Original Research Paper

Volume - 12 | Issue - 01 | January - 2022 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Microbiology

DEVELOPMENT OF FUNCTIONAL NON- DAIRY PROBIOTIC PRODUCTS FROM PLANTS: A REVIEW

Bhagyashri N. Maniyar* Research Scholar, Microbiology Research Laboratory, Rajasthan Aryans College, Washim, MS, India. *Corresponding Author

Dr. Rachana R. Pachori Associate Professor and Head, U.G., P.G. and Research section, Department of Microbiology, Rajasthan Aryans College, Washim (M.S.), India 444505.

ABSTRACT Probiotics have emerged as the major nutritional factor impacting and influencing gastrointestinal physiology and function. Milk -based fermented products have been utilized as convenient substrate for probiotic transfer since ancient times. Recently, consumer's interest increases towards healthy diet emphasize with plant-based food which has specified the new area of research in the development of non-dairy probiotic food. Plant based food are getting more attention as potential substrate as they contain beneficial nutrients and many bioactive compounds. Various plant-basedfood such as cereals, fruit juices, vegetable juices, herbal plants can be utilized as a substrate for delivering the beneficial microorganisms. The present review provides an approach to exploit the various plants-basedfood as a good carrier medium to develop the non-dairy probiotic foods with additional benefits and can be serve as healthy product.

KEYWORDS : Plant based food, Functional food, Probiotics, Non-dairy products, Nutrients

INTRODUCTION

From ancient time Plant-based foods have been known to play a vital role in basic human nutrition and health. Plant foods are known to have prospective health-benefiting properties and this fact led to the use of plant-based food as alternatives to conventional strategies for disease management, as well as the potential to prevent onset of certain diseases and reduce health care costs. Additionally Plant-based foods contain a variety of bioactive substances like phenols, flavonoids, carotenes, which provide essential nutrients for human health. Diet that restrain plant-based foods that are high in fiberfavorably alter the gut microbiota and may have considerable impact for health. Present evidences suggest that plant-based foods play important roles in the prevention of disease. Chronic diseases such as heart disease, cancer, stroke, diabetes, Alzheimer's disease, cataracts, and age-related function decline can be prevented by healthy eating strategy with increased consumption of plant-basedfood [1]. With the emergence of fortified foods, there is a worldwide increase in health awareness and interest in adding plant-based food in daily diet and food products [2]. Increasing number of scientific literatures revealed that the market for value added functional foods has expanded globally Due to the increased consumer awareness and interest to follow healthy nutrition and dietary strategy in achieving health benefits from foods beyond their basic nutrition [3]. In addition to the traditional nutritional effects, "functional foods" exert beneficial health effects on body. Well-recognized examples of functional foods are those containing bioactive compounds like dietary fibres, oligosaccharides, vitamins, minerals and active "friendly" bacteria, called probiotics that promote the equilibrium of intestinal microflora [4-5].

As defined by probiotics are live microorganisms (mainly bacteria and few yeast strains) that confer a beneficial health effect on the host if administered in appropriate amount [6]. Milk is the ideal source for probiotics growth and basically probiotics have been added to yoghurt and other fermented dairy products. However, in recent years, demand for non-dairy probiotic products rises due to several disadvantage related to probiotic foods based on dairy including lactose intolerance, high cholesterol content, vegetarianism, milk allergy and other factors [7]. Therefore, development of non-dairy probiotic products from various plant-basedfood is very important. Plant based food would be a better option due to highly nutritive value of itself. Wide variety of plant-based food can be a suitable substrate for probiotics transfer due to having minerals, vitamins, dietary fiber, antioxidants [8-9]and have prebiotic characteristics.

Probiotics products from Plant based food

Today most probiotic foods available in the market are milk based, but consumers' awareness towards healthy food lie more with botanical dietary supplements, which are either free from or have minimal cholesterol content. Plant-based foods are generally classified into fruits, vegetables, legumes, grains, cereals, nuts, seeds; and some herbs and spices are available locally that could be feasible to be exploited for probiotics. Studies may be classified based on the source of raw material for the production of the nondairy probiotic product.

