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Review
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Review

Safety and quality of bacterially fermented functional foods and beverages: a mini review

Tolulope Joshua Ashaolu*,**

*Department for Management of Science and Technology Development and **Faculty of Applied Sciences, Ton Duc Thang University, Ho Chi Minh City, Vietnam

Correspondence to: Tolulope Joshua Ashaolu, 19 Nguyen Huu Tho, District 7, Ho Chi Minh City, Vietnam. E-mail: tolulopeashaolu@tdtu.edu.vn

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Abstract

Bacteria have been employed widely in the food and beverage industry, with evolving dimensions in recent years. Proteases derived from lactic acid bacteria (LAB) are useful in the production of fermented functional beverages and are of particular use in conditioning their shelf life, nutritional content, flavour, and texture quality, thus making fermented foods and beverages functional and therapeutic. This review focuses on bacteria, especially protease-producing LAB used in food processing, and their usefulness in the production of functional foods and beverages. A case study of oat beverages was briefly explored due to its popularity. The safety and quality importance of the food products were also considered with a few recommendations.

Key words: protease; functional foods; fermented beverages; lactic acid bacteria; safety.

Introduction

The link between the consumption of beverages and healthy living is one that has enjoyed scientific scrutiny over the past few years. Foods are increasingly outgrowing their conventional nutritional function and energy supply to the body and are fast taking up medicinal capabilities. Since the times of Hippocrates, the Greek Philosopher once quoted 'let food be thy medicine and medicine be thy food' (Otles and Cagindi, 2012), evolving civilizations afford nutritionists curated ways of enriching and fortifying foods to supply nutrients in excess of the natural nutritional components in the raw food, with preventive and therapeutic medicinal aims. Beverages based on composition may be regarded as the most active functional foods around today, having certain inherent capacities for modification and can be tailored to meet specific consumer needs (Ashaolu, 2019a).

The production of fermented foods and beverages was originally performed to enhance the shelf life of perishable raw materials of agricultural and animal husbandry origin. Today, this bioprocess technology aims at the use of microorganisms and their enzymes, through acidification, alcoholization, proteolysis, and/or amino acid conversions, to make products with desirable quality characteristics regarding shelf life, texture, taste, mouthfeel, flavour, and colour (De Roos and De Vuyst, 2018; Ashaolu, 2019a). Among the microorganisms and microbial enzymes used are proteolytic bacteria such as lactic acid bacteria (LAB) and their proteases. In the food industry, proteases are useful for fermentation and digestion. These enzymes are renowned for their activities such as enhancement of oil recovery from seafood, meat tenderization, and reduction of allergenicity in food substances (Ashaolu and Yupanqui, 2017; Ashaolu et al., 2017). Much has been documented on the usefulness of proteolytic bacteria in detergents, pharmaceutical, leather processing, waste treatment, silk degumming, and food industries (Borla et al., 2010; Heredia-Sandoval et al., 2016; Hammami et al., 2018). This review however focuses on bacteria, especially protease-producing LAB used in food processing, and their usefulness in the production of functional foods and beverages. The safety and quality importance of the food products were also considered with a few recommendations.

Functional Foods—Oat Beverage as a Case Study

Apart from its nutritional profile, functional food has the ability to confer immune health to an individual. This only occurs when the food is administered in an efficacious quantity, which can be active, biologically (Chua et al., 2013; Staka et al., 2015). It is noteworthy that functional and conventional foods may appear similar, except that functional foods have the tendencies and abilities to reduce the possibilities of chronic diseases than what ordinary nutritional functions can offer, and they help to maintain gut health (FAO, 2007). The preparation of foods by 'scientific intelligence' either with pre-emptive knowledge of why the food is being taken or not results in *functional foods*. Recently, there is a considerable evolution of the request for functional foods and beverages due to the concerns and attention of people about the quality of life they live as well as their health (Salmero´n et al., 2015; Shah et al., 2016).

