., yeasts such as *Saccharomyces*, *Geotrichium* and *Candida* species and moulds, including *Fusarium*, *Aspergillus* and *Cephalosporium* species (Okeke et al., 2015; Ajayeoba & Ijabadeniyi, 2019; Itaman et al., 2021). Fermentation during steeping produces lactic acid, leading to lower pH value. The low pH confers microbial stability and inhibition of pathogenic bacterial growth (Ozabor et al., 2020). For instance, elimination of enterobacteriaceae and a reduction in yeast and mould with an increase in LAB count have been reported by some authors (Anumudu et al., 2018 & Chaves-López et al., 2020). Moreover, high LAB count in steep liquor accounted for reduction and loss of mycotoxins including aflatoxin M_1, citrinin, cyclopiazonic acid, zearalenone and beauvericin due to fermentation during steeping which confer strong probiotic property to the ogi (Okeke et al., 2015; Afolayan et al., 2017; Anumudu et al., 2018; Bello et al., 2018; Ajayeoba & Ijabadeniyi, 2019; Chaves-López et al., 2020). Although different steeping duration and approach have been reported, the main purpose of soaking to soften the grains and reduce the hardness, force, and energy necessary to break whole grains including maize, in ogi production can be achieved between 12 and 24 h and with a minimum required energy for a large-scale operation (Bolaji et al., 2018).

Milling and Sieving

The soaked grain is washed thoroughly to remove any unpleasant odour emanating due to degradation before milling. Wet milling is carried out to create a large surface area in the grain and facilitate the extraction of starch from the cereal grain. Some authors have reported different approaches to grain preparation prior to milling, which involves drying of the steeped grain before milling and also milling of the whole grain without steeping. These variations are with the attempt to reduce loss of nutrients and the leaching of some minerals and soluble vitamins following the wet milling procedure. However, starch damage is reported to increase at higher drying temperature, also loss of heat sensitive nutrients, and powdered ogi has been documented to have least gelation, irrespective of the maize varieties. Wet milling produces a slurry of the grain which is then subjected to wet sieving. Sieving is performed on the wet ground grain to separate the coarse material (chaff) from the starch which may also lead to further leaching of nutrients since the protein, which is majorly in the testa and germ of cereal grains is sifted off at this stage. Hence, some ogi processing may omit the sieving if milling is smoothly done, such that nutrients are better retained in the unsieved ogi. Sieving may be carried out manually by means of muslin cloth, meshed or perforated vessel, with diverse mesh sizes (Bolaji et al., 2014; Farinde, 2015; Anyanwu et al., 2021; Itaman et al., 2021;Obinna-Echem et al., 2023;Ukwuru & Muritala, 2023).

Sedimentation and Fermentation

Sedimentation is an important step after sieving. The filtrate from sieving is allowed to stand for some time, varying from 12 to 48 hours during which the starch separates from the excess water and settles to the bottom, forming sediments. The excess clear water at the top is then decanted from the sediment. Sedimentation stage is the second fermentation period in ogi production.

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The duration also determines the microbiological and physicochemical qualities, taste and acceptability of the end-product ogi. The souring and acidification which impart important and desirable qualities such as product stability and flavor development is further facilitated during the sedimentation stage. Therefore, this secondary fermentation period may be extended from 12 to 72 h depending on the desired level of sourness (Bolaji et al., 2017; Bello et al., 2018; Adisa and Enujiugha, 2020 & Obinna-Echem et al., 2023).

Pressing and Drying

The final stage in ogi processing involves dispensing the ogi sediment into a cloth bag or sack which is then tightly closed. Pressure is applied on the sack by placing on it a heavy object to express water from the ogi sediment until it forms a semi-solid cake. Thereafter, it is stored under a cold temperature or in a cool place as the stock from where samples can be taken and prepared into a gel-like cereal-gruel called *ogi*, *akamu* or pap. Conversely, the wet semi-solid cake can be subjected to drying by drum or tray which has been reported to prolong shelf-life of ogi (Bolaji et al., 2015; Kiin-Kabari et al., 2018; Obinna-Echem et al., 2023; Ukwuru & Muritala, 2023).

Nutritional Composition and Need for Fortification of Ogi

Nutrient composition of ogi is dependent on the cereal used in processing as the proportion of nutrients varies in different cereal crops. Diverse regions, ethnic groups and social classes have preference for different grains used in the production of ogi for various reasons. Cereal grains usually contain average to two-thirds carbohydrates (50-80%) of their weight. The carbohydrates are available in the form of starches and digestible sugars; they contain proteins (5-6%) and lipids (1-10%), though, in much lower but significant amount.

They also contain calcium, iron, vitamin B complex as well as dietary fibre however, cereals are deficient in vitamin A, D and B_{12}. Method of soaking and wet milling of cereal grains to produce ogi results in a further depletion of substantial vitamin content as the vitamins flow out in the wash water causing a reduction that affects the final product consumed (Garg et al., 2021 & Garutti et al., 2022).

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Maize-based ogi, though widely consumed, has poor nutritional quality due to the deficiency in some essential amino acids including L-lysine, L-tryptophan, and L-methionine in maize. Though, maize is a valuable source of carbohydrates, vitamins and minerals, the deficiency of protein and niacin in it makes its nutritional profile slightly inferior to the other cereals (Omole et al., 2017 & Adepeju et al., 2024).

Sorghum is equally energy-dense and dietary fibre loaded like maize but more promising with a nutritional superiority and functional qualities as it contains bioactive compounds, vitamin B and minerals such as potassium, iron and zinc. Like maize, sorghum is limited in essential amino acids and protein digestibility. Sorghum lacks lysine, vitamins B_{12}, vit. C and folate. It is relatively low in calcium, iron and zinc compared to some other grains (Moriconi et al., 2023 & Opaleke & Adam, 2025).