Cereals and legumes

One of the staple foods that are consumed daily all over the world are cereals like wheat, maize, oat, barley, and other grains, which have complex nutrient composition. Another reason for the use of cereal food products is due to the availability of dietary fibres and the presence of non-digestible carbohydrates such as oligosaccharides that can act as a prebiotic and can stimulate the growth of probiotic LAB present in the colon [10]. Cereals offer a substantial number of vitamins, minerals, proteins, carbohydrates, fiber, and oligosaccharides. The constituents present in the cereals are suitable to grow probiotic bacteria, therefore, cereals considered healthy non-dairy carriers for the preparation of probiotic foods [11]. It is therefore concluded that by fermenting cereals can be an inexpensive way to obtain a rich substrate which supports the probiotic bacterial growth [12]. A probiotic beverage with the fermented cassava flour using mixed culture of *Lb. plantarum*, which were amylolytic strains of *Lb. casei*Shirota and *Lb. acidophilus* was developed [13]. a symbiotic functional drink from the oats by combining a probiotic starter culture and whole-grain oat substrate was produced [14]. The oats and barley are the cereals with highest content of β-glucan, recognized as the main functional component of the cereal fibers. In another study, a fermented beverage was produced from breadfruit flour as a substrate and a mixture of probiotic *L. acidophilus* and *L. plantarum*DPC 206 strains [15]. The beverage formulated was found to have acceptable organoleptic characteristic and good cell viability. Some examples of non-dairy cereal based fermented product created historically are summarized in Table 1

Table 1: Cereal and Legumes based Probiotic products

Name of the product	Source	Probiotic Strain	Reference
Boza,	Wheat, rye, millet, maize and other cereals mixed with sugar, or saccharine.	*L. plantarum, L. acidophilus, L. fermentum, L. brevis, L.coprophilus, Leuconostocreffinolactis, Leuconostocmesenteroides , Saccharomyces cerevisiae, Candida tropicalis, Candida glabrata, Geotrichumpenicillatum, and Geotrichumcandidum*	[16]
Bushera	shorgum or millet flour.	*L. brevis, Lactococcus, Leuconostoc, Enterococcus, and Streptococcus*	[17]
Mahewu	maize, sorghum, millet, malt and wheat flour	*Lactococcuslactis subsp. lactis*	[18]

Togwa.	multi-grains like maize, sorghum, finger millet flour	*L. plantarum and Streptococcus*	[19]
Pozol	Maize		[20]

Fruit and vegetables

Despite potential sensory challenges, there is a genuine interest in the development of fruit and vegetable -juice based functional beverages, fortified with the probiotic and prebiotic ingredients. Fruit juices are perceived as being healthy and refreshing properties with taste profiles that are pleasing to all the age groups [21]. Fruits and vegetables are considered healthy foods and are an ideal medium for the functional ingredients as they contain several beneficial nutrients such as various phytochemicals, antioxidants, minerals, vitamins, and dietary fibres [22]. High nutrient and sugar content of fruit juices enable suitable growth of probiotic and in combination with the fast passage through the harsh acidic conditions of stomach result in high probiotic cell viability [23]. Drinks, purées, fermented vegetables, table olives and minimally processed fruits are the Products made from fruits and vegetables, have been used for preparation of probiotic foods [24-25]. Some fruits used in commercial preparations include cranberry, blueberry, pomegranate, apple, blackcurrant, acai, acerola, guarana, mango, bilberries, grapes, cherries, kiwifruits, strawberries, feijoa, peach, and plums [26]. Gaanappriya tested the juices from watermelon, sapodilla, and orange as a suitable carrier for lactobacilli to prepare health beverage [27]. Additionally, a wide range of functional beverages containing probiotics as active ingredients have been developed in the various parts of world which are relished by customers [28]. Some examples of fruit and vegetables probiotic products are summarised in Table 2.

