IJBPAS, April, 2020, 9(4): 791-802

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

TRADITIONAL CEREAL-BASED ALCOHOLIC BEVERAGES OF INDIA: A RICH SOURCE OF UNEXPLORED MICROORGANISMS FOR POTENTIAL HEALTH BENEFITS

ROY A

Department of Microbiology, Ramakrishna Mission Vidyamandira, Belur Math, Howrah, West Bengal, 711202

*Corresponding Author: E Mail: arindam_roy97@rediffmail.com; Mobile: 8900468492

Received 18th Oct. 2019; Revised 13th Nov. 2019; Accepted 22nd Dec. 2019; Available online 1st April 2020

https://doi.org/10.31032/IJBPAS/2020/9.4.5025

ABSTRACT

India has the second largest tribal community in the world. Most of the tribals in India live in the hilly stretch of the Himalayan range from Ladakh or Uttarakhand to Arunachal Pradesh. They possess a rich cultural heritage. Preparation of various fermented foods is intimately associated with their custom and rituals. Fermented foods are foods with active microbiological activity. Traditional fermented foods are those which are used by human beings from time immemorial. Ethnic communities of India have a rich heritage of practicing this technique. The traditional knowledge in most of the cases is secret and they pass them to future generation as their right. However, with the social development and urbanization, younger generations are less interested to preserve this inherited knowledge. So this traditional knowledge must be protected before they disappear. On the other hand, origin of fermented foods was basically to preserve locally grown crops and harvest. But with the advent of modern preservation techniques, this aspect of fermented foods has become less important. Recently health promoting activities of fermenting microflora have renewed interest on these foods. Production of bioactive metabolites by the fermenting microflora has immense therapeutic potential. This review aims at preserving their cultural heritage and emphasizes the need of microbiological research for the benefit of mankind.

Keyword: Fermented food, alcoholic beverage, tribes, microorganisms, probiotics, starter culture

INTRODUCTION

Fermentation of food substrates is the predecessor of modern day biotechnology. The history of origin of many of the fermented foods may have been lost in antiquity but their importance to shape up human civilization is worth mentioning **[1]**. It is well approved that the formation of alcohol from barley, discovered by some wise persons of the ancient time, marked the starting point of fermentation technology. With passage of time continuous trial and error resulted in dramatic improvement of the various fermentation parameters including incubation time, temperature and humidity as well as explored suitable raw materials. Today thousands of fermented foods produced from different raw materials are consumed throughout the world. Fermentation is a type of anaerobic respiration performed by microorganisms. A food is considered fermented when one or more of its constituents have been acted upon by microorganisms or their enzymes so that desirable biochemical changes cause significant modifications to the food acceptable for human use. Fermented foods are widely consumed making an important part of the diet of one third population worldwide **[2, 3]**. Traditional or indigenous fermented foods are those foods that were invented centuries ago and even predate written historical records **[4]**. These foods can be prepared in household or cottage industry using relatively simple techniques and equipments **[5]**. Some south Asian countries including India, Bangladesh, Afghanistan and Pakistan have the highest percentage of malnourished people exceeding that of sub-Saharan Africa. In India, 46% of the children below 5 years of age are malnourished. Efficient utilization of the locally available low cost food substrates to prepare functional foods by fermentation should be included in the integrated approach of malnutrition management. Functional foods provide health benefits beyond basic nutrition by enrichment and bioavailability of particular components having beneficial effect or removal of toxic substances by biochemical processes **[6]**. Fermented foods have a number of attributes over their raw materials including improved flavour and texture, destruction of undesirable components present in raw materials including mycotoxins, improved keeping quality, enhanced nutritional value, improved digestibility of proteins and carbohydrates, changing physical state of the product from raw materials, imparting color to the products and providing dietary variety to otherwise

monotonous meal. Mineral content in fermented products may increase due to hydrolysis of chelated compounds **[7]**.