Millets are more nutritious than maize and sorghum. They are rich in vitamins, proteins and minerals. Millet-based ogi has potential of higher health benefits as fermented millet contained more catechol, p-coumaric, ascorbic, and gallic acid than the unfermented millet (Sadh et al., 2024). Pearl millet (*Pennisetum glaucum*) contains higher amounts of protein than maize and sorghum. The levels of fat and energy in the millet are close to those of maize. Pearl millet has good amount of tryptophan and threonine, with rich source of minerals such as potassium, phosphorus and calcium, iron, zinc, magnesium, copper, folic acid and b-carotene (Krishnan & Meera, 2018; Gerhard et al., 2021).

However, lysine content in millet is very poor. There is an inverse association between the general protein content of millet and its protein-lysine content (Pei et al., 2022). This inadequacy of lysine in millet and the presence of several antinutrients such as phytic acid, polyphenols and tannins which reduces mineral bioavailability especially iron and zinc call for concern in infant feeding and children's growth as well as the rural population that largely feed on millet-based diets (Tumwine et al., 2018; Sheethal et al., 2021).

Food fortification is a practice of adding vitamins and minerals to commonly consumed foods during processing to increase their nutritional value.

In the past two decades, there has been increasing awareness on the necessity of food fortification of some African diets. Fortification of ogi is necessary for three main reasons; to produce complementary amino acid profiles, higher-quality protein and better absorption of vital elements. Studies on ogi fortification have been continuous to improve its nutritional value with either plant protein (melon, okro, cowpea, and soybean; spices) or animal protein sources (egg and milk, etc) (Jude-Ojei et al., 2017; Olson et al., 2021 & Ahmed, 2025).

A common and easily achieved fortification of ogi at local level is the inclusion of spices before milling. Spices are culinary herbs used to enhance taste, aroma and nutritional value of food. They are derived from different parts of plants such as seeds (nutmeg, cumin, coriander), fruits (black pepper, paprika), bark (cinnamon), rhizomes (ginger, turmeric), bulbs (garlic), flower buds (clove) stigmas (saffron); to mention the commonly used. Spices have a long history of health benefits in addition to enhancement of organoleptic properties of food. They possess bioactive compounds and antioxidants with potentials to protect against common cold, fight inflammation, lowers blood pressure and cholesterol levels, boosting heart health and supporting the immune system. They also offer health benefits against cellular oxidative damage. Phenolic compounds such as tea catechins, oleuropein, ferulic acid, ellagic acid and coumaric acid in these spices have been found to prevent the growth of some spoilage and pathogenic bacteria as well as fungi; as such increase the shelf-life and decreasing or eliminating foodborne pathogens in ogi (El-Sayed & Youssef, 2019; Adepeju et al., 2024 & Ozabor et al., 2025).

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In addition to the use of spices, fortification of ogi with economical protein-rich plant mixtures like soybeans, groundnut, fermented locust bean seeds (*iru*), *ugba* etc are within the reach of the rural and low-income cereal-based diet group who can seldom feed on the expensive animal-protein sources like fish, crayfish, meat, eggs, milk etc. However, there is need for enlightenment and further training on the preparation especially for nursing mothers. This will go a long way to mitigate against nutrient-deficiency diseases in children from these localities mostly in developing countries (Ukegbu & Anyika 2012).

Health Benefits and Antimicrobial Activities of Lactic Acid Bacteria in Ogi

The fermentation of cereal-based foods like ogi involve activities of endogenous and contaminating microorganisms with lactic acid bacteria (LAB) as the dominant microbiota (Grujovi et al., 2022). LAB are a heterogenous group of Gram-positive, nonmotile, non-sporulating, non-pathogenic, catalase and cytochrome oxidase negative bacteria that produces lactic acid as the main product of carbohydrate fermentation (Bintsis, 2018; Kalhoro et al., 2023 & Anumudu et al., 2024). Latic acid bacteria involved in cereal fermentation include varied LAB genera such as *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Bifidobacteria* and *Pediococcus* which are either microaerophilic or anaerobic, producing lactic acid as the major metabolic end product of homo- and hetero-carbohydrate fermentations (Mokoena 2017).

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Lactic acid bacteria possess the capacity to displace or prevent colonization of gut pathogens, as well as keeping proper balance of intestinal pH by the release of acetic and lactic acids. LAB are able to efficiently prevent constipation and diarrhoea triggered by the effect of lactose intolerance or pathogenic bacteria. They have also been implicated in suppressing cholesterol intensity in blood, production of antimicrobial compounds promoting probiotic properties, stabilization of gut microflora and modulation of gut-associated lymphoid tissue immune activity (David et al., 2019).

Studies have indicated high antimalarial potentials of ogi slurry (Omeiza et al., 2020). This is also greatly dependent on its usage. These all agree with the ancient use of ogi slurry and palm wine as solvents in some herbal formulations in western Nigeria. This has proved effective to a very large extent over the years. Ogi and its slurry contains large number of LAB accounting for its great medicinal value.

The health benefits and antimicrobial activities of Lactic acid bacteria obtained from ogi represents promising source of healthy LAB which have antioxidant, antimicrobial and probiotic properties which are all health promoting.