Table 2: Examples of fruit and vegetables probiotic products

Juice base	Probiotic strain	Reference
Red grape juice (Hardaliye)	*L. paracasei, L. casei subsp. Pseudoplantarum, L. brevis, L. pontis, L. acetotolerans, L. sanfransisco and L. vaccinostercus*	[29]
Pomegranate juice	*L. plantarum, L. elbrueckii, L. paracasei, L. acidophilus*	[30]
Tomato, Sugar beet and Cabbage juices	*L. plantarum, L. acidophilus and L. casei.*	[9,31-32]
Beet root and Carrot juice	*L. acidophilus.*	[33]
Carrot juice	*Bifidobacterium strains (B. lactis Bb-12, B. bifidum B7.1 and B3.2).*	[34]
Apple and Orange juice	*L. acidophilus and Bifdobacteriumbifidum.*	[35]
Peach juice	*lactic acid bacteria.*	[36]
Blackcurrant juice	*L. plantarum 299v*	[37]
Apple juice	*L.casei and L.plantarum ATCC14917*	[38,39]
Cherry juice	*L.plantarum ,L.casei, L.paracasei and L.rhamnosus*	[40]
Pumpkin juice	*L. reuteri*	[41]

Vegetables like cabbages, cucumbers and olives are used for the lactic acid fermentation which has an industrial significance [42,43]. A literature revealed the lactic acid fermentation of cabbages and olives for making sauerkrauts and table olives [44]. Table 3 shows some examples of traditional fermented vegetables which are manufactured in various worldwide regions.

Table 3: Examples of traditional fermented vegetables

Product	Source	Probiotic strain
Kimchi	Chinese cabbages (Brassica pekinensis) and radish, garlic, green onion, ginger, red pepper, mustard, parsley	*Leuc. mesenteroides, Leuconostockimchii, Leuconostoccitreum, Leuconostocgasicomitatum, Leuc. pseudomesenteroides, L. plantarum, L. brevis, L. curvatus, L. sakei, L. maltaromicus, L.bavaricus, P. pentosaceus, Weissellaconfusa, Weissellakimchii, Weissellakoreensis*
Cucumbers	Cucumbers, vinegar, salt	*Pediococcuspentosaceus*
Capers	Caper, water, salt	*L. plantarum, L. pentosus, L. fermentum, L. brevis, L.paraplantarum, Enterococcus faecium, P. pentosaceus*
Sinki	Radish roots	*L. fermentum, L. plantarum, L. brevis, Leuconostocfallax*
Khalpi	Cucumber	*L. plantarum , L. brevis , Leuc. Fallax, peddicoccus species*

Herbal plants

Medicinal herbs are used by 80% of the people living in rural areas as Primary healthcare system. Medicinal plants are gaining acceptance in society mainly due to nonexistence of side effects. Since the ancient times, herbs have been used not just as food flavourings, but also as medicine and preservatives. Nowadays addition of herbs in different food products has demanded because herbal plant have high medicinal and nutritive value. The fermented beverages prepared using medicinal plants are superior with respect to the antioxidant properties. Aloe vera pulp, due to its composition, is a food plant likely to promote the growth of probiotic agents [45]. It has long been used for the treatment and prevention of gastrointestinal diseases in several countries [46]. In the food industry, Aloe vera juice has been used for preparation of soft drinks with healthy nutritional qualities and tonics containing amino acids and minerals. Various nutritional bars, jams, yoghurts and dietary supplements are prepared by using Amla extracts. Owing to the growing global nutraceuticals and functional food market, the potential for amla extract as a food ingredient is increasing significantly. Increase in the demand of health drinks has given road for the development of various value-added beverages [47]. Wijemanna studied the Formulation of probiotic fruit drink using amla with Saccharomyces boulardii and Lactobacillus acidophilus with required cell count and good sensory qualities [48].Nagpal studied the effect of Aloe vera juice on growth and activities of *lactobacilli* in vitro [49]. The scientific data explaining the beneficial effect of lactic acid fermented beverage made from medicinal plants is scantily available.

