NARRATIVE

Traditional Fermented Food of India:- Sources of Probiotic Bacteria May Maintain Diversity of Gut Microbiota and Manage The Symptoms of Asthma

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DOI: 10.55489/njcm.141120233195

ABSTRACT

The fermented foods that we consume contain certain beneficial bacteria. They occur naturally in some foods and others added culture. Consuming these foods keeps the balance between pathogenic bacteria and symbiotic beneficial bacteria in our intestine. It improves the overall health in ways science has just discovered. There are many studies available in this area and the results are very promising. Feeding fermented foods improved gut microbiome diversity as reported in many research studies. Since there were very handful numbers of research articles in this area, the current review gives a comprehensive idea about the fermented food, and the bacteria responsible for the fermentation and their health benefits are well described. In addition, there is also focus on the role of the symbiotic beneficial bacteria in managing the allergy and asthma.

Key words: Asthma, Fermented food, Gut microbiota, Probiotic bacteria

ARTICLE INFO

Financial Support: None declared
Conflict of Interest: None declared
Received: 28-06-2023, **Accepted**: 12-09-2023, **Published**: 01-11-2023
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How to cite this article: Das M, Thajuddin N, Pundir M, Patra S. Traditional Fermented Food of India:- Sources of Probiotic Bacteria May Maintain Diversity of Gut Microbiota and Manage The Symptoms of Asthma. Natl J Community Med 2023;14(11):774-780. DOI: 10.55489/njcm.141120233195

www.njcmindia.com | pISSN09763325 | eISSN22296816 | Published by Medsci Publications

INTRODUCTION

The use of fermented foods is a 10,000-year-old food culture in India. India has a diverse culture, different religions, different climatic conditions, different cooking methods and different regional cooking ingredients (grains, pulses, fruits, vegetables, leaves, and spices), but the whole India uses different form of traditional fermented food. Fermentation is usually caused by a group of fermenting bacteria and fungi growing on a sugar medium (*Lactobacillus* grows on lactose or *Saccharomyces cerevisiae* on glucose) to produce a fermented product such as ethanol. These bacteria extend the shelf life of food and protect food against pathogenic microorganisms.[1] Fermented foods have many health benefits for the human body because it makes the complex form of proteins and fibers digestible and improves the bioavailability of minerals and the metabolism of carbohydrates, lipids, and amino acids.[2] Fermented food is a good source of vitamins and antioxidants and also causes the hydrolysis of some inactive enzymes into their active form. The use of simple sugar-fermenting bacteria can lead to the production of exopolysaccharides (EPS). EPS is a high molecular weight polysaccharide that participates in antigen recognition and stimulates the development of the immunological response of the human body.[3] In this review, we attempt to clarify the relationship between traditional Indian fermented foods and their effects on gut microbiota diversity and role in asthma prevention.

METHODOLOGY

A narrative review of peer-reviewed studies released between 2000 and 2023 was carried out by the study team. Fermented food, Health benefits of fermented food, Asthma and Gut Microbiota, were thoroughly searched in four electronic databases: Web of Science, PubMed, Google Scholar, and Science Direct. We screened the titles and abstracts, and then we obtained potential eligible citations for full text analysis. References of included articles and articles of prominent nonindexed peer-reviewed journals were searched in order to have a complete understanding of the subjects and relevance with the stated title.

Diversity of Fermented foods in India

Indians use grains, vegetables, fruits, leaves, fish, and meat for fermentation. The cereal-based fermented product is most widely used in South India. Fermented food based on plant and meat is more used in Northeast India and the western Himalayas. Vegetable-based and pulses based fermented food is most commonly used in northern and western states of India. East India prepares as much fermented milk-based sweets.

Table 1: Fermented food of India

Component of food material	Name of the fermented food of India
Cereal based fermented food	*Idly, Dosa, KouzhuI, Pazhaiyasoru, Ambali, Apam, Ada, Uthapam, Ragi dosa, Rava Idly, Pakhal/Pantabhat, Enduripitha, Chitau, Muhapitha, Tala chakuli, PanasaPitha, Tala Muha, Haladipatrapitha, Jalebi, Gulgule, Seera,, Bhature, Manna, Marjag, Sel Roti, Sinki, Ragi hurihittu, Kanji*
Pulses based Fermented food	*Khomon Dhokla, Mung dal Dhokla, Khandavi, Kinema, Bari, Masyara, Tungrymbai, Axone, Bari, Ballae, Borhe, Wari, Chila, Adai dosa, Amriti*
Milk based fermented food	*Dahi /Curd, Butter milk/Chanch, Lashi(sweater curd), Rabdhi, Khadi, Shrikhand, Paneer*(cottage cheese), *Chena poda*(Indian cheesecake), *Rasa gola, Chena Paiyas, Sandesh, Chena mudik, Misti doi* (sweeten curd), *Chhurchirpen, Philu, Smar*
Vegetable based fermented food	*Karadi, Mesu, Kanji, Sauernohi, Tapyo, Rep, Bikang, Rai, Midukeye, Amalaintoi,*
Fish and meat based fermented food	*Lona ilish, Ilishangari, Nagari, Shedal, Ngawun, Ngapi, Tungtap, Dang –pui-thu, Saum, Geema , Arjia, Chartayshya*