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LAB as Antimicrobials

Antimicrobial activity of LAB is explained in three mechanisms; the production of bacteriocins; the yield of organic acids and other inhibitory substances such as ethanol, carbon (iv) oxide and hydrogen peroxide; and the competition for nutrients (Muruzović, 2018). Bacteriocins refer to antimicrobial proteins or peptides, ribosomally produced by bacteria and are either bacteriostatic or bacteriocidal in activity and can be narrow or broad spectrum in nature. Studies on bacteriocins shows they are promising tools for the production of novel antimicrobials. A few bacteriocins have gone beyond preclinical trials but none is currently approved for use by humans yet. Research have shown that bacteriocins are able to modify and improve physicochemical properties, pharmacological effects, and biosafety of clinically relevant bacteria. At the present when the increasing rates of antimicrobial resistance and their side effects threaten the use of antibiotics currently in clinical use, there is need for more research on bacteriocins. These agents are known for their antimicrobial potency at relatively lower concentrations compared with other antimicrobials (Oshoma et al., 2020 & Solis-Balandra et al., 2024). LAB converts carbohydrate substrates to produce organic acids along with a wide range of metabolites. Organic acids, including propionic acid, formic acid, succinic acids, butyric acid, acetic acid and lactic acid, create unfavourable environment for the growth of spoilage and pathogenic microorganisms (Özcelik, 2016). Organic acids are one of the potential antibacterial metabolic byproducts of LAB. They are generally more effective than inorganic acids at preventing bacterial growth. This has led to their extensive use as topical agents to treat infected wounds, particularly burns and diabetic ulcers (Bushell, 2019 & Efendi et al., 2023). Raw ogi is effectively used locally to soothe pains and inflammation from burns, also as remedy against diarrhea, reducing the frequency of stooling amongst rural dwellers, especially where proper healthcare is not easily accessible (Audu et al., 2019 & Kwasi et al., 2019).

LAB act to suppress activities of gut pathogens through exclusive competition, depriving harmful microbes of essential nutrients and space by releasing a variety of bioactive compounds and signal molecules that antagonises colonisation and invasion of pathogenic microorganisms. LAB and their metabolites interact with the gut microbiome to maintain intestinal pH and promote body health (Alp and Kuleaşan, 2020; Anumudu et al., 2024 & El-Garhi et al., 2025). In the sequencing of the following LAB strains; *Lactobacillus plantarum, Lactobacillus fermentum, Pediococcus pentosaceus* and *Weissella cibara* from ogi steep liquor, Ajayeoba and Ijabadeniyi, (2019) reported production of bioactive compounds which displayed the following characteristics; bile and lysozyme tolerance, hydrophobicity and auto-aggregation, cholesterol removal, exopolysaccharide production, β-galactosidase, and antimicrobial and haemolytic activities. LAB serves as the key element in balancing the microbial diversity of the intestine by their adhesion and competitive abilities.

LAB as Probiotics

Lactic Acid Bacteria (LAB) are known for their characteristic probiotic effects, in addition to enhancing organoleptic properties of fermented food and ensuring extended shelf life by protecting against pathogens and spoilage organisms (Onwusoba et al., 2025). Probiotics are live microorganisms, which when administered in adequate amount confer health benefit on the host (Alakeji & Oloke, 2020). Main mechanisms through which probiotics exert their actions have been summarised thus; competitive exclusion of pathogens for adhesion sites, improvement of the intestinal mucosal barrier, gut immunomodulation, and neurotransmitter synthesis (Latif et al., 2023). Several methods have been used to assess ideal probiotics properties. The following are basic criteria usually considered for LAB strains to be used as probiotics: (i) they should have 'generally referred too as safe' (GRAS) status, (ii) resistant to low pH and high bile concentration, as well as survival in gastrointestinal fluids, (iii) strong adhesion capabilities, (iv) antibacterial activities against enteric pathogens, and (v) survival as well as viability during the processing and storage. In addition is lysosomal and proteolytic activity assay to evaluate the organism's ability to resist hydrolytic lysosomal and proteolytic enzymes respectively (Ahmed et al., 2023 & Kalhoro et al., 2023). Probiotics are beneficial in making gastrointestinal infections mild, such as diarrhoea, dysentery or typhoid, reduces risk of colon cancer, generates bioactive compounds against diabetics, food allergy and lactose intolerance.

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They boost the immune system and thereby reduce respiratory tract infections to mention a few. With the emergence of antibiotic resistance in enteric pathogens there is therefore a call to awaken the use of probiotics and consequently, that probiotics should be considered as alternatives to antibiotics (Otunba et al., 2021 & Kalhoro et al., 2023). Studies have shown that antimicrobial activities of LAB are usually exhibited along side with their probiotic properties. Eji et al. (2023) demonstrated the antibacterial activity of *Lactobacillus plantarum* and *Lactobacillus acidophilus* isolated from ogi against food pathogens (*Escherichia coli* and *Staphylococcus aureus*) and reported the probiotics property of both strains through their production of bacteriocins; the yield of organic acids and other inhibitory substances such as ethanol, carbon(iv)oxide and hydrogen peroxide; and the competition for nutrients.

LAB as Antioxidants

There is increased interest in the study of natural antioxidant activity and LAB are the key agents of consideration. LAB constitute a strong natural xenogeneic antioxidant during fermentation of foods as it provides nutritive value, safety, and functions of probiotics (Kim et al., 2022). An antioxidant is the substance that prevents the oxidation of molecules caused by excessive free radicals in a cell and which causes complications leading to severe disease conditions. LAB produces several components with antioxidant effects such as bacterial exopolysaccharides, bioactive peptides, antioxidant enzymes, and manganese ions. They further stimulate the gut microflora (being the most abundant) to produce bioactive dietary antioxidants (such as vitamins C and E, carotenoids, flavonoids and low-molecular-weight thiol compounds) through bioconversion processes using various enzymatic reactions (Łepecka & Kołożyn-Krajewska, 2019; Kim et al., 2022). LAB have good, natural, safe antioxidant activity that is economical and readily available.

Depending on strains and species, LAB utilise different mechanisms to exert their antioxidant effects. They can be found scavenging free radicals, chelating metals, increasing antioxidant enzyme levels, degrading lipid peroxides, and modulating the gut microbiota thereby preventing cell death and tissue damage (Hu et al., 2023). Studies have shown that LAB strains obtained from ogi liquor and tested against some pathogens exhibited both antimicrobial and antioxidant potentials (Ajayeoba and Ijabadeniyi, 2019).