CONCLUSION:

Ongoing trend of vegetarianism, issues of lactose intolerance and the demand for low-fat and low- cholesterol foods have created a rapid demand for the development of non-dairy probiotic products. Plant based food represent a suitable carrier for the delivery of probiotics. Since, plants sources are naturally rich in essential macro and micro-elements. Use of plant-based sources as a substrate for probiotic transfer makes a healthier product with high nutritional value. The present review is an effort to highlight the potential of plant-based sources as a suitable carrier for producing various non-dairy probiotic products.

ACKNOWLEDGEMENT:

We would like to pay our gratitude and respect to our guide Late Dr. N.S. Kulkarni, Associate Prof. at department of Microbiology, R.A. College, Washim for initiating and organizing the idea about writing this review article.

REFERENCES

1. Liu RH. Potential synergy of phytochemicals in cancer prevention: mechanism of action. J Nutr.2004. 134: 3479S–85S.
2. Ansari MM, Kumar DS.Fortification of food and beverages with phytonutrients. Food Pub Health2012; 2(6): 241-253.
3. Kumar Prevesh, Kumar Nirdesh, Omer Tushar.A review on neutraceutical critical supplement for building a healthy world. World J Pharmacy & Pharmaceutical Sci., 2016; 5(3): 579-594.
4. Jankovic, I., Sybesma, W., Phothirath, P., Ananta, E. and Mercenier, A. 2010. Application of probiotics in food products-challenges and new approaches. Current Opinions in Biotechnology 21: 175–181.
5. Shah N. and Prajapati J.B. 2013. Effect of carbon dioxide on sensory attributes, physico-chemical parameters and viability of Probiotic L. helveticus MTCC 5463 in fermented milk. Journal of food Science and Technology 51 (12):
6. FAO/WHO. 2001. Health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria. Cordoba, Argentina: Food and Agriculture Organization of the United Nations and World Health Organization Expert Consultation Report
7. Priya, M.D., and Khatkar, B.S. (2012). Effect of processing methods on keeping quality of aonla (Emblica officinalis Gaertn.) preserve. International Journal of Food Research, 20(2), 617-622.
8. Moraru D, BlancaI, Segal R. 2007. Probiotic vegetable juices, Food Technology 4, 87- 91.
9. Yoon K, Woodams E, Hang Y. 2004. Probiotication of tomato juice by lactic acid bacteria, The Journal of Microbiology 42, 315-318.
10. Kumar, B.V.; Vijayendra, S.V.N.; Reddy, O.V.S. Trends in dairy and non-dairy probiotic products—A review. J. Food Sci. Technol. 2015, 52, 6112–6124. [CrossRef]
11. Prado, F.C.; Parada, J.L.; Pandey, A.; Soccol, C.R. Trends in non-dairy probiotic beverages. Food Res. Int. 2008, 41, 111–123. [CrossRef]
12. Sridharan, S.; Das, K.M.S. A Study on Suitable Non Dairy Food Matrix for Probiotic Bacteria—A Systematic Review. Curr. Res. Nutr. Food Sci. J. 2019, 7, 5–16.
13. Santos, M. C. R. 2001. Desenvolvimento de bebida e farinha la´cteafermentada de ac¸a˜oprobio´tica a base de soro de leite e farinha de mandiocaporculturamista de Lactobacillus plantarum A6, Lactobacillus caseiShirotae Lactobacillus acidophilus. MSc thesis. UFPR: 106 pp.
14. Angelov, A.,Gotcheva, V., Kuncheva, R. andHristozova, T. 2006. Development of a new oat-based probiotic drink. International Journal of Food Microbiology 112: 75–80.