Microorganism involved in the process of Fermentation

The fermentation process involves a number of microorganisms, including fermentative bacteria and fungi. *Arthrobacter, Bacillus, Bifidobacterium, Brachybacterium, Brevibacterium, Enterobacter, Hafnia, Haloanaerobium, Halobacterium, Halococcus, Klebsiella, Kocuria, Micrococcus, Pseudomonas*, and *Staphylococcus* are the bacterial genera involved in fermentation.[4]

The genera of yeast and filamentous moulds found in the fermented food include *Brettanomyces, Candida, Cryptococcus, Debaryomyces, Dekkera, Galactomyces, Geotrichum, Hansenula, Hanseniaspora, Hyphopichia, Issatchenkia, Kazachstania, Kluyveromyces, Metschnikowia, Pichia, Rhodotorula, Rhodospori.*[5] Overnight fermentation of cereal and pulses makes the batter rich in a no of health beneficiary bacteria *Weissella paramesenteroides*, *Lactobacillus fermentumL. plantaram, Enterococcus faecalis, Pediococcusacidilactici, P.cerevisiae*,*Lmesenteroides*, *L. plantarum*. Curd is an important ingredient for fermentation. Several curd-based recipes such as *Kouzhu, Pazhaiyasoru, Rava Idly,* and *Jalebi*. Indian cottage cheese (*chhena*) can be prepared from milk by using fermented water ex-

tracted from milk (*chhenaPani*). *Chena* (cottage cheese) is mostly utilized for the preparation of eastern Indian sweets like *Rosagola* and *Chenapoda*. This milk-based fermented food is shown to be beneficial to a wide variety of microbial species, including *Streptococcus cremoris, S. lactis, S. thermophilus, Lactobacillus bulgaricus, L. acidophilus, L. helveticus, L. cremoris, L. plantarum, L. curvatus, L. fermentum, L. paracaseisubsp. pseudoplantarum, L. alimentar*.[6] Indians mostly use a mixture of cereal and pulses, which provide all nutritional benefits like the availability of all essential amino acids and minerals. Indian cuisines like *Dosa, Idly, Dhokla, chakli, Masyara*, and *Eda* all will be prepared as a mixture of cereals and pulses. Cereals and pulses provide the substrate (beta–glucan, arabinoxylan, galacto oligosaccharides) for probiotic bacterial growth like *Lactobacilli* and *Bifidobacteria*.[7] Vegetables are typically preserved in the form of fermentable vegetables in the northeastern Indian state, the Himalayan areas (Uttarakhand and Himachal Pradesh), and the eastern part of India (Darjeeling Hills). It's possible that these Indian regions' ancestors used fermentation as a method of food preservation due to their geographic location, the availability of food throughout the winter, and the absence of transportation infrastructure. *Pediococcus pentasaceous, L. cellubiosus, L. plantarum, L. fermentum, L. brevis, L. mesenteroides, L. lactis, E. faecium*, and *P. acidilactici* are abundant in these fermentable vegetables. Fermented pulses are a rich source of *E. faecium, L. mesenteroides, L. fermentum, L. bulgaricus,* and *Streptococcus thermophilus* and enhance the probiotic content of food.*P.acidilactici* and *P.pentosaceous.*[6]

Health benefits of Fermented food

Source of *Fibrinolytic* Enzyme: Soybeans is a source of *Bacillus. subtilis* and *Bacillus amyloliquefaciens* produce a *fibrinolytic* enzyme that provides protection against cardiovascular disease.[8–10]

Moreover, they produce ACE inhibiting peptides Fermented milk (curd) with *Lactobacillus helveticus* is a source of ACE-inhibitory peptides reduces mild high blood pressure.[11] Fermented soybean which is a good source of *Lactobacillus plantarum* produces ACE inhibitory peptides that lower the risk of cardiovascular diseases.[12]

Antimicrobial activity: Antimicrobial peptides (S1-casein, S2-casein, -casein, and -casein) found in fermented dairy products exhibit antimicrobial activity against pathogenic Gram-negative bacteria.[13] *Listeria, Staphylococcus*, and *Salmonella*, as well as filamentous fungi , gram-positive bacteria (*Escherichia, Helicobacter*, and *Salmonella),* and. *S. aureus, Escherichia coli*, and *P. aeruginosa* were all susceptible to *S. aureus*-producing *Lactobacillus* found in Khadi (a fermented milk product).[14]