Traditional cereal-based alcoholic beverages of India

Due to her diverse agro-climatic locations, social behavior, cultural and religious beliefs, and dietary habits among the multi-ethnic population, India harbours an excellent source of fermented foods. Every society and group has their own conception of food and own history of food habits, rather indigenous, which shape their food culture. Preparation and consumption of cereal based alcoholic beverages is very popular among various tribes inhabiting Eastern and Northeastern parts of India. These beverages play an important role in the socio-cultural life of them as these are associated with various rituals, occasions and ceremony. However, they try to keep the indigenous know-how secret and pass them through future generations. The various tribes prepare their own type of beverage. The substrates in all cases are locally grown cereals, mostly rice (*Oryza sativa*) or finger millet (Ragi, *Elcusine coracona*) and sometimes pearl millet (Bajra, *Pennisetum glaucum*), barley (*Hordeum vulgare*), corn (*Zea mays*) or wheat (*Triticum aestivum*) are also employed. Though the production procedure is broadly similar, local variation exists. In most of the cases starter cultures are employed. Due to biochemical variation in wild varieties of a particular species of cereal, differences in fermentation temperature, physical factors, differences in starter culture, the aroma and taste of the beverages differ. This implies differences in metabolic activity of fermenting microflora. Some of the popular cereal based beverages of India are listed in **Table 1**.

Apart from their cultural and social relevance, these beverages are used by the tribal people for therapeutic purposes against common ailments like diarrhoea, jaundice, kidney stone etc. **(Table 2)**. Synthesis of various bioactive secondary metabolites including maltooligosaccharides such as maltotetrose, maltotriose, and maltose, during fermentation of alcoholic beverages is well documented. Besides these, pyranose derivatives such as 1,2,3,6-tetra-O-acetyl-4-O-formy-D-glucopyranose, β-D-mannopyranose pentaacetate, 2,3,4,5-tetra-O-acetyl-1-deoxy-β-D-glucopyranose, and β-D-galactopyranose pentaacetate, along with phenolic and flavanol are synthesized during fermentation imparting medicinal value **[11, 22]**. Another important aspect of research on these alcoholic beverages is their fermenting microflora. However, knowledge regarding

the fermenting microflora in these beverages is scanty. Little work has been done to find out microorganisms present in starter culture and the fermentation substrate. Microorganisms, including lactic acid bacteria like *Lactobacillus*, *Leuconostoc* and yeasts like *Saccharomyces*, *Pichia* and mould like *Rhizopus*, have been reported in cereal-based alcoholic beverages **(Table 2)**.

Table 1: List of traditional cereal-based alcoholic beverages of India

Beverage	Basic Ingredient	Starter culture	Tribe	Reference
Jhara/Handia	Rice	Bakhar or ranu	Santhals, Oraons and Mundas of West Bengal, Bihar, Orissa, Jharkhand	[8, 9]
Apong	Rice or millet	Apop pitha in Assam, Ipoh or epob in Arunachal Pradesh	Mising people of Assam, Nyshing and Apatani of Arunachal Pradesh	[10, 11, 12]
Jou	Rice	Amao	Bodo of Assam	[13, 14]
Chu	Rice	Wansi	Garo tribes of Assam and Meghalaya	[14]
Chako	Rice	Bakhar or phab	Rabha of Assam and West Bengal	[14]
Kodo ko jaanr	Dry seeds of finger millet	Marcha	Gorkha, Bhutia, Lepcha, Monpa of Darjeeling hills of West Bengal and Sikkim	[15]
Bhaati jaanr	Rice	Marcha	Gorkha, Bhutia, Lepcha, Monpa of Darjeeling hills of West Bengal and Sikkim	[15]
Lugari/Chakti	Rice	Phab or dhaeli	Uttarakhand	[16]
Judima	Rice	Leaves or barks of trees	Dimasa tribes of Northeast India	[17]
Yu	Rice	Hamei or chamri	Meitei tribe of Manipur	[18]
Pukyu/Waiy	Rice	Hamei or chamri	Meitei tribe of Manipur	[18]
Zutho/Zhuchu	Rice		Mao Naga tribes in Nagaland	[19]
Kiad	Rice	Thiat	Jaintia tribe of Meghalaya	[19]
Xaj-pani	Rice	Vekur pitha	Assam	[19]
Sur/Sura	Finger millet	Dheli	Kullu district in Uttarakhand	[20]
Eu	Finger millet	No report	Toto tribes in Norther parts of West Bengal	[21]
Ara	Barley	Phab or dhaeli	Uttarakhand	[16]
Chhang	Wheat	Phab or dhaeli	Uttarakhand	[16]
Shhang or Ccharo-kham	Barley	Ipoh	Karbi tribe of Arunachal Pradesh	[22]
Opo	Rice	burnt rice husk	Adi, Nyshing and Mishmi, tribes of East and West Siang, Lohit, Changlang, Upper and Lower Subansiri districts of Arunachal Pradesh	[22]

Table 2: Therapeutic uses and microflora in cereal-based alcoholic beverages of India