15. Gao, Y.; Hamid, N.; Gutierrez-Maddox, N.; Kantono, K.; Kitundu, E. Development of a probiotic beverage using breadfruit flour as a substrate. Foods 2019, 8, 214. [CrossRef] [PubMed]
16. Heperkan, D.; Daskaya-Dikmen, C.; Bayram, B. Evaluation of lactic acid bacterial strains of boza for their exopolysaccharide and enzyme production as a potential adjunct culture. Process Biochem. 2014, 49, 1587–1594. [CrossRef]
17. Muyanja, C.; Narvhus, J.A.; Treimo, J.; Langsrud, T. Isolation, characterisation and identification of lactic acid bacteria from bushera: A Ugandan traditional fermented beverage. Int. J. Food Microbiol. 2003, 80, 201–210. [CrossRef]
18. Blandino, A.; Al-Aseeri, M.; Pandiella, S.; Cantero, D.; Webb, C. Cereal-based fermented foods and beverages. Food Res. Int. 2003, 36, 527–543. [CrossRef]
19. Panghal, A.; Janghu, S.; Virkar, K.; Gat, Y.; Kumar, V.; Chhikara, N. Potential non-dairy probiotic products—A healthy approach. Food Biosci. 2018, 21, 80–89. [CrossRef]
20. Wacher, C., Can˜ as, A., Ba´rzana, E., Lappe, P., Ulloa, M. and Owens, J. D. 2000. Microbiology of Indian and Mestizo pozolfermentation. Food Microbiology 17: 251–256.
21. Tuorila, H. and Cardello, A. V. 2002. Consumer responses to an off-flavour in juice in the presence of specific health claims. Food Quality and Preference 13: 561– 569
22. Slavin, J.L.; Lloyd, B. Health benefits of fruits and vegetables. Adv. Nutr. 2012, 3, 506–516. [CrossRef]
23. Kandylis, P.; Pissaridi, K.; Bekatorou, A.; Kanellaki, M.; Koutinas, A.A. Dairy and non-dairy probiotic beverages. Curr. Opin. Food Sci. 2016, 7, 58–63. [CrossRef]
24. Peres, C.M., Peres, C., Hernández-Mendoza, A. and Malcata, F.X. 2012. Review on fermented plant materials as carriers and sources of potentially probiotic lactic acid bacteria—with an emphasis on table olives. Trends in Food Science & Technology. 26: 31–42.
25. Rößle, C., Auty, M.A.E., Brunton, N., Gormley, R.T. and Butler, F. 2010. Evaluation of fresh-cut apple slices enriched with probiotic bacteria. Innovative Food Science and Emerging Technologies. 11: 203–209
26. Sun-Waterhouse, D. 2011. The development of fruit-based functional foods targeting the health and wellness market: a review. Int J Food Sci Technol. 46: 899–920.
27. Gaanappriya, M., Guhankumar, P., Kiruththica, V., Santhiya, N. and Anita, S. 2013. Probiotication of fruit juices by Lactobacillus acidophilus. Int J AdvBiotechnol Res. 4: 72–7.
28. Corbo, M.R., Bevilacqua, A., Petruzzi, L., Casanova, F.P. and Sinigaglia, M. 2014. Functional beverages: the emerging side of functional foods commercial trends, research, and health implications. Comprehensive Reviews in Food Science and Food Safety. 13: 1192- 1206.
29. Arici, M. and Coskun, F. 2001. Hardaliye: Fermented grape juice as a traditional Turkish beverage. Food Microbiology. 18: 417–421.
30. Mousavi, Z.E., Mousavi, S.M., Razavi, S.H., EmamDjomeh, Z. and Kiani, H. 2011. Fermentation of pomegranate juice by probiotic lactic acid bactéria. World Journal of Microbiology and Biotechnology. 27: 123– 128.
31. Yoon, K.Y., Woodams E.E. and Hang, Y.D. 2005. Fermentation of beet juice by beneficial lactic acid bacteria. Lebensm.-Wiss. u.-Technol. 38: 73–75.
32. Yoon, K.Y., Woodams, E.E. and Hang, Y. D. 2006. Production of probiotic cabbage juice by lactic acid bacteria. Bioresource Technology. 97: 1427–1430. Received on 21-10-2015 Accepted on 26