Fermented food is beneficial for the digestive system: *Gundruk*, zinc and *iniyangsang* (leaf-based fermented food) are used to treat indigestion.[15] *Tromba* is made from wood beans and can be a good appetizer. *Handua* or *Kardi* are used to treat constipation.[16]

Lowers serum cholesterol: Acidified food is good *L. acidophilus* lowers serum cholesterol.[17]

Reduces the effects of lactose intolerance: Lactose intolerance is an autosomal inherited disease caused by a lack of the lactase enzyme. A person cannot digest lactose, causing diarrhea, bloating, abdominal pain and gas. Fermented foods, such as curds, are rich in the genus *Lactobacillus*, contribute to the availability of lactose in a soluble and digestible form).[18]

Fermentation increases nutritional value: Cellulose, hemicellulose and pectin are called useless carbohydrates because human enzyme cannot break them down. Fermented food turns the digestive environment into an acidic environment. Acidic pH increases the activity of microbial enzymes to convert unused carbohydrates into SCFA, neurotransmitters and vitamins.[19]

Antioxidant properties: -Antioxidant peptides are present in protein-rich fermented foods like cheese, curd, and fermented fish. An antioxidant peptide produced from K-casein extracted from fermented milk in the presence of *Lactobacillus delbrueckii*.[20]

Prevent candidiasis: Candidiasis is mainly caused by *Candida albican*. The development of *Candida albicans* is prevented by the group of bacteria Lactobacillus (*L.paracaesi*, L. *fermentum, L.rhamonus*), which originate from fermented foods.[21]

Antitumor effect: Peptides from fermented foods have an anticancer effect. Anti-proliferative activities of HL-60 cells are seen with cow's milk and goat's milk cheeses.[22] Fermented goat's milk, which is a rich source of *Lb. plantarum* and *Lactobacillus paracasei* showed decreased viability of HeLa cells.[23]

Prevention of atopic dermatitis (eczema): Dermatitis is called dermatitis mainly because it is caused by abnormal activation of IgE antibodies against common environmental allergens such as pollen and dust particles. *L. rhamnosus* inhibits IgE antibody concentrations in a mouse model.[24]

Antidiabetic effect: Fermented food rich in bacteria *L.acidophilus*, *L.casei* and *Bifidobacterium bifidum*. Ingestion of bacteria *L.acidophilus*, *L.casei* and *Bifidobacterium bifidum* shows a significant decrease in blood sugar levels.[25]

Prevention of gastritis: Inflammation of the stomach is called gastritis. Fermented symbiotic bacteria produce a peptide called bacteriocin, which inhibits the growth of *Helicobacter pylori.*[26]

Prevention of Anxiety and depression: The female participant's attention and brain activation are improved when she consumes a fermented dairy beverage produced with probiotics (*Bifidobacterium an-*

imalis lactis, *Streptococcus thermophiles, Lactobacillus bulgaricus,* and *Lactococcus lactis*).[27]

Fermented food prevents the growth of the pathogenic bacteria

The most popular fermented meal made from cereal and a great source of *Lactobacillus* in India is called a dosa. Pathogenic bacteria such as *Bacillus cereus, Staphylococcus aureus, Listeria monocytogenes, Pseudomonas aeruginosa, V. parahaemolyticus,* and *Aeromonas hydrophilaare* all inhibited by the antibacterial protein bacteriocin generated by *Lactobacillus.*[28]