Beverage	Fermenting fungi	Fermenting bacteria	Therapeutic uses	Reference
Handia	***Saccharomyces cerevisiae* KpY, *S. cerevisiae* 18VSL, *S. cerevisiae* H15, *S. cerevisiae* H17, *Hanseniaspora guilliermondii* G1, *H. guilliermondii* G4, *Pichia kudriavzevii* H21L, *Candida glabrata* H3, C. *glabrata* H8, *C. glabrata* H11, *C. glabrata* H12 and *C. tropicalis* 18VLL.**	*Brevibacillus agri*, *Leuconostoc mesenteroides* and *Kocuria* sp	Dysentery, diarrhoea, amebiasis, acidity, and vomiting	**[23]**
Apong	**Not available**	**Not available**	**Prevent the formation of kidney stones**	**[11]**
Jou	**Not available**	**Not available**	**Prevent jaundice and urinary disorders**	**[11]**
Judima	**Not available**	**Not available**	**Possess antiinflammatory, antiallergic, antioxidant, antibacterial, antifungal, antispasmodic, hepatoprotective, hypolipidemic, neuroprotective, hypotensive, antiaging and antidiabetic potentialities**	**[11]**
Zutho	**Not available**	**Not available**	**Boost the immune system, lower the blood insulin level, prevent loss of appetite, lower bad cholesterol, assist in wound healing, and prevent infection**	**[11]**
Bhaati jaanr	***Saccharomycopsis fibuligera* and *Rhizopus* spp.**		**Recommended for ailing persons and postnatal women to regain their physical strength**	**[11, 24]**

Fermented foods are important source of probiotics

In recent years, isolation of lactic acid bacteria with probiotic activity has renewed interest on traditional fermented foods. In 1960, the term "probiotic" was coined to name substances produced by microorganisms which promoted the growth of other microorganisms **[25, 26]**. Probiotics was later redefined as "A live microbial feed supplement which beneficially affects the host animal by improving its intestinal balance" **[27]**. A more recent, but probably not the last definition is "live

microorganisms, which when consumed in adequate amounts, confer a health effect on the host" **[28]**. Important health benefits conferred by probiotic microflora are as follows.

Prevention of diarrhoea

Diarrhoea is the leading cause of malnutrition and mortality among children in developing countries. Probiotics are well-known for prevention and management of acute viral and bacterial diarrhoea as well as control of antibiotic associated colitis. A number of specific strains, including *Lactobacillus* GG, *Lactobacillus reuteri*, *Saccharomyces boulardii*, *Bifidobacteria* spp., and others, have been shown to have significant benefits for diarrhoeal diseases in young children caused by *Escherichia coli, Salmonella, Shigella, Campylobacter*, *Giardia, Entamoeba*, rotaviruses etc. **[29, 30, 31, 32]**.

In the paediatric population, probiotics act as antiviral agent possibly by increasing secretory IgA and decreasing viral shedding, suggesting an immunological mechanism. Probiotics might prevent diarrhoea because they outcompete pathogenic viruses and bacteria for binding sites on epithelial cells, producing bacteriocins such as nisin **[33]**, increased production of mucin which prevent attachment of enteropathogens or steric hindrance between bacterial ligand and host receptor **[34]**. A major problem associated with antibiotic treatment is the appearance of diarrhoea, often caused by *Clostridium difficile*. This organism is not uncommon in a healthy intestinal tract, but the disruption of intestinal microflora by antibiotics lead to an abnormal elevation of their numbers, and subsequent symptoms related to toxin production. Probiotics in such patients can be administered to restore microflora to one that more closely resemble the normal flora prior to antibiotic therapy **[35]**.

Inhibition of *Helicobacter pylori* infection

H. pylori is a gram negative pathogen responsible for type B gastroenteritis, peptic ulcers and gastric cancer. It can remain viable in the acidic environment of the stomach owing to its urease activity and subsequently colonize there. There is evidence that production of lactic acid by probiotic bacteria viz. *Lactobacillus salivarius* may inhibit the gastric colonization and activity of *H. pylori in vitro* **[36, 37]**.

Alleviation of Irritable bowel syndrome

Inflammatory bowel diseases, such as pouchitis and Crohn's disease, as well as irritable bowel syndrome may be caused or aggravated by alterations in the gut flora

including infection. In one of the most common functional disorders, irritable bowel syndrome, *L. plantarum* 299v and DSM 9843 strains were shown in clinical trials to reduce abdominal pain, bloating, flatulence and constipation **[38]**. It was also observed that *Sacc. boulardii* decreased diarrhoea in irritable bowel syndrome, but was not effective in alleviating other symptoms of the syndrome **[39]**. The lack of therapeutic options in inflammatory bowel diseases is a serious issue and lactic acid bacteria have utmost potential to alleviate the syndrome **[40]**.