LAB as Bio-Preservatives

LAB strains generally fulfilled the first requirement of a biopreserver which is, 'generally recognised as safe' (GRAS) status. Biopreservation is a technique of prevention of food spoilage using probiotics potentials and antimicrobial activities of some microorganisms or their metabolites. This is a satisfactory alternative approach to the use of synthetic chemicals as the organoleptic properties of the food properties remain intact (Rathod et al., 2021 & Kalhoro et al., 2023). The production of organic acids (such as lactic, acetic, propionic acids), resulting in acidic pH as well as other bioactive compounds including carbon(iv)oxide, hydrogen peroxide, ethanol, reuterin, diacetyl and bacteriocins among others, which antagonises the growth of both pathogenic and spoilage organisms makes LAB a significant tool in the biopreservation of foods (Otunba et al., 2021). LAB are ancient and most widely utilized microorganisms for food preservation and fermentation.

They have been studied and long proposed and preferred to the usual application of chemical preservers. This is because they are safer, uphold dietary enrichment, and are good label additives. Natural preservatives are effective as many offer broad -spectrum protection and are also biodegradable (Arowolo et al., 2024). Several of LAB species such as *Lactococcus lactis* subsp. *lactis* from ogi have been reported to exhibit antimicrobial activity against some foodborne pathogens and spoilage organisms e.g. *Bacillus cereus, Salmonella typhi, Escherichia coli* and *Staphylococcus aureus* with highest antimicrobial activity (Ohaegbu et al., 2022). Foodborne pathogens are a threat to food quality/safety and result in several diseases and disorders such as respiratory infections, inflammatory diseases, intestinal disorders, and cancer (Kumariya et al., 2019).

LAB are strong agents for antifungal biopreservation. In addition to spoilage, some fungi pose serious risks of mycotoxin production which can lead to liver cancer, nephropathy, immunosuppression, and growth impairment in both humans and animals.

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LAB thereby provides preservative measure that is efficient in extension of shelf-life, enhanced food safety with no negative effect on nutritional quality (Kaveh et al., 2023 & Rahman et al., 2025).

LAB as Starter Cultures

LAB are of great importance in industries as they are used as starter cultures in fermentation processes. Starter cultures or primary starters are single or mixed microbial cultures of carefully selected strains (bacteria, moulds, yeasts) supplied to raw materials to initiate fermentation under appropriate conditions. They are usually used on a large scale in the food industry to allow controlled production process and end products with the desired organoleptic characteristics (Enan et al., 2013 & Zarzecka et al., 2020). Primary starters create acidic pH by production of organic acids for fermentation process to progress. In spontaneous fermentation, there is dependent on the growth of microflora of the raw material. The best adapted strain outgrows and suppresses the growth of other competitive microbes which are usually harmful or may negatively impact the characteristics of the end-products.

The metabolic product of LAB decreases pH and hinders the development of pathogenic and spoilage organisms (Sionek et al., 2023). In back slopping fermentations, starter cultures are added by the introduction of a small portion of an earlier successful fermentation batch. This is expected to contain the fermenting microbe(s) and guarantee effective transfer to the new fermentation process. This is a common practice in low-income households and small-scale commercial industries (Adebo et al., 2022).

Starters are considered as GRAS (generally regarded as safe); must be able to accelerate the production of lactic acids from the fermentation of sugars which results in the establishment of unfavorable conditions that reduce the growth rate of undesirable microorganisms hence providing antimicrobial and biopreservation properties to foods as well as imparting distinct and desirable organoleptic characteristics (Laranjo et al., 2019 & Mannaa et al., 2021).

In controlled fermentations, starters consisting of large population of suitable fermenting microbial strains are added to the raw materials to lead and take control of the fermentation process ensuring that competing-spoilage microorganisms do not prevail against the fermenting microflora (Voidarou et al., 2021).

LAB starter cultures of controlled fermentations or microflora of many traditionally fermented foods produce antimicrobial compounds which include carbon(iv)oxide, diacetyl, acetaldehyde, hydrogen peroxide, D-isomers of amino acids, reuterin and bacteriocin in addition to organic acids. All these contribute to flavour, texture and aroma development of the end-product (Ayivi et al., 2020; Oshoma et al., 2020 & Anumudu et al., 2024).

Conclusion and Recommendations

Fermented foods are not only important for the nutrients they provide to the body; they are quite significant for the health benefits they confer through the probiotic activities of beneficial microbes (Cuamatzin-García et al., 2022). Cereal-based fermented foods continue to form one of the ancient and cheapest staple diet of most populations of Africa, both in urban and rural areas. Ogi provides a proper complementary and weaning food for babies and therefore its nutrient deficiency is a cause for concern or else this contributes to protein energy malnutrition (PEM) and micronutrient deficiency diseases that are persistent in children from developing countries (Ezeokeke & Onuoha 2016). Advancement in ogi processing therefore calls for improvement of techniques of production and fortification so as to improve on the nutritional and sensory attributes in addition to extending the shelf life (Ndukwe et al., 2003; Bolaji et al., 2015). Ogi is characterised with a set of lactic acid bacteria that confer some acidic (pH < 4), probiotic and antimicrobial attributes (Arowolo et al., 2024). They exhibit multiple effects on host gut mucosa, providing improved, and modulating the immune system by regulating cytokine production amongst others (Cuamatzin-García et al., 2022 & Arowolo et al., 2024). Ogi can therefore, serve as a good source of LAB for industrial and medical use. Standardisation of ogi production techniques and fortification is highly recommended.

References

Adebo, J.A., Njobeh, P.B., Gbashi, S., Oyedeji, A. B., Ogundele, O.M., Oyeyinka, S.A. & Adebo, O. A. (2022). Fermentation of Cereals and Legumes: Impact on Nutritional Constituents and Nutrient Bioavailability. *Fermentation*, 8, 63.

Adebukunola, M., Omemu, A.M. & Bankole, M. O. (2015). Consumer's Knowledge, Attitude, Usage and Storage Pattern of Ogi – A Fermented Cereal Gruel in South West, Nigeria. *Food and Public Health*, 5(3), 77-83.

Adepeju, A.B., Aladesiun, O.A., Oyinloye, A.M., Olugbuyi, A. & Oni, K. (2024). Spice Fortification of "Ogi" from Maize, Millet and Sorghum Blend. *FUOYE Journal of Pure and Applied Sciences*, 9 (2), 93-110.