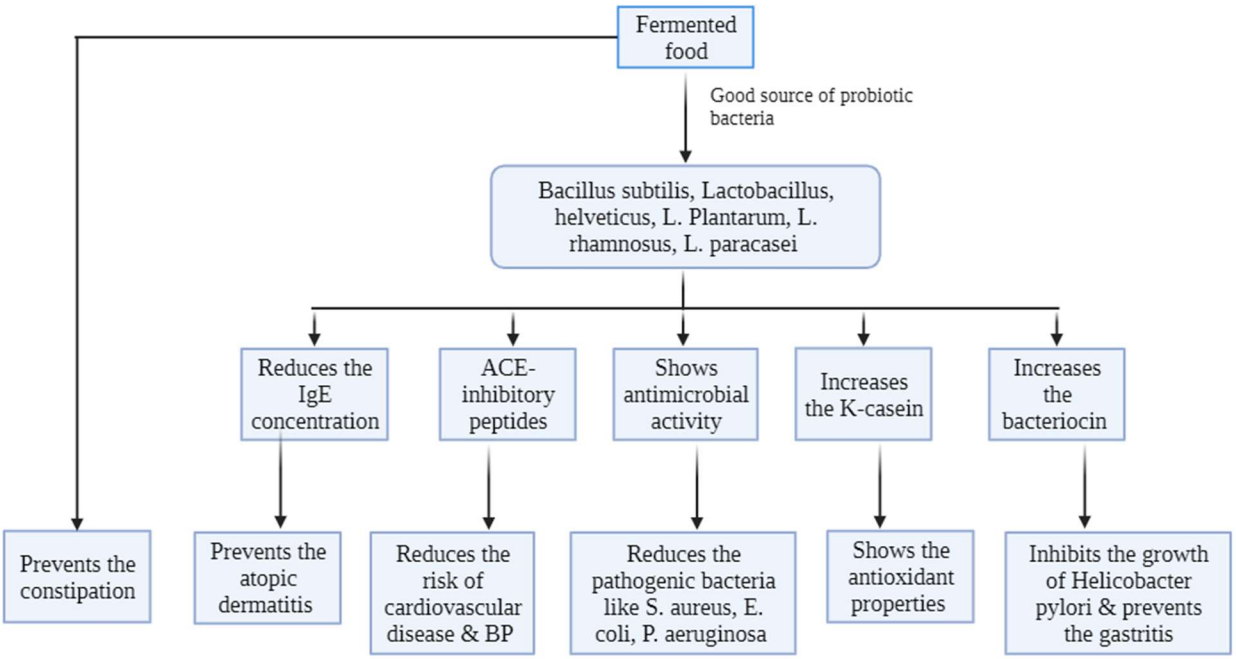

Figure 1: Fermented food of India and its health benefits

How does fermented food affect the human gut micro biota?

Fermented food is a good source of beneficiary symbiotic bacteria. A biologically significant peptide produced by the symbiotic bacteria has anti-inflammatory, antioxidant, and immunomodulatory properties. One study that looked at people who consumed fermented foods (fermented vegetables) revealed the diversity of *Bacteroides* species, *Pseudomonas* species, *Dorea*species, *Lachnospiraceae, Prevotella* species, *Alistipesputredinis* species, *Oscillospira*species, *Enterobacteriaceae*, *Fusobacterium* species, *Actinomyces* species, *Achromobacter*species, *Clostridium clostridioform.*[29] According to a different study, drinking fermented milk increases the relative number of species in the *Prevotellaceae* and *Bacteroidaceae* families of faeces while decreasing the abundance of Firmicutes (*Ruminococcaceae*and *Lachnospiraceae*). People who consume yoghurt have higher levels of alpha diversity than those who do not, and those who consume yoghurt also have much higher levels of *Ruminococcaceae*, *Streptococcus*, *Lachnospiraceae*, and *Christensenellacaea.*[3]

Effect of fermented food on Allergy including Asthma

In adult asthmatics, *Lactobacillus*-enriched yogurt/curd lowers eosinophil levels and interferes with gamma immunoglobulin production.[30] In people with atopic rhinitis or nasal allergies, consuming yoghurt or curd lowers IgE serum levels.[31,32] The epithelial lining of the lungs and intestines are protected by fermented meals, which also modify mucosal immunity. The mitogen-activated protein kinase (MAPK) signaling pathway is under the control of metabolites from fermented meals, which also encourage epithelial cell synthesis of tight junction proteins. paracellular diffusion of allergens is prevented.[30–32] IFN gamma, TNF-alpha, IL-6, IL-12, and IL-1 are all produced more readily in in vitro cell cultures when fermented foods rich in lactic acid bacteria are consumed.[33,34] *L. casei* (mainly used in fermented dairy products) increases the number of lymphocytes, eosinophils, neutrophils and Th2 cytokines (IL-4, IL-5, IL-13, IL-9) and Th17 cytokines (IL-4, IL-5, IL-13, IL-9, IL-17A) levels have been found to be reduced, and chemokines (such as eotaxin-1) in BALF (broncho alveolar lavage fluid). By primarily encouraging *Firmicutes* proliferation and elevating SCFA levels (acetate and propionate) maintain, *L.casei* strains reduced serum HDM-specific Ig G1 and total IgE levels, as well as gut microbiota diversity.[35] *L.Kefiranofacien* (from fermented dairy products) boosted Treg activity and lowered Th2 (IL-4, IL-5, IL-13), Th 17 cytokines and BAL Finsplenocytes, and serum IgE production can diminish allergen-induced asthma. In OVA-allergic asthmatic mice, *L.*