Cancer immunotherapy

Many of the undesirable microflora in the colon have enzymes (like β-glucuronidase, azoreductase and nitroreductase) that can activate procarcinogens, either present in food or produced through metabolism of undesirable bacteria, to active carcinogens that, in turn cause colon cancer by activation of genes controlling cell growth and division **[41]**. It has been hypothesized that probiotic cultures might i) detoxify ingested carcinogens ii) decrease undesirable metabolic activities of bacteria producing procarcinogens iii) suppress the growth of undesirable bacteria that convert procarcinogens to carcinogens iv) produce antitumour agents v) stimulate immune system to better defense against cancer cell proliferation **[42]**. Lactic acid bacteria has been shown to reduce carcinogenesis due to their influence on immunomodulation, which can stand as a proof of interaction between bacterial metabolites like short chain fatty acids and immune and epithelial cells **[43]**.

Alleviation of lactose intolerance

Lactose-intolerant individuals, because of a genetic disorder, are unable to produce lactase (β-galactosidase) in the small intestine leading to passage of consumed milk to the colon where different undesirable bacteria hydrolyze lactose to glucose and galactose and then further metabolized to produce acids and gas, resulting in fluid accumulation, diarrhea and flatulence. Different lactic acid bacteria hydrolyze lactose present in the milk during fermentation and may or may not colonize small intestine further supplying lactase thereby alleviating the symptoms of lactose-intolerance **[44, 45]**.

Control of blood cholesterol

Cholesterol acts as a precursor to certain hormones and vitamins and it is a component of cell membranes and nerve cells. However, elevated level of total blood cholesterol or other blood lipids are considered risk factors for developing

coronary heart disease. There have been some human studies that suggest that blood cholesterol level can be reduced by consumption of probiotic-containing dairy foods by people with elevated blood cholesterol, but in general the evidence is not overwhelming **[42]**. Hypocholesteromic activity is attributed to i) ability of some intestinal lactobacilli to metabolize dietary cholesterol, thereby reducing amounts absorbed in blood ii) some lactobacilli can deconjugate bile salts and prevent their re-absorption in the liver. The liver, in turn, uses more serum cholesterol to synthesize bile salts and indirectly help reduce cholesterol level in serum **[41]**.

Prevention of urogenital tract disorders

Excluding sexually transmitted diseases, almost all infections of the vagina and bladder are caused by microorganisms that originate in the bowel. There is some evidence that probiotic microorganisms delivered as foods and tropical preparations have a role in preventing urogenital tract disorders possibly by producing hydrogen peroxide and acidic environment **[46]**.

CONCLUSION

India has a rich heritage of traditional cereal-based alcoholic beverages. These are home-made and produced in very small scale. Due to their long lineage to the custom and culture of various tribal communities, this knowledge should be preserved and intellectual property rights should be assigned to them. Standardization of the production procedure for industrial production may improve socioeconomic condition of these people. Moreover, the fermenting microorganisms have immense potential for health-promoting activities. So Research on the probiotic potential of cereal-based alcoholic beverages of India is highly warranted.

ACKNOWLEDGEMENT

Author is thankful to Principal, Ramakrishna Mission Vidyamandira for providing infrastructural facility and financial assistance through Swami Vivekananda Research Centre (SVRC).

Bibliography

[1] Tamang JP, Watanabe K, Holzapfel WH, Review: Diversity of Microorganisms in Global Fermented Foods and Beverages, Frontiers in Microbiology, 7, 2016, 377.

[2] van Veen AG, Fermented Protein-rich Foods, FAO Report No FAO/57/3/1966, 1957.

[3] Campbell-Platt G, Fermented Foods of the World. A Dictionary and Guide, Butterworth Scientific Ltd, Guildford, Surrey, UK, 1987.

[4] Hesseltine CW, Ray ML, Lactic acid bacteria in murcha and ragi, J. Appl. Bacteriol., 64, 1988, 395-401.

[5] Aidoo KE, Nout MJR, Sarkar PK, Occurrence and function of yeasts in Asian indigenous fermented foods, FEMS Yeast Research, 6(1), 2006, 30-39.