An example of functional foods is the fermented oat beverage and this classification may be due to the effects of dependent probiotic starter cultures and prebiotic fibre β-glucan (Iserliyska et al., 2015; Russo et al., 2017) on the beverage. Oats have high functional potentials. Considered rich in dietary fibre, they possess protein in appropriate ratios (Londono et al., 2013; Staka et al., 2015; Shah et al., 2016). When compared to other grain crops, oats make provision for more fibre, iron, calcium, zinc, and other important amino acids needed by the body (Sangwan et al., 2014; Tosh and Chu, 2015; Shah et al., 2016). The group of cereals under which oats are classified is known for its therapeutic powers in ameliorating a wide range of diseases and ailments including diabetes, dyslipidemia, vascular injury, and hypertension (Londono, 2013; Vasudha and Mishra, 2013; Sangwan et al., 2014; Shah et al., 2016).

The health benefits attributed to oats have been fundamentally attached to the proportion of β-glucan, which makes oats highly sticky. The β-glucan is quite effective in lowering the cholesterol levels present in the blood as well as the absorption rate of glucose by the intestine (Iserliyska et al., 2015; Tosh and Chu, 2015). The drinks made from oats come from the processing of oat in addition to milk or other aqueous formulations. This mixture is labelled in the market as a supplementary food that is good for human health, convenient, and fast (Angelov et al., 2018).

Fermented Functional Foods and Beverages

One of the primitive processes involved in preserving food is fermentation. In the developing world, the importance of beverages and fermented foods cannot be overestimated (Blandino et al., 2003; Nyanzi and Jooste, 2012). Conventionally, fermentation is used in different places around the world to get various products from different cereals. Several benefits are attributed to fermentation of food including energy saving during matrix processing, desired biochemical alterations for nutritional improvement, safety of food, product shelf life, and improved sensory properties (Blandino et al., 2003; Guyot, 2012; Nionelli et al., 2014). Different types of beverages derived from traditional cereals can be seen in different parts of the globe (Nyanzi and Jooste, 2012; Mäkinen et al., 2016). These products are largely consumed in Africa and their preparations are mostly from millets, sorghum, and maize through the use of self-generated formation process obtained from diluted microbial cultures, especially yeasts and LAB. In Africa, Kanunzaki is produced from Nigeria, Ben-saalga from Burkina Faso, Koko from Ghana, Munkoyo from Zambia and Congo, Thobwa from Malawi and Tanzania, Uji from Uganda, Kenya and Tanzania, Mageu from Southern Africa and Arabian Gulf countries, Bushera from Uganda, and so on. Both infant and general populations in these countries consume these products (Nyanzi and Jooste, 2012; Vasudha and Mishra, 2013; Nionelli et al., 2014; Mäkinen et al., 2016; Ashaolu, 2019a).

In the Balkan region of Turkey, Bulgaria, Albania, and Romania, Boza is a renowned traditional beverage. Its preparation is achieved through mixing either rye, wheat, millet, or other cereals with sugar and water (Nyanzi and Jooste, 2012; Vasudha and Mishra, 2013; Mäkinen et al., 2016). In Eastern Europe, the common local drink is Kvass, and it is prepared from barley malt flour or rye and rye bread that is stale (Nyanzi and Jooste, 2012). Pozol is the beverage drink in Mexico prepared by soaking maize in limewater over an extended period. Before dissolving in water, Nixtamal, known as dough balls, is enclosed in the leaves of banana and allowed to ferment for 0.5–4 days (Nyanzi and Jooste, 2012; Vasudha and Mishra, 2013; Ashaolu, 2019a).