Adisa, A.M. & Enujiugha, V.N. (2020). Microbiology and Safety of Ogi Fermentation: A. Review. *European Journal of Nutrition and Food Saf*ety, 12 (5), 90-100.

Afolayan, A.O., Ayeni, F.A. & Ruppitsch, W. (2017). Antagonistic and Quantitative Assessment of Indigenous Lactic acid Bacteria in Different Varieties of *Ogi* against Gastrointestinal Pathogens. *Pan African Medical Journal*, 27, 22.

Ahmed, R., Oli, A.N., Etando, A., Sharma, P., Sinha, S., Chowdhury, K., et al. (2023). Lactic acid bacteria fermented foods: Impact on immune system and consequences over type 2 diabetes mellitus. *Journal of Applied Pharmaceutical Science,* 13(6), 18-56.

Ahmed, Z. (2025). Optimization the Nutrient Composition and Anti-nutrient of Cereal-Legume Mixtures for Infant Complementary Feeding: A Review. *American Journal of Food. Science and Technol*ogy, 4 (1), 60-66.

Ajayeoba, T.A. & Ijabadeniyi, O.A. (2019). Characterization and antioxidant ability of potential probiotic lactic acid bacteria in *ogi* liquor and lemon juice-*ogi* liquor. *Annals of Microbiology*, 69, 777–786.

Alakeji, T.P. & Oloke, J.K. (2020). Association of probiotic potential of strains of *Pichia kudriavzevii* isolated from "ogi" with the number of open reading frame (ORF) in the nucleotide sequences. *African Journal of Biotechnology*, 19 (3), 148-155.

Alp, D. & Kuleaşan, H. (2020). Determination of competition and adhesion abilities of lactic acid bacteria against gut pathogens in a whole-tissue model. *Bioscience of Microbiota, Food and Health*, 9 (4), 250–258.

Anumudu, C.K., Miri, T. & Onyeaka, H. (2024). Multifunctional Applications of Lactic Acid Bacteria: Enhancing Safety, Quality, and Nutritional Value in Foods and Fermented Beverages. *Foods*, 13, 3714.

Anumudu, C.K., Omeje, F.I. & Obinwa, G.N. (2018). Microbial succession pattern in Ogi fermentation. *International Journal of Advanced Research in Biological Sciences*, 5(7), 247-251.

Anyanwu, C.N., Ibelegbu, C.I., Ugwu, C.N., Okonkwo, V.C. & Mgbemene, C.A. (2021). Comparative evaluation of mesh sieve performance of a wet cereal slurry sieving machine. *Agricultural Engineering International: CIGR Journal*, 23(1), 115-127.

Apotiola, Z.O. (2013). Effect of Soaking Period on the Ogi Powder Produced from Sorghum. *Nigerian Food Journal*, 31 (1), 103 – 107.

Arowolo, M.T., Arowolo, A.O. & Falade, O.O. (2024). The melibiase activity of lactic acid bacteria isolated from yellow Ogi: A fermented cereal gruel. *Journal of New Discovery in Microbiology*, 2(3), 81-93.

Audu, H. J., Abiodun, O.A. & Ayeni, F.A. (2019). Beneficial effects of a fermented maize product with its supernatant, *Lactobacillus fermentum* and *Lactobacillus brevis* in rat model of colitis. *North African Journal of Food and Nutrition Researc*h, 3 (6), 195-200.

Ayivi, R.D., Gyawali, R., Krastanov, A., Aljaloud, S.O., Worku, M., Tahergorabi, R., et al. (2020). Lactic Acid Bacteria: Food Safety and Human Health Applications. *Dairy*, 1, 202–232.

Bello, O.O., Bello, T.K., Amoo, O.T. & Atoyebi, Y.O. (2018). Comparative evaluation of microbiological and nutritional qualities of various cereal-based pap (Ogi) in Ondo State, Nigeria. *International Journal of*

Citation: Omolara *et al.* (2026). Health Benefits and Antimicrobial Activities of Lactic Acid Bacteria in Probiotic-Rich Cereal Gruel, 'Ogi'. *International Journal of Microbiology and Applied Sciences*, *5(2)*, 88 – 100.

Environment, Agriculture and Biotechnology, 3(2), 676-685.

Bintsis, T. (2018). Lactic Acid Bacteria: Their applications in Foods. *Journal of Bacteriology & Mycology: Open Access*, 6(2), 89–94.

Bolaji, O.T., Adenuga-Ogunji, L. & Abegunde, T.A. (2017). Optimization of processing conditions of Ogi produced from maize using response surface methodology (RSM). *Cogent Food & Agriculture*, 3, 1.

Bolaji, O.T., Adepoju, P. A. & Olalusi, A.P. (2015). Economic implication of industrialization of a popular weaning food ogi production in Nigeria: A review. *African. Journal of Food Science*, 9(10), 495-503.

Bolaji, O.T., Awonorin, S.O., Sanni, L.O., Shittu, T.A. (2018). Modelling of mechanical properties of five maize varieties at critical processing conditions in the production of fermented slurry-ogi, 21 (1), 1619–1632.

Bolaji, O.T., Oyewo, A.O., Adepoju, P.A., Bolaji, O.T., Oyewo, A.O. & Adepoju, P.A. (2014). Soaking and drying effect on the functional properties of ogi produce from some selected maize varieties. *African Journal of Food Science and Technology*, 2(5), 150-157.

Bushell, F.M.L., Tonner, P.D., Jabbari, S., Schmid, A.K. & Lund, P.A. (2019). Synergistic Impacts of Organic Acids and pH on Growth of Pseudomonas aeruginosa: A Comparison of Parametric and Bayesian Non-parametric Methods to Model Growth. *Frontier in Microbiol*ogy, 9, 3196.

Chaves-López, C., Rossi, C., Maggio, F., Paparella, A. & Serio, A. (2020). Changes occurring in Spontaneous Maize Fermentation: An Overview. *Fermentation*, 6 (1), 36.