[6] Pederson CS, Microbiology of Food Fermentations, 2nd edition, Westport, AVI Publishing Company, 1979.

[7] Holzapfel WH, Use of starter cultures in fermentation on a household scale, Food Control, 8, 1997, 241–258.

[8] Panda SK, Bastia AK, Sahoo G, Process characteristics and nutritional evaluation of Handia-A cereal based ethnic fermented food from Odisha, Indian Journal of Traditional Knowledge, 13(1), 2014, 149-156.

[9] Ghosh C, Das AP, Preparation of rice beer by the tribal inhabitants of tea gardens in Terai of West Bengal, Indian Journal of Traditional Knowledge, 3(4), 2004, 373-382.

[10] Pegu R, Gogoi J, Tamuli AK, Teron R, Apong, an alcoholic beverage of cultural significance of the Mising community of Northeast India, Global Journal of Interdisciplinary Social Sciences, 2(6), 2013, 12-17.

[11] Ray M, Ghosh K, Singh S, Mondal KC, Folk to functional: an explorative overview of rice-based fermented foods and beverages in India. J. Ethn. Foods, 3, 2016, 5–18.

[12] Krishna B, Baishya K, Ethno medicinal value of various plants used in the preparation of traditional rice beer by different tribes of Assam, India Drug Invention Today, 5(4), 2013, 335

[13] Basumathary et. al., Jou: the traditional drink of the Boro tribe of Assam and North East India, Journal of Scientific and Innovative Research, 3(2), 2014, 239-243.

[14] Narzary Y, Brahma, J, Brahma C, Das S, A study on indigenous fermented foods and beverages of Kokrajhar, Assam, India, Journal of Ethnic Foods, 3, 2016, 284-291.

[15] Karki DB, Kharel GP, Solid Versus Semi-solid Fermentation of Finger Millet (*Eleusine coracana* L.), J. Food Sci. Technol. Nepal, 6, 2010, 31-35.

[16] Kanwar SS, Gupta MK, Katoch C, Kanwar P, *et al*., Cereal based traditional alcoholic beverages of Lahaul and Spiti area of Himachal

Pradesh. Indian Journal of Traditional Knowledge, 10(2), 2011, 251–257.

[17] Das AJ, Deka SC, Miyaji T, Methodology of rice beer preparation and various plant materials used in starter culture preparation by some tribal communities of North-East India: A survey. International Food Research Journal, 19, 2012, 101-107.

[18] Soibam H, Ayam VS, The traditional fermented foods of meiteis of Manipur, India: A case study, Journal of Pharmacognosy and Phytochemistry, 7(4), 2018, 535-539.

[19] Khapudang R, Sharma S, Joshi VK, Indigenous Fermented Food Products of Eastern and Western Himalayan Region: A review, Intl. J. Food. Ferment. Technol., 8(2), 2018, 119-139.

[20] Navdeep et. al., Microbiological and biochemical characterization of experimentally produced Sura - a traditional fermented millet based alcoholic beverage of Kullu District of Himachal Pradesh, India, International Journal of Food and Fermentation Technology, 5(2), 2015, 129-135.

[21] Dawn A, A peep into the lifestyle of the endangered Toto tribe of Jalpaiguri district of West Bengal, International Journal of Modern Research and Reviews, 2(4), 2014, 161-164.

[22] Shrivastava K, Greeshma AG, Srivastava B, Biotechnology in Tradition – A process technology of alcoholic beverages practiced by different tribes of Arunachal Pradesh, North East India, Indian Journal of Traditional Knowledge, 119 (1), 2012, 81-89.

[23] Das G, Patra JK, Singdevsachan SK, Gouda S, Shin H-S, Diversity of traditional and fermented foods of the Seven Sister states of India and their nutritional and nutraceutical potential: a review, Frontiers in Life Science, 9(4), 2016, 292-312.

[24] Maji J, Mukhopadhyay BC, Mitra S, Biswas SR, Molecular Characterization of Yeasts and Bacteria Isolated From Handia, an Indian Traditional Rice Fermented Alcoholic Beverage, American Journal of Current Microbiology, 6(1), 2018, 1-12.

[25] Tamang JP, Thapa S, Fermentation Dynamics During Production of Bhaati Jaanr, a Traditional Fermented Rice Beverage of the Eastern Himalayas, Food Biotechnology, 20(3), 2006, 251-261.

[26] Lilly DM, Stilwell RH, Probiotics: Growth promoting factors produced by microorganisms, *Sci* 147, 1965, 747-748.