Lactobacillus genera is often used in the fermentation of cereals, and they include *L. plantarum*, *L. casei*, *L. rhamnosus*, *L. reuteri*, *L. fermentum*, *L. brevis*, *L. acidophilus*, and others; *Pediococcus* (*P. acidilactici*, *P. pentosaceus*, etc.), *Bifidobacterium*, *Candida*, *Debaryomyces*, *Endomycopsis*, *Hansenula*, *Pichia*, *Saccharomyces*, and *Trichosporon* (Guyot, 2012; Nyanzi and Jooste, 2012; Vasudha and Mishra, 2013; Nionelli et al., 2014; Russo et al., 2017; Angelov et al., 2018) are also used. There are different other fermented foods with the use of different bacteria that have been developed all around the world depending on regions and culture. Table 1 represents examples of such foods and beverages.

Protease-Producing LAB Versus Functional Foods and Beverage Industry

Every living organism including plants and animals relies on proteolytic activity to some extent. Bacterial proteases are useful for a diverse range of industrial processes, which include pharmaceutical, medical, animal (leather-based products), and food industries. Proteolysis by LAB plays paramount roles in the formation of the unique flavour of fermented meat because the peptides and amino acids generated are the major precursors of specific flavour compounds (Hughes et al., 2002; Mcfeeters, 2004). However, the proteolytic pathway of LAB may cause certain proteins to degrade, such as sarcoplasmic and myofibrillar proteins (Fadda et al., 2002). Proteolysis is one of the major physiological traits of LAB and its importance is derived from its contribution to the development of organoleptic properties of fermented food and production of bioactive health beneficial peptides (Savijoki et al., 2006). In addition, the proteolytic system of LAB also affected the texture development of fermented fish (Riebroy and Benjakul, 2005). Bacteria aid in the production of proteases that then assist in fermented foods flavour and texture formation. Therefore, a number of proteases from multifarious strains of bacteria have been purified and characterized for industrial applications (Silva et al., 2011; Hsiao et al., 2014; Li et al., 2014).

Bacterial proteases are very important in the production of beverage products. For example, milk beverages when produced from the factory are shipped to a variety of retailers from where they are dispatched to the final consumer. Thus, enzymes present in milk beverages often aid the products to survive a variety of harsh conditions during transportation. LAB isolated from milk products are multiple amino acid auxotroph (Chopin, 1993). Apart from the common functional properties of proteases such as coagulation and gel strength and foaming, the catalytic function of proteases is relevant in the preparation of protein hydrolysates, which is found in most infant food products, fruit juice, and soft drinks (Nekluyov et al., 2000; Gupta et al., 2002; Ashaolu and Yupanqui, 2018). In the dairy industry, proteases are primarily used in cheese manufacturing

Table 1. Selected common fermented foods and beverages worldwide and their fermentative bacterial species