kefiranofaciens inhibits AHR to methacholine, airway inflammation, eosinophil infiltration into the lung, and mucous glandular per secretion.[36] Immunomodulatory effects are produced by *Lactobacillus helveticus* that is isolated from fermented milk. In addition to lowering total serum IgE levels, *Lactobacillus helveticus* also inhibits immune cell proliferation, lowers lymph node cytokine secretion, and controls IL-10 and Foxp3 expression.[34] Fermented milk that has been augmented with *L. reuteri* has a higher predominance of *Lactobacilli, Bifidobacteria*, and *Enterococci. L. reuteri* lowered airway inflammation, blocked Th2-associated pro-inflammatory cytokines (IL-5, IL-13), increased SCFA, decreased total IgE, and decreased total IgE.[37] Lactic acid bacteria isolated from fermented brown rice contain high levels of ferulic acid and protocatechuic acid, show anti-allergic activity.[38] Ramulus mori and Salvia plebeian, which are used in Ayurvedic medicine, were introduced, and their fermented extracts significantly suppressed the release of pro-inflammatory cytokines (IL-4 and IL-17) and decreased IgE levels. also prevented inflammatory cells from entering BALF.[39] In addition to suppressing OVA-induced nasal allergy symptoms, red ginseng extracts fermented by the bacterium *Bifidobacteria* also decreased IgE levels, eosinophil and mast cell infiltration, differentiated Th2 cells, and reduced IL-4, IL-5, and IL-13 levels in BALF and nasal fluid.[40] A fermented multi-fruit beverage supplemented with *Saccharomyces cerevisiae* increased the Th1 immune responses in mice, and the Th2-associated cytokines IL-4 and IL-5 were subsequently reduced.[38,40] Isoflavones (polyphenolic chemicals) found in fermented soy products like genistein, daidzein, and glycitein prevent allergic inflammation, block dendritic cell maturation, and stop IgE-mediated mast cell degranulation.[40–42]