Chibuzor-Onyema, I.E., Ezeokoli, O.T., Sulyok, M., Notununu, I., Petchkongkaew, A., Elliott, C.T. et al. (2021). Metataxonomic analysis of bacterial communities and mycotoxin reduction during processing of three millet varieties into ogi, a fermented cereal beverage. *Food Research International*, 143, 110241.

Cuamatzin-García, L., Rodríguez-Rugarcía, P., El-Kassis, E.G., Galicia, G., Meza-Jiménez, Md., Baños-Lara, M. dR., et al. (2022). Traditional Fermented Foods and Beverages from around the World and Their Health Benefits. *Microorganisms*, 10, 1151.

David, A.A.D., Orukotan, A.A. & Mohammed, S.S.D. (2019). Conventional and Molecular Characterization of Selected Lactic Acid Bacteria from Fermented Corn Gruel (Ogi) and Fermented Milk (Nono). *Science World Journal*, 14(4), 28-34.

Efendi, R., Rossi, R.E. & Zalfiatri, Y. (2023). Antimicrobial properties of lactic acid bacteria from fermented palm sap against *E. coli* and *S. aureus* growth. The 6th International Conference on Agriculture, Environment and Food Security. *IOP Conference Series: Earth and Environmental Science*, 1241, 012092. IOP Publishing.

Eji, C.A., Okwuokei, G.C. & Okafor, J.G. (2023). Antibacterial activity of lactic acid bacteria isolated from traditionally fermented food against food pathogen. *GSC Advanced Research & Reviews*, 15(2), 020–031.

Eke-Ejiofor, J. & Beleya, E.A. (2017). Chemical, Mineral, Pasting and Sensory Properties of Spiced Ogi (Gruel). *African Journal of Food Science and Technology*, 5(5), 204-209.

El-Garhi, H-E.M., Abd-Elghany, A.A., Ibrahim, A.M.A., El-Aidie, S.A.M. & Castro-Muñoz, R.(2025). Effect of Organic Acids on Pathogenic and Lactic Acid Bacteria in Directly Raw Milk Cheddar Cheese. *Probiotics and Antimicrobial Proteins*, 18,1917–1937.

El-Sayed, S.M. & Youssef, A.M. (2019). Potential application of herbs and spices and their effects in functional dairy products. *Heliyon* 2019, 5:e01989.

Enan, G., Abdel-Shafi, S., Abdel-Haliem, M.F. & Negm, S. (2013). Characterization of probiotic lactic acid bacteria to be used as starter and protective cultures for dairy fermentations. *International journal of probiotics & prebiotics*, 8(40),157-164.

Ezeokeke, C.T. & Onuoha, A.B. (2016). Nutrient composition of cereal (maize), legume (soybean) and fruit (banana) as a complementary food for older infants and their sensory assessment. *Journal of Food Science and Engineering*, 6, 139-148.

Farinde, E.O. (2015). Chemical and sensory properties of sieved and unsieved fortified 'ogi'. *Natural Sci*ences, 13(1),49-53.

Garg, M., Sharma, A., Vats, S., Tiwari, V., Kumari, A., Mishra, V., et al. (2021). Vitamins in Cereals: A Critical Review of Content, Health Effects, Processing Losses, Bioaccessibility, Fortification, and Biofortification Strategies for Their Improvement. *Frontiers in Nutrition*, 8, 586815.

Garutti, M., Nevola, G., Mazzeo, R., Cucciniello, L., Totaro, F., Bertuzzi, C.A., et al. (2022). The Impact of Cereal Grain Composition on the Health and Disease Outcomes. *Frontiers in Nutrition*, 9, 888974.

Gerhard, B., Elbasheir, A.A.E. & Ndiko, L. (2021). Indigenous African cereal crops can contribute to mitigation of the impact of climate change on food security. *Journal of Oasis Agriculture and Sustainable Development*, 3 (3), 36-41.

Grujovi, M.Ž., Mladenovi, K.G., Semedo-Lemsaddek, T., Laranjo, M., Stefanovi, O.D., Koci-Tanackov, S.D. (2022). Advantages and disadvantages of non-starter lactic acid bacteria from traditional fermented foods: Potential use as starters or probiotics. *Comprehensive Reviews in Food Science and Food Safety*, 21(2),1537-1567.

Hu, Y., Zhao, Y., Jia, X., Liu, D., Huang, X., Wang, C., et al. (2023). Lactic acid bacteria with a strong antioxidant function isolated from "Jiangshui," pickles, and feces. *Frontiers in Microbiology*, 14, 1163662.

Itaman, V.O. & Nwachukwu, E. (2021). "Microbial Profile of Fermented Maize Flour (Ogi) and African Oil Bean (Pentaclethra Macrophylla) Seeds". *Journal of Advanced Microbiology*, 21(8), 16-27.

Izah, S.C., Kigigha, L.T. & Okowa, I.P. (2021). Microbial quality assessment of fermented maize Ogi (a cereal product) and options for overcoming constraints in production. *Biotechnological Research*, 2(2), 81-93.

Jude-Ojei, B.S., Lola, A., Ajayi, I.O. & Ilemobayo, S. (2017). Functional and Pasting Properties of Maize 'Ogi' Supplemented with Fermented Moringa Seeds. *Journal of Food Processing and Technology*, 8, 5.

Kalhoro, M.S., Anal. A.K., Kalhoro, D.H., Hussain, T., Murtaza, G. & Mangi, M.H. (2023). Antimicrobial Activities and Biopreservation Potential of Lactic Acid Bacteria (LAB) from Raw Buffalo (Bubalus bubalis) Milk. *Oxidative Medicine and Cellular Longevity*, 2023, Article ID 8475995.

Kaveh, S., Hashemi, S.M.B., Abedi, E., Amiri, M.J. & Conte, F.L. (2023). Bio-Preservation of Meat and Fermented Meat Products by Lactic Acid Bacteria Strains and Their Antibacterial Metabolites. *Sustainability*, 15, 10154.