Fermented product	Raw material/substrates	Country/region	Bacterial species used
Amasi	Milk (cow, various)	Zimbabwe/East Africa	*Lactococcus* (*L. lactis*), *Lactobacillus*, *Leuconostoc*, *Enterococcus*
Aryan	Milk (cow, various)	Turkey	*Lactobacillus bulgaricus*, *Streptococcus thermophilus*
Garris	Milk (camel)	Sudan/East Africa	*Lactobacillus* (*Lb. paracasei*, *Lb. fermentum*, and *Lb. plantarum*), *Lactococcus*, *Enterococcus*, *Leuconostoc*
Kefir	Milk (cow, various)	Eastern Europe	*Lactococcus*, *Lactobacillus*, *Leuconostoc*, *Acetobacter*
Kivuguto	Milk (cow)	Rwanda	*Leuconostoc* (*Leu. mesenteroides*, *Leu. pseudomesenteroides*) and *L. lactis*
Koumiss	Milk (horse)	Eurasia	*Lactobacillus*
Kumis	Milk (cow)	South America Columbia	*Lb. cremoris*, *L. lactis*, *Enterococcus* (*E. faecalis*, *E. faecium*)
Nyarmie	Milk (camel)	Ghana/West Africa	*Leu. mesenteroides*, *Lb. bulgaricus*, *Lb. helveticus*, *Lb. lactis*, *L. Lactis*
Rob	Milk (unspecified)	Sudan	*Lb. fermentum*, *Lb. acidophilus*, *L. lactis*, *Streptococcus salivarius*
Suusac	Milk (unspecified)	Kenya	*Leu. mesenteroides*, *Lactobacillus* (*Lb. plantarum*, *Lb. cruvatus*, *Lb. salivarius*, *Lb. raffinolactis*)
Shubat	Milk (camel)	China	*Lactobacillus* (*Lb. sakei*, *Lb. Helveticus*, *Lb. brevis*), *Enterococcus* (E. *faecium*, *E. faecalis*), *Leu. lactis and Weissella hellenica*
Boza	Various (barley, oats, rye, millet, maize, wheat, or rice)	Balkans (Turkey, Bulgaria)	*Leuconostoc* (*Leu. paramesenteroides*, *Leu. sanfranciscensis*, *Leu. mesenteroides*), *Lactobacillus* (*Lb. plantarum*, *Lb. acidophilus*, *Lb. fermentum*)
Bushera	Sorghum, millet flour	Uganda	*Lactobacillus*, *Streptococcus*, *Enterococcus*
Koko Sour Water	Cereal (pearl millet)	Ghana	*Weissella confusa*, *Lb. fermentum*, *Lb. salivarius*, *Pediococcus* spp.
Kvass	Rye bread, rye, and barley malt/flour	Russia	*Lb. casei*, *Leu. mesenteroides*
Pozol	Maize	Mexico	*L. lactis*, *Streptococcus suis*, *Lactobacillus* (*Lb. plantarum*, *Lb. casei*, *Lb. alimentarium*, *Lb. delbruekii*), *Bifidobacterium*, *Enterococcus*
Togwa	Maize flour, finger millet malt	Tanzania	*Lactobacillus* spp.
Hardaliye	Grapes/mustard seeds/cherry leaf	Turkey	*Lactobacillus* spp.
Kombucha	Tea	China, Worldwide	*Gluconacetobacter (G. xylinus)*, *Acetobacter*, *Lactobacillus*
Kivunde	Cassava	Tanzania	*Lb. Plantarum*
Sausages	Meat, pork	Italy, Thailand	*Pediococcus acidilactici, Lb. pentosus, Lb. plantarum, P. pentosaceus*
Kefir	Kefir grains, Cow's milk	Iran, Spain	*Lb. kefir, Lb. casei, Lb. brevis, Lb. plantarum, Lactococcus lactis* subsp. *lactis*, *L. lactis* subsp. *cremoris*, *L. lactis* subsp. *lactis biovar diacetylactis*, *Leuconostoc mesenteroides* subsp. *cremoris*, *Streptococcus lactis*
Kimchi	Cabbage	Korea	*Weissella cibaria, W. confusa, W. koreensis*
Sauerkraut	Cabbage	China, USA	*Leu. mesenteroides, Lb. plantarum, Lb. casei, L. lactis*
Fermented milk	Milk	Europe	*L. acidophilus, L. rhamnosus, Streptococcus thermophilus, L. bulgarius, L. casei, Lb. plantarum, P. jensenii, Propionibacterium freudenreichii*
Plaa-som	Fish	Thailand	*Lb. plantarum*, *Lb.reuteri*
Sourdough	Wheat	Greece, South Korea	*L. brevis, L. paralimentarius, P. pentosaceus, W. cibaria, Leu. citreum, W. koreensis*
Fermented olives	Green olives	Spain	*Enterococcus casseliflavus Lactobacillus pentosus, Lb. plantarum*
Cheddar cheese	Milk	Ireland, Australia	*Streptococcus thermophilus, Lactobacillus acidophilus, Lb. casei, Lb. paracasei, Bifidobacterium* spp.
Yogurt	Sheep milk	Bulgaria	*Streptococcus thermophilus, Lb. delbrueckii* subsp. *bulgaricus*
Sauce	Soybean, fish	Thailand	*Tetragenococcus, Halophilus*

Sources: Marsh et al. (2014), Macori and Cotter (2018), and Ashaolu (2019a).

to hydrolyse specific peptide bonds to produce casein and macro peptides (Rao, 1998; Ashaolu, 2019b). In addition, the ability of proteases to hydrolyse connective tissues and muscle fibre proteins is applied in meat tenderization (Kumar and Takagi, 1999).