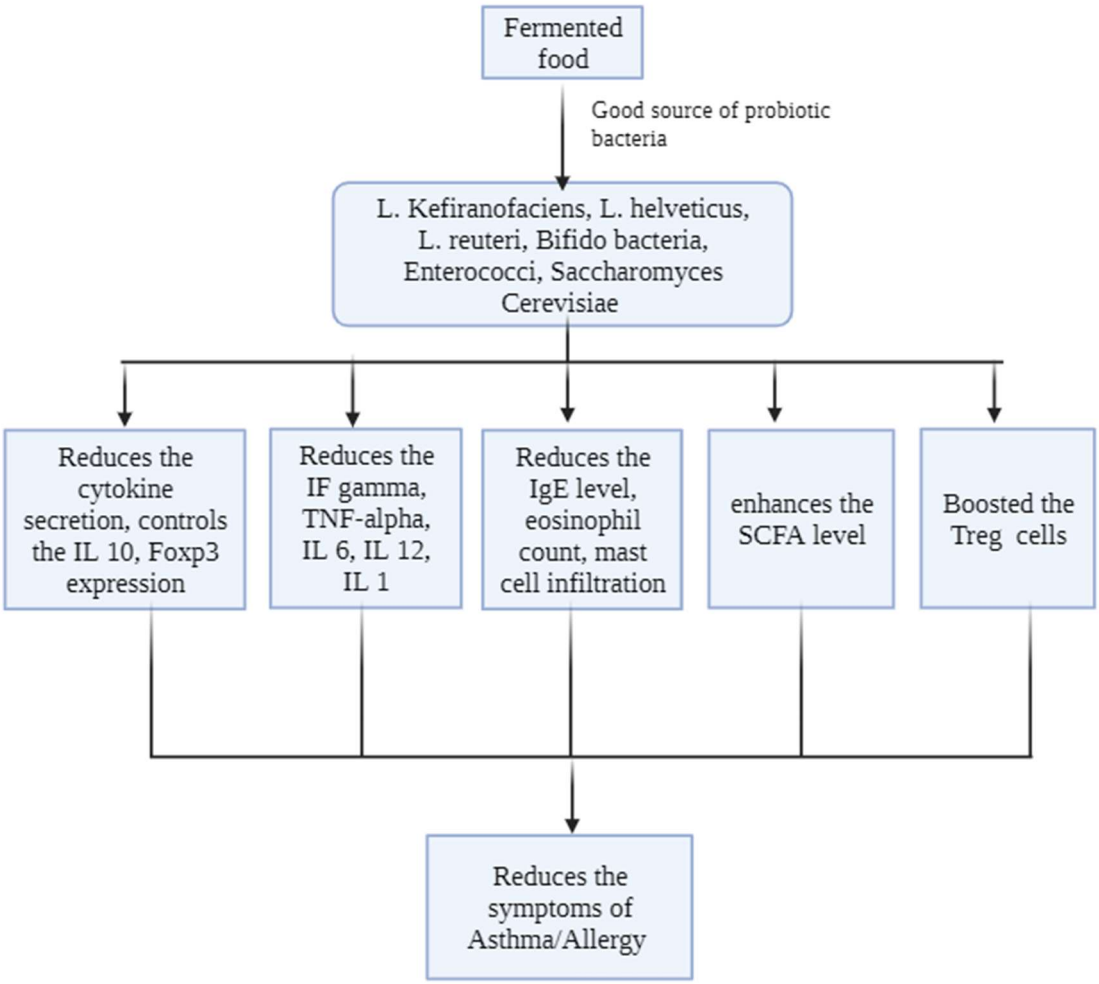

Figure 2: Effects of fermented food on Allergy /Asthma

Conclusion

Probiotic bacteria like *Lactobacillus* and *Bifidobacterium* are abundant in fermented foods from India. In addition, eating fermented foods broadens the range of bacteria in the gut that belong to the families *Lachnospiraceae, Prevotella, Fusobacterium, Akkeermansia*, and *Bacteroidetes*. The majority of these bacteria are in charge of producing SCFA. Asthmatics may experience anti-inflammatory effects from butyric acid, a short-chain fatty acid (SCFA) produced by *L. reuteri* from the fermentation of fibre. The anti-

asthma bacteria *Lachonospiraceae, Akkermansia, Bifidobacterium,* and *Lactobacillus* lessen the symptoms of asthma. The growth of pathogens like *Staphylococcus aureus, Escherichia coli*, and *Pseudomonas aeruginosa* is inhibited by fermented foods like cottage cheese. Asthma is brought on by the dangerous microorganisms *Clostridium, Staphylococcus*, and *Pseudomonas*. The main pathogenic bacterium in asthmatics, *Pseudomonas aeruginosa,* causes neutrophilic inflammation and is steroid-resistant. The diversity of gut microbiota and anti-microbial activity of the majority of Indian fermented foods are unknown, despite the fact that this study focuses on the effects of traditional Indian fermented foods on human gut microbiota and anti-asthmatic activity. As a result, this area of inquiry could be the focus of future study.

Acknowledgement

We appreciate the faculty at Bharathidasan University, Department of microbiology, Tiruchirappalli Tamil Nadu.