Kim, S., Lee, J.Y., Jeong, Y. & Kang, C-H. (2022). Antioxidant Activity and Probiotic Properties of Lactic Acid Bacteria. *Fermentation*, 8, 29.

Krishnan, R. & Meera, M.S. (2018). Pearl millet minerals: effect of processing on bioaccessibility. *Journal of Food Science & Technology*, 55(9), 3362–3372.

Kumariya, R., Garsa, A.K., Rajput, Y.S., Sood, S.K., Akhtar, N. & Patel, S. (2019). "Bacteriocins: classification, synthesis, mechanism of action and resistance development in food spoilage causing bacteria," *Microbial pathogenesis*, 128, 171-177.

Kwasi, R.E., Aremu, I.G., Dosunmu, Q.O. & Ayeni, F.A. (2019). Viability of lactic acid bacteria in different components of Ogi with antidiarrhoeagenic *E. coli* activities. *North African Journal of Food and Nutrition Research*, 3 (6), 206-213.

Laranjo, M., Potes, M.E. & Elias, M. (2019). Role of Starter Cultures on the Safety of Fermented Meat Products. *Frontiers in Microbiol*ogy, 10, 853.

Latif, A., Shehzad, A., Niazi, S., Zahid, A., Ashraf, W., Iqbal, M.W., et al. (2023). Probiotics: mechanism of action, health benefits and their application in food industries. *Frontiers in Microbiology*, 14, 1216674.

Łepecka, A. & Kołożyn-Krajewska, D. (2019). Antioxidant Properties of Food-Derived Lactic Acid Bacteria: A Review. *Microbial Biotechnology*, 18, e70229.

Mannaa, M., Han, G., Seo, Y.-S. & Park, I. (2021). Evolution of Food Fermentation Processes and the Use of Multi-Omics in Deciphering the Roles of the Microbiota. *Foods*, 10, 2861.

Citation: Omolara *et al.* (2026). Health Benefits and Antimicrobial Activities of Lactic Acid Bacteria in Probiotic-Rich Cereal Gruel, 'Ogi'. *International Journal of Microbiology and Applied Sciences*, *5(2)*, 88 – 100.

Mathew, B.K., Adebowale, A.O., Oladayo, B.O. (2018). Effect of traditional and modified grain-soaking methods on physicochemical characteristics and consumersâ€™ acceptability of sorghum ogi. *African Journal of Food Science*, 12(3), 28-37.

Mokoena, M.P. (2017). Lactic Acid Bacteria and Their Bacteriocins: Classification, Biosynthesis and Applications against Uropathogens: A Mini-Review. *Molecules*, 22(8),1255.

Moriconi, L., Vittadini, E., Linnemann, A.R., Fogliano, V. & Ngadze, R.T. (2023). Designing sustainable weaning foods for developing countries: not only a matter of nutrients. *Food & Function*, 14, 9194-9203.

Muruzović, M.Ž., Mladenovi´c, K.G., Žugić- Petrović, T.D. & Čomić, L.R. (2018). Characterization of lactic acid bacteria isolated from traditionally made Serbian cheese and evaluation of their antagonistic potential. *Journal of Food Processing and Preservation*, 42(4),e13577.

Ndukwe, J.K., Aduba, C.C., Ughamba, K.T., Chukwu, K.O., Eze, C.N., Nwaiwu, O. & Onyeaka, H. (2003). Diet Diversification and Priming with Kunu: An Indigenous Probiotic Cereal-Based Non-Alcoholic Beverage in Nigeria. *Beverages*, 9, 14.

Obinna-Echem, P.C., Enente, U.J., Amadi, A.O. & Fyne-Akah, H. (2023). Effect of Processing Methods on the Quality Characteristics of Ogi From two Varieties of Millet. *Research Journal of Food Science and Quality Control*, E-ISSN 2756-5483.

Ohaegbu, C.G., Anayochukwu, C.A. & Coulthard, O.D. (2022). Characterization and Antibacterial Activity of Lactic Acid Bacteria Isolated from Traditionally Fermented Foods against Some Selected Food Pathogens. *Journal of Advances in Microbiology*, 22 (10), 15-24.

Okeke, C.A., Ezekiel, C.N., Nwangburuka, C.C., Sulyok, M., Ezeamagu, C.O., Adeleke, R.A., et al. (2015). Bacterial diversity and mycotoxin reduction during maize fermentation (steeping) for ogi production. *Frontiers in Microbiology*, 6, 1402.

Olson, R., Gavin-Smith, B., Ferraboschi, C. & Kraemer, K. (2021). Food Fortification: The Advantages, Disadvantages and Lessons from Sight and Life Programs. *Nutrients*, 13, 1118.

Omeiza, F.O., Ademowo, G.O. & Ayeni, F.A. (2020). Evaluation of in vivo anti-malarial potential of omidun obtained from fermented maize in Ibadan, Nigeria. *Malaria Journal*, 19, 414.

Omemu, A.M., Okafor, U.I., Obadina, A.O., Bankole, M.O. & Adeyeye, S.A.O. Microbiological assessment of maize ogi co-fermented with pigeon pea. *Food Science & Nutrition*, 6, 1238–1253.

Omole, J.O., Ighodaro, O.M. & Durosinolorun, O. (2017). Fortification of Ogi with Whey Increases Essential Amino Acids Content of Fortified Product. *International Scholarly Research Notices*, Article ID 7450845.

Onwusoba, R.C., Evurani, S.A., Attama, A.A., Ofokansi, K.C., Eze, C.O., Ozioko, C.A., et al. (2025). Antimicrobials of lactic acid bacteria isolated from artisanal nutraceuticals mitigated foodborne and multidrug-resistant pathogens. *Tropical Journal of Pharmaceutical Research*, 24 (6), 803-809.

Opaleke, D.O. & Adam, R.O. (2025). Acceptability and Nutritional Potential of Instant Pap (Ogi) Enriched with Landolphia togolana Stem Powder. *Toros University Journal of Food, Nutrition and Gastronomy*, (1), 25-38.