Safety and Quality Needs of Functional Foods and Beverages

It is paramount that there should be continuous improvement and development of newer starter cultures for the production of functional foods and beverages, in order to ensure safety and quality maintenance, as well as better defined and characterized bacterial strains meant for local foods fermentation. This can ensure more qualitative sensory properties of the food and beverage products. Additionally, pathogens found in fermented food products and beverages are largely due to unhygienic processing conditions, which should not be a problem due to much lower pH obtained during the fermentation process and the reduction of toxic metabolites (Ashaolu, 2019a). However, diverse contaminating avenues ranging from vessels used, starting raw materials to acidophilic pathogens, cause huge health risks. Therefore, the benefits and risks found with fermentative and pathogenic bacteria should be critically investigated. Bacterial toxins are of health concerns in this regard and more pronounced in tropical developing regions of the world including

Africa and South Asia. Furthermore, phytate, lectins, tannins, saponins, oligosaccharides, protein inhibitors, and cyanogenic glycosides serve as natural anti-nutritional elements in most of the raw materials employed in bacterial fermentation of foods and beverages (Ashaolu, 2019a). Therefore, fermented foods should be monitored properly for their nutrient content and safety. Most of the traditionally fermented beverages have not been thoroughly investigated for their alcohol content levels, which the modern-day consumer is interested in. This information can help to monitor the health of an individual. Finally, biochemical residues should be assessed in fermented foods.

Conclusions

The use of diverse bacterial strains especially LAB groups in the production of functional fermented foods and beverages has huge commercial applications with even more futuristic advantages. Since many functional foods and beverages are produced locally, it is recommended that several improvements be made on the safety and quality of the food products.

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Conflict of interest statement

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References

Angelov, A., Yaneva-Marinova, T., Gotcheva, V. (2018). Oats as a matrix of choice for developing fermented functional beverages. *Journal of Food Science and Technology*, 55: 2351–2360.

Ashaolu, T. J. (2019a). A review on selection of fermentative microorganisms for functional foods and beverages: the production and future perspectives. *International Journal of Food Science and Technology*, 54:2511–2519.

Ashaolu, T. J. (2019b). Protein hydrolysates and their impact on gut microbiota: an editorial. *CPQ Medicine*, 5: 01–05.

Ashaolu, T. J., Yupanqui, C. T. (2017). Suppressive activity of enzymatically-educed soy protein hydrolysates on degranulation in IgE-antigen complex-stimulated RBL-2H3 cells. *Functional Foods in Health and Diseases*, 7: 545–561.

Ashaolu, T. J., Yupanqui C. T. (2018). Hypoallergenic and immunomodulatory prospects of pepsin-educed soy protein hydrolysates. *Croatia Journal of Food Science and Technology*, 10: 270–278.

Ashaolu, T. J., Yantiam, N., Yupanqui, C. T. (2017). Immunomodulatory effects of pepsin-educed soy protein hydrolysate in rats and murine cells. *Functional Foods in Health and Diseases*, 7: 889–900.

Blandino, A., Al-Aseeri, M. E., Pandiella, S. S., Cantero, D., Webb, C. (2003). Cereal-based fermented foods and beverages. *Food Research International*, 36: 527–543.

Borla, O. P., Davidovich, L. A., Roura, S. I. (2010). Isolation and characterization of proteolytic microorganisms from fresh and fermented cabbage. *LWT-Food Science and Technology*, 43: 298–301.