References

1. Leeuwendaal NK, Stanton C, O'Toole PW, Beresford TP. Fermented foods, health and the gut microbiome. Nutrients. 2022;14(7):1527. https://doi.org/10.3390/nu14071527
2. Beermann C, Hartung J. Physiological properties of milk ingredients released by fermentation. Food and Function. 2013;4(2):185-99. https://doi.org/10.1039/c2fo30153a
3. Ryan PM, Ross RP, Fitzgerald GF, Caplice NM, Stanton C. Sugar-coated: Exopolysaccharide producing lactic acid bacteria for food and human health applications. Food Funct. 2015;6(3):679-93. https://doi.org/10.1039/c4fo00529e
4. Swennen K, Courtin CM, Delcour JA. Non-digestible oligosaccharides with prebiotic properties. Crit Rev Food Sci Nutr. 2006;46(6):459-71. DOI: 10.1080/10408390500215746
5. Satish Kumar R, Kanmani P, Yuvaraj N, Paari KA, Pattukumar V, Arul V. Traditional Indian fermented foods: A rich source of lactic acid bacteria. Vol. 64, International Journal of Food Sciences and Nutrition. 2013;64(4):415-28. https://doi.org/10.3109/09637486.2012.746288
6. Tamang JP, Watanabe K, Holzapfel WH. Review: Diversity of microorganisms in global fermented foods and beverages. Vol. 7, Frontiers in Microbiology. 2016;7:377. https://doi.org/10.3389/fmicb.2016.00377
7. Tamang JP, Holzapfel WH, Shin DH, Felis GE. Editorial: Microbiology of ethnic fermented foods and alcoholic beverages of the world. Vol. 8, Frontiers in Microbiology. 2017;8:1377. https://doi.org/10.3389/fmicb.2017.01377
8. Peng Y, Huang Q, Zhang RH, Zhang YZ. Purification and characterization of a fibrinolytic enzyme produced by Bacillus amyloliquefaciens DC-4 screened from douchi, a traditional Chinese soybean food. Comparative Biochemistry and Physiology - B Biochemistry and Molecular Biology. 2003;134(1):45-52. https://doi.org/10.1016/s1096-4959(02)00183-5
9. Singh TA, Devi KR, Ahmed G, Jeyaram K. Microbial and endogenous origin of fibrinolytic activity in traditional fermented foods of Northeast India. Food Research International. 2014;55:356-62. DOI: 10.1016/j.foodres.2013.11.028
10. Mine Y, Kwan Wong AH, Jiang B. Fibrinolytic enzymes in Asian traditional fermented foods. In: Food Research International. 2005;38(3):243-50. DOI: 10.1016/j.foodres.2004.04.008
11. Ashar MN, Chand R. Fermented milk containing ACE-inhibitory peptides reduces blood pressure in middle aged hypertensive subjects. Milchwissenschaft. 2004;59(7–8):363-6.
12. Feng C, Ming T. Beneficial Effects of Bioactive Peptides Derived from Soybean on Human Health and Their Production by Genetic Engineering. In: Soybean and Health. 2011:311-29.
13. Haque E, Chand R. Antihypertensive and antimicrobial bioactive peptides from milk proteins. European Food Research and Technology. 2008;227(1):7-15.
14. Meira SM, Daroit DJ, Helfer VE, Corrêa AP, Segalin J, Carro S, Brandelli A. Bioactive peptides in water-soluble extracts of ovine cheeses from Southern Brazil and Uruguay. Food Research International. 2012 Aug 1;48(1):322-9. https://doi.org/10.1016/j.foodres.2012.05.009
15. Rajyalakshmi P, Geervani P. Studies on tribal foods of South India: effect of processing methods on the vitamin and in vitro protein digestibility (IVPD) of cereals/millets and legumes. J Food Sci Technol. 1990;27(5):260-3.
16. Tamang JP, Tamang B, Schillinger U, Guigas C, Holzapfel WH. Functional properties of lactic acid bacteria isolated from ethnic fermented vegetables of the Himalayas. Int J Food Microbiol. 2009;135(1):28-33. https://doi.org/10.1016/j.ijfoodmicro.2009.07.016
17. Singh A, Singh RK, Sureja AK. Cultural significance and diversities of ethnic foods of Northeast India. Vol. 6, Indian Journal of Traditional Knowledge. 2007. http://nopr.niscpr.res.in/ handle /123456789/853
18. Grunewald kk. Serum Cholesterol Levels in Rats Fed Skim Milk Fermented by Lactobacillus Acidophilus. J Food Sci. 1982; 47(6):2078-9. DOI:10.1111/j.1365-2621.1982.tb12955.x
19. Ebringer L, Ferenčík M, Krajčovič J. Beneficial health effects of milk and fermented dairy products. Folia microbiologica. 2008; 53(5): 378-94. DOI: 10.1007/s12223-008-0059-1
20. Mokoena MP, Chelule PK, Gqaleni N. Reduction of fumonisin B1 and zearalenone by lactic acid bacteria in fermented maize meal. J Food Prot. 2005;68(10)2095-9. https://doi.org/10.4315/0362-028x-68.10.2095
21. Kim HI, Kim JK, Kim JY, Han MJ, Kim DH. Fermented red ginseng and ginsenoside Rd alleviate ovalbumin-induced allergic rhinitis in mice by suppressing IgE, interleukin-4, and interleukin-5 expression. J Ginseng Res. 2019;43(4):635-644. https://doi.org/10.1016/j.jgr.2019.02.006
22. Kudoh Y, Matsuda S, Igoshi K, Oki T. Antioxidative peptide from milk fermented with Lactobacillus delbrueckii subsp. bulgaricus IFO13953. Nippon Shokuhin Kagaku Kogaku Kaishi. 2001;48(1):44-55. http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=1043077
23. Yasuda S, Kuwata H, Kawamoto K, Shirakawa J, Atobe S, Hoshi Y, et al. Effect of highly lipolyzed goat cheese on HL-60 human leukemia cells: Antiproliferative activity and induction of apoptotic DNA damage. J Dairy Sci. 2012;95(5):2048-60. https://doi.org/10.3168/jds.2011-4153
24. Sy JBA, Hsu TC, Limaye A, Liu JR. Oral administration with a traditional fermented multi-fruit beverage modulates non-specific and antigen-specific immune responses in BALB/c mice. PLoS One. 2020;15(5). https://doi.org/10.1371/journal.pone.0233047
25. Smith BN, Dilger RN. Immunomodulatory potential of dietary soybean-derived isoflavones and saponins in pigs. J Anim Sci. 2018;96(4):1288-1304. https://doi.org/10.1093/jas/sky036
26. Kim DH, Jung WS, Kim ME, Lee HW, Youn HY, Seon JK, Lee HN, Lee JS. Genistein inhibits pro-inflammatory cytokines in human mast cell activation through the inhibition of the ERK

pathway. International Journal of Molecular Medicine. 2014 Dec 1;34(6):1669-74. DOI: 10.3892/ijmm.2014.1956