Ortiz, D., Nkhata, S.G., Rocheford, T. & Ferruzzi, M.G. (2019). Steeping of Biofortified Orange Maize Genotypes for Ogi Production Modifies Pasting Properties and Carotenoid Stability. *Agronomy*, 9 (11), 771.

Oshoma, C.E., Allen, O.A. & Oyedoh, P.O. (2020). Growth Enhancement of Lactic Acid Bacteria for Production of Bacteriocin Using a Local Condiment Supplemented with Nitrogen Sources. *Tropical Journal of Natural Product Research*, 4(8),411-416.

Otitoju, G.T.O. (2020). Effect of dry and wet milling processing techniques on the nutrient composition and organoleptic attributes of fermented yellow maize (Zea mays). *African Journal of Agriculture and Food Science*, 8 (6), 1-4.

Citation: Omolara *et al.* (2026). Health Benefits and Antimicrobial Activities of Lactic Acid Bacteria in Probiotic-Rich Cereal Gruel, 'Ogi'. *International Journal of Microbiology and Applied Sciences*, *5(2)*, 88 – 100.

Otunba, A.A., Osuntoki, A.A. & Olukoya, D.K. (2021). Genomic, biochemical and microbial evaluation of probiotic potentials of bacterial isolates from fermented sorghum products. *Heliyon*, 7:e08536.

Ozabor, P.T., Fadahunsi, I.F. & Adepeju, A.O. (2020). Physicochemical, microbiologically nutritional and sensory evaluation of ogi (a traditional cereal-based beverage in Nigeria) produced from two varieties of sorghum. *International Journal of Biotechnology*, 9(1), 38-49.

Ozabor, T., Makanjuola, M., Jejeniwa, M., Adekomi, I., Oni, G., Oluwajide, O., Olaitan, J. (2025). Effects of fermentation on proximate, mineral elements and total antioxidant activity of cloves-cinnamon formulated cereal gruels. *Journal of food quality and hazards control*, 12, 118-126.

Özcelik, S., Kuley, E. & Özogul, F. (2016). Formation of lactic, acetic, succinic, propionic, formic and butyric acid by lactic acid bacteria. *LWT- Food Science and Technology*, 73, 536-542.

Pei, J., Umapathy, V.R., Vengadassalapathy, S., Hussain, S.F.J., Rajagopal, P., Jayaraman, S., et al. (2022). Review of the Potential Consequences of Pearl Millet (*Pennisetum glaucum*) for Diabetes Mellitus and Other Biomedical Applications. *Nutrients*, 14, 2932.

Rahman, M.S., Soltani, S., LaPointe, G., Karboune, S. & Fliss, I. (2025) Lactic acid bacteria: beyond fermentation to bio-protection against fungal spoilage and mycotoxins in food systems. *Frontiers in Microbiology*, 16, 1580670.

Rathod, N.B., Phadke, G.G., Tabanelli, G., Mane, A., Pagarkar, A.U., Tabanelli, G., et al. (2021). Recent advances in bio-preservatives impacts of lactic acid bacteria and their metabolites on aquatic food products. *Food Bioscience*, 44, 101440.

Sadh, P.K., Kamboj, A., Kumar, S., Chawla, P., Kumar, R., Saharan, B.S., et al. (2024). Perspectives of millets for nutritional properties, health benefits and food of the future: a review. *Discover Food*, 4, 187.

Sanya, A.C., Madode, Y.E., Schoustra, S.E., Smid, E.J. & Linnemann, A.R. (2023). Technological variations, microbial diversity and quality characteristics of maize ogi used for akpan production in Benin. *Food Reserch International*, 170, 113038.

Sheethal, H., Baruah, C., Subhash, K., Ananthan, R. & Longvah, T. (2022). Insights of Nutritional and Anti-nutritional Retention in Traditionally Processed Millets. *Frontiers in Sustainable Food Systems*, 5,735356.

Sionek, B., Szydłowska, A., Küçükgöz, K. & Kołozyn-Krajewska, D. (2023).Traditional and New Microorganisms in Lactic Acid Fermentation of Food. *Fermentation*, 9, 1019.

Solis-Balandra, M.A. & Sanchez-Salas, J.L. (2024). Classification and Multi-Functional Use of Bacteriocins in Health, Biotechnology, and Food Industry. *Antibiotics*, 13, 666.

Tumwine, G., Atukwase, A., Tumuhimbise, G.A., Tucungwirwe, F. & Linnemann, A. (2018). Production of nutrient-enhanced millet-based composite flour using skimmed milk powder and vegetables. *Food Science & Nutrition*, 7, 22–34.

Ukegbu, P.O. & Anyika, J.U. (2012). Chemical analysis and nutrient adequacy of maize gruel (pap) supplemented with other food sources in Ngor-Okpala lga, Imo State, Nigeria. *Journal of Biology, Agriculture and Healthcare*, 2(6),13-22.

Ukwuru, M.U. & Muritala, A. (2023) A Compendium of Major Traditional Fermented Foods and Beverages in Nigeria. *Journal of Advances in Food Science & Technology*, 10(2), 20-45.

Voidarou, C., Antoniadou, M., Rozos, G., Tzora, A., Skoufos, I., Varzakas, T., et al. (2021). Fermentative Foods: Microbiology, Biochemistry, Potential Human Health Benefits and Public Health Issues. *Foods*, 10, 69.

Zarzecka, U., Zadernowska, A. & Chajęcka-Wierzchowska, W. (2020). Starter cultures as a reservoir of antibiotic-resistant. *LWT-Food Science and Technology*, 127, 109424.

Citation: Omolara *et al.* (2026). Health Benefits and Antimicrobial Activities of Lactic Acid Bacteria in Probiotic-Rich Cereal Gruel, 'Ogi'. *International Journal of Microbiology and Applied Sciences*, *5(2)*, 88 – 100.