Chopin, A. (1993). Organization and regulation of genes for amino acid biosynthesis in lactic acid bacteria. *FEMS Microbiology Reviews*, 12: 21–37.

Chua, Y. F. *et al*. (2013). *In vitro* antioxidant capacity and anti-inflammatory activity of seven common oats. *Food Chemistry*, 139: 426–431.

De Roos, J., De Vuyst, L. (2018). Acetic acid bacteria in fermented foods and beverages. *Current Opinion in Biotechnology*, 49: 115–119.

Fadda, S., Oliver, G., Vignolo, G. (2002). Protein degradation by *Lactobacillus plantarum* and *Lactobacillus casei* in a sausage model system. *Journal of Food Science*, 67: 1179–1183.

Food and Agriculture Organization of the United Nations (FAO). (2007). Report on functional foods, food quality and standards service (AGNS). http://www.fao.org/ag/agn/agns/files/Functional_Foods_Report_Nov2007.pdf (accessed 24 December 2019).

Gupta, R., Beg, Q. K., Lorenz, P. (2002). Bacterial alkaline proteases: molecular approaches and industrial applications. *Applied Microbiology and Biotechnology*, *59*: 15–32.

Guyot, J. P. (2012). Cereal-based fermented foods in developing countries: ancient foods for modern research. *International Journal of Food Science and Technology*, 47: 1109–1114.

Hammami, A., Fakhfakh, N., Abdelhedi, O., Nasri, M., Bayoudh, A. (2018). Proteolytic and amylolytic enzymes from a newly isolated *Bacillus mojavensis* SA: characterization and applications as laundry detergent additive and in leather processing. *International Journal of Biological Macromolecules*, 108: 56–68.

Heredia-Sandoval, N. G., Valencia-Tapia, M. Y., Calderón de la Barca, A. M., Islas-Rubio, A. R. (2016). Microbial proteases in baked goods: modification of gluten and effects on immunogenicity and product quality. *Foods*, 5: 59.

Hsiao, N. W. *et al*. (2014). Purification and characterization of an aspartic protease from the *Rhizopus oryzae* protease extract, Peptidase R. *Electron Journal of Biotechnology*, 17: 89–94.

Hughes, M. C., Kerry, J. P., Arendt, E. K., Kenneally, P. M., McSweeney, P. L., O'Neill, E. E. (2002). Characterization of proteolysis during the ripening of semi-dry fermented sausages. *Meat Science*, 62: 205–216.

Iserliyska, D., Sv Aleksandrov, E., Angacheva, A., Iliev, A., Angelov. Acceptability of a nutritious flavored oat based beverage biovessina. In: International Scientific-Practical Conference, Food, Technologies and Health-2015, 20 November, Proceedings Food Research and Development Institute, Plovdiv, Bulgaria, pp. 54–59.

Kumar, C. G., Takagi, H. (1999). Microbial alkaline proteases: from a bioindustrial viewpoint. *Biotechnology Advances*, 17: 561–594.

Li, C. H., Xu, D. F., Zhao, M. M., Sun, L. J., Wang, Y. L. (2014). Production optimization, purification, and characterization of a novel acid protease from a fusant by *Aspergillus oryzae* and *Aspergillus niger*. *European Food Research and Technology*, 238: 905–917.

Londono, D. M. *et al*. (2013). Avenin diversity analysis of the genus *Avena* (oat). Relevance for people with celiac disease. *Journal of Cereal Science*, 58: 170–177.

Macori, G., Cotter, P. D. (2018). Novel insights into the microbiology of fermented dairy foods. *Current Opinion in Biotechnology*, 49: 172–178.

Mäkinen, O. E., Wanhalinna, V., Zannini, E., Arendt, E. K. (2016). Foods for special dietary needs: non-dairy plant-based milk substitutes and fermented dairy-type products. *Critical Reviews in Food Science and Nutrition*, 56: 339–349.