27. Tillisch K, Labus J, Kilpatrick L, Jiang Z, Stains J, Ebrat B, et al. Consumption of fermented milk product with probiotic modulates brain activity. Gastroenterology. 2013;144(7):1394-401. https://doi.org/10.1053/j.gastro.2013.02.043

28. Dacheux D, Toussaint B, Richard M, Brochier G, Croize J, Attree I. Pseudomonas aeruginosa cystic fibrosis isolates induce rapid, type III secretion-dependent, but ExoU-independent, oncosis of macrophages and polymorphonuclear neutrophils. Infect Immun. 2000;68(5):2916-24. https://doi.org/10.1128/iai.68.5.2916-2924.2000

29. Shida K, Makino K, Morishita A, Takamizawa K, Hachimura S, Ametani A, et al. Lactobacillus casei inhibits antigen-induced IgE secretion through regulation of cytokine production in murine splenocyte cultures. Int Arch Allergy Immunol. 1998;115(4):278-87. https://doi.org/10.1159/000069458

30. LeBlanc JG, Matar C, Valdéz JC, LeBlanc J, Perdigon G. Immunomodulating effects of peptidic fractions issued from milk fermented with Lactobacillus helveticus. J Dairy Sci. 2002;85(11):2733-42. https://doi.org/10.3168/jds.s0022-0302(02)74360-9

31. LeBlanc J, Fliss I, Matar C. Induction of a humoral immune response following an Escherichia coli O157:H7 infection with an immunomodulatory peptidic fraction derived from Lactobacillus helveticus-fermented milk. Clin Diagn Lab Immunol. 2004;11(6):1171-81. https://doi.org/10.1128/cdli.11.6.1171-1181.2004

32. Vinderola G, Matar C, Perdigón G. Milk fermented by Lactobacillus helveticus R389 and its non-bacterial fraction confer enhanced protection against Salmonella enteritidis serovar Typhimurium infection in mice. Immunobiology. 2007;212(2):107-18. https://doi.org/10.1016/j.imbio.2006.09.003

33. Wheeler JG, Bogle ML, Shema SJ, Shirrell MA, Stine KC, Pittler AJ, et al. Impact of dietary yogurt on immune function. American Journal of the Medical Sciences. 1997;313(2):120-3. https://doi.org/10.1097/00000441-199702000-00011

34. Trapp CL, Chang CC, Halpern GM, Keen CL, Gershwin ME. The influence of chronic yogurt consumption on populations of young and elderly adults. International Journal of Immunotherapy. 1993;9(1):53-64.

35. Halpern GM, Vruwink KG, Van De Water J, Keen CL, Gershwin ME. Influence of long-term yoghurt consumption in young adults. International Journal of Immunotherapy. 1991;7(4):205-10.

36. Van De Water J, Keen CL, Gershwin ME. Nutritional and Health Benefits of Inulin and Oligofructose The Influence of Chronic Yogurt Consumption on Immunity. J. Nutr. 1999;129 (10):1932. https://doi.org/10.1093/jn/129.7.1492s

37. Velez EMM, Maldonado Galdeano C, Carmuega E, Weill R, Bibas Bonet ME, Perdigón G. Probiotic fermented milk consumption modulates the allergic process induced by ovoalbumin in mice. British Journal of Nutrition. 2015;114(4):556-76. https://doi.org/10.1017/s0007114515001981

38. Hong WS, Chen YP, Chen MJ. The antiallergic effect of kefir lactobacilli. J Food Sci. 2010;75(8)H224-53. https://doi.org/10.1111/j.1750-3841.2010.01787.x

39. Makino T, Yamashita M, Takeuchi N, Kabuki T, Hattori M, Yoshida T. Lactobacillus helveticus SBT2171 alleviates allergic symptoms in a murine model for pollen allergy. Biosci Biotechnol Biochem. 2019;83(12):2298-2306. https://doi.org/10.1080/09168451.2019.1654847

40. Li L, Fang Z, Lee YK, Zhao J, Zhang H, Lu W, et al. Prophylactic effects of oral administration of: Lactobacillus casei on house dust mite-induced asthma in mice. Food Funct. 2020;11(10):9272-9284. DOI: 10.1039/d0fo01363c

41. Dhong KR, Park HJ. Pediococcus pentosaceus from the sweet potato fermented ger-minated brown rice can inhibit type i hypersensitivity in rbl-2h3 cell and balb/c mice models. Microorganisms. 2021;9(9):1885. https://doi.org/10.3390/ microorganisms9091855

42. An M, Oh M, Park KT, Seon KH, Jo JE, Lee SK, et al. Anti-asthma and antitussive effects of a fermented extract of a mixture of Ramulus mori, Anthriscus sylvestris, and Salvia plebeian. Food Sci Biotechnol. 2021;30(9):1257-1268. https://doi.org/10.1007/s10068-021-00955-3