[27] Orrhage K, Brismer B, Nord CE, Effect of supplement with *Bifidobacterium longum* on the intestinal microbiota during administration of clindamycin, *Microb Ecol Heal;th Dis* ,7, 1994, 17-22.

[28] Fuller R, Probiotics in man and animals, *J. appl microbiol* 66, 1989, 365-378.

[29] Guarner F, Schaafsma GJ, Probiotics, *Int J Food Microbiol,* 39, 1998, 237-238.

[30] Hilton E, Kolakowski P, Singer C, Smith M, Efficacy of *Lactobacillus* GG as a diarrheal preventive in travelers, *J Travel Med* 4, 1977, 41-43.

[31] Vanderhoof, JA, Probiotics and intestinal disorders in infants and children, *Journal of Pediatric Gastroenterology and Nutrition,* 30, 2000, S34-S38.

[32] Kyne L, Kelly, CP, Recurrent *Clostridium difficile* diarrhea, *Gut,* 49, 2001, 152-153.

[33] Benchimol EI, Mack DR, Probiotics in relapsing and chronic diarrhea, *J Pediatr Hematol Oncol,* 26, 2004, 515-517.

[34] del Miraglia GM, De Luca MG, The role of probiotics in the clinical management of food allergy and atopic dermatitis, *J Clin Gastroenterol,* 38, 2004,S84-S85.

[35] Ren C, Dokter-Fokkens J, Figueroa Lozano S, Zhang Q *et al*., Lactic acid bacteria may impact intestinal barrier function by modulating goblet cells, *Molecular Nutrition and Food Research,* 62(6), 2018, 1700572.

[36] Yanxia W, Fan Y, Qiong W, Jing G, et. al., Protective effects of bifidobacterial strains against toxigenic *Clostridium difficile*. Frontiers in Microbiology, 9, 2018, 888.

[37] Aiba Y, Suzuki N, Kabir AM, Takagi A, Koga Y, Lactic acid-mediated suppression of

Helicobacter pylori by the oral administration of *Lactobacillus salivarius* as a probiotic in a gnotobiotic murine model. *Am J Gastroenterol,* 93, 1998, 2097-2101.

[38] Cervantes-Elizarrarás A, Cruz-Cansino NS, Ramírez-Moreno E, Vega-Sánchez V et.al. In Vitro probiotic potential of lactic acid bacteria isolated from aguamiel and pulque and antibacterial activity against pathogens, Applied Sciences, 9, 2019, 601.

[39] MacFarlane GT, Cummings JH, Probiotics, infection and immunity. *Curr opin infec dis,* 15, 2002, 501-506.

[40] Marteau P, de Vrese M, cellier CJ, Schrezenmeir J, Protection from gastrointestinal diseases with the use of probiotics. *Am. J Clin Nutr,* 73, 2001, 430S-436S.

[41] Clarke G, Cryan JF, Dinan TG, Quigley EM, Review article: probiotics for the treatment of irritable bowel syndrome – focus on lactic acid bacteria, Alimentary Pharmacology and Therapeutics, 35, 2012, 403-413.

[42] Ray B, Bhunia, A, Fundamental Food Microbiology. CRC Press, Boica Raton, FL, 2008.

[43] Parvez S, Malik A, Ah Kang S, Kim HY, Probiotics and their fermented food products are beneficial for health. *J Appl Microbiol,* 100, 2006, 1171-1185.

[44] Górska A, Przystupski D, Magdalena J. Niemczura, Kulbacka J, Probiotic Bacteria: A promising tool in cancer prevention and therapy, Current Microbiology, 76, 2019, 939–949.

[45] Marteau P, Flourie B, Pochart F, Chastang C, Desjeux JF, Rambaud JC, Effect of the microbial lactase (EC 3.2.1.23) activity in yoghurt on the intestinal absorption of lactose: an *in vivo* study in lactase-deficient humans. *Br J Nutr* 64, 1990, 71-79.

[46] Changlu Ma, Shuwen Z, Jing Lu, Cai Z, *et al.* Screening for cholesterol-lowering probiotics from lactic acid bacteria isolated from corn silage based on three hypothesized pathways, International Journal of Molecular Sciences, 20, 2019, 2073.

[47] McLean NW, Rosenstein IJ, Characterization and selection of a *Lactobacillus* species to re-colonise the vagina of women with recurrent bacterial vaginosis. *J Med Microbiol,* 49, 2000, 543-552.