Marsh, A. J., Hill, C., Ross, R. P., Cotter, P. D. (2014). Fermented beverages with health-promoting potential: past and future perspectives. *Trends in Food Science and Technology*, 38: 113–124.

Mcfeeters, R. F. (2004). Fermentation microorganisms and flavor changes in fermented foods. *Journal of Food Science*, 69: 35–37.

Neklyudov, A. D., Ivankin, A. N., Berdutina, A. V. (2000). Properties and uses of protein hydrolysates. *Applied Biochemistry and Microbiology*, 36: 452–459.

Nionelli, L., Coda, R., Jose´, A. C., Poutanen, K., Gobbetti, M., Carlo, G. R. (2014). Manufacture and characterization of a yogurt-like beverage made with oat flakes fermented by selected lactic acid bacteria. *International Journal of Food Microbiology*, 185: 17–26.

Nyanzi, R., Jooste, P. J. (2012). *Cereal-based functional foods*. In Rigobelo EC, ed. Probiotics InTech. pp. 161–197. doi:10.5772/50120. https://www.intechopen.com/books/probiotics/cereal-based-functional-foods

Otles, S., Cagindi, O. (2012). Safety considerations of nutraceuticals and functional foods. In: McElhatton A., do Amaral Sobral P. (eds.) *Novel Technologies in Food Science*. Integrating Food Science and Engineering Knowledge into the Food Chain, vol 7. Springer, New York, NY, pp. 121–136.

Rao, M. B., Tanksale, A. M., Ghatge, M. S., Deshpande, V. V. (1998). Molecular and biotechnological aspects of microbial proteases. *Microbiology and Molecular Biology Reviews: MMBR*, 62: 597–635.

Riebroy, S., Benjakul, S. (2005) Physical properties and microstructure of commercial Som-fug, a fermented fish sausage. *European Food Research Technology*, 220: 520–525.

Russo, P., Arena, M. P., Fiocco, D., Capozzi, V., Drider, D., Spano, G. (2017). *Lactobacillus plantarum* with broad antifungal activity: a promising approach to increase safety and shelf-life of cereal-based products. *International Journal of Food Microbiology*, 247: 48–54.

Salmero´n, I., Thomas, K., Pandiella, S. S. (2015). Effect of potentially probiotic lactic acid bacteria on the physicochemical composition and acceptance of fermented cereal beverages. *Journal of Functional Foods*, 15: 106–115.

Sangwan, S., Singh, R., Tomar, S. K. (2014). Nutritional and functional properties of oats: an update. *Journal of Innovative Biology*, 1: 003.

Savijoki, K., Ingmer, H., Varmanen, P. (2006). Proteolytic systems of lactic acid bacteria. *Applied Microbiology and Biotechnology*, 71: 394–406.

Shah, A., Masoodi, F. A., Gani, A., Ashwar, B. A. (2016). Newly released oat varieties of Himalayan region—techno-functional, rheological, and nutraceutical properties of flour. *LWT-Food Science and Technology*, 70: 111–118.

Silva, T. A. S. E., Knob, A., Tremacoldi, C. R., Brochetto-Braga, M. R., Carmona, E. C. (2011). Purification and some properties of an extracellular acid protease from *Aspergillus clavatus*. *World Journal of Microbiology and Biotechnology*, 27: 2491–2497.

Staka, A., Bodnieks, E., Puķītis, A. (2015). Impact of oat-based products on human gastrointestinal tract. *Proceedings of the Latvian Academy of Sciences*, 69: 145–151.

Tosh, S. M., Chu, Y. (2015). Systematic review of the effect of processing of whole-grain oat cereals on glycaemic response. *The British Journal of Nutrition*, 114: 1256–1262.

Vasudha, S., Mishra, H. N. (2013). Non-dairy probiotic beverages. *International Food Research Journal*, 20: 7–15.