33. Rakin, M., Vukasinovic, M., Siler-Marinkovic, S. and Maksimovic, M. 2007. Contribution of lactic acid fermentation to improved nutritive quality vegetable juices enriched with brewer's yeast autolysate. Food Chemistry. 100: 599–602.
34. Kun, S., Rezessy-Szabo, J.M., Nguyen, Q.D. and Hoschke, A. 2007. Changes of microbial population and some components in carrot juice during fermentation with selected Bifidobacterium strains. Process Biochemistry. 43: 816–821.
35. Marhamatizadeh, M.H., Rezazadeh, S., Kazemeini, F. and Reza, M. K. 2012. The study of probiotic juice product conditions supplemented by culture of Lactobacillus acidophilus and Bifidobacteriumbifidum. Middle-East Journal of Scientific Research. 11: 287-295.
36. Pakbin, B., Razavi, S.H., Mahmoudi, R. and Gajarbeygi, P. 2014. Producing probiotic peach juice. Biotech Health Sci. 1: e24683.
37. Luckow, T. and Delahunty, C. 2004. Consumer acceptance of orange juice containing functional ingredients. Food Research International. 37: 805–814.
38. de Souza NevesEllendersen, L.; Granato, D.; BigettiGuergoletto, K.; Wosiacki, G. Development and sensory profile of a probiotic beverage from apple fermented with Lactobacillus casei. Eng. Life Sci. 2012, 12, 475–485. [CrossRef]
39. Li, Z.; Teng, J.; Lyu, Y.; Hu, X.; Zhao, Y.; Wang, M. Enhanced Antioxidant Activity for Apple Juice Fermented with Lactobacillus plantarum ATCC14917. Molecules 2019, 24, 51. [CrossRef] [PubMed]
40. Ricci, A.; Cirlini, M.; Maoloni, A.; Del Rio, D.; Calani, L.; Bernini, V.; Galaverna, G.; Neviani, E.; Lazzi, C. Use of Dairy and Plant-Derived Lactobacilli as Starters for Cherry Juice Fermentation. Nutrients 2019, 11, 213. [CrossRef]
41. Semjonovs, P.; Denina, I.; Fomina, A.; Sakirova, L.; Auzina, L.; Patetko, A.; Upite, D. Evaluation of Lactobacillus reuteri strains for pumpkin (Cucurbitapepo L.) juice fermentation. Biotechnology 2013, 12, 202–208. [CrossRef]
42. Montet, D., Loiseau, G., Kakhia-Rozis, N., 2006. Microbial technology of fermented vegetables. In: Ray, R.C., Ward, O.P. (Eds.), Microbial Biotechnology in Horticulture, vol. 1. Science Publishers, Inc., New Hampshire, USA, pp. 309e343.
43. Rodrìguez, H., Curiel, J.A., Landete, J.M., de Las Rivas, B., de Felipe, F.L., GòmezCordovés, C., Mancheño, J.M., Muñoz, R., 2009. Food phenolics and lactic acid bacteria. International Journal of Food Microbiology 132, 79e90.
44. Hurtado, A., Reguant, C., Bordons, A., Rozes, N., 2012. Lactic acid bacteria from fermented table olives. Food Microbiology 31, 1e8.
45. Contreras-Pinzon M, Dominguez-Espinosa R, GonzalezBurgos A. Biotransformation process lactic Aloe vera juice. Sci Mag Tech Ed 2007; 22: 35-42.
46. Arguelles M, Borovoy J, Toussaint G, Garcia-Aranda J. Use of probiotics in children. Newslett. Med. Hosp. infantile de Mexico 2000; 57: 454-63.
47. Jain, S.K., and Khurdiya, D. S. (2004). Vitamin C enrichment of fruit juice based ready to serve beverages through blending of Indian gooseberry (Emblica officinalis). Plant Foods for Human Nutrition, 59(2), 63-66.
48. WijemannaN.D., Ravindra U.(2018).Amla as a potential substrate for production of probiotic drink. Original Research Article https://doi.org/10.20546/ ijcmas. 2018. 709.341
49. Nagpal R, Kaur A. Synbiotic effect of various prebiotics on in-vitro activities of probiotic lactobacilli. Ecology of Food & Nutrition 2011; 50: 63-68.