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V Jayalalitha
Assistant Professor, Veterinary University Training and Research Centre, Tiruchirappalli, Tamil Nadu, India

A Elango
Professor, Post Graduate Research Institute in Animal Sciences, Kattupakkam, Kancheepuram, Tamil Nadu, India

TR Pugazhenthi
Professor, Department of Dairy Science, Madras Veterinary College Chennai, Tamil Nadu, India

B Balasundaram
Assistant Professor, Department of Animal Genetics and Breeding Veterinary College and Research, Institute, Namakkal, Tamil Nadu, India

Correspondence
V Jayalalitha
Assistant Professor, Veterinary University Training and Research Centre, Tiruchirappalli, Tamil Nadu, India

Yoghurt: Ideal vehicle for healthy ingredients: A review

V Jayalalitha, A Elango, TR Pugazhenthi and B Balasundaram

Abstract
Functional food is a food which is not only satisfying the nutritional requirements of individual and also to meet out the consumer's health aspect. In such case the functional ingredients *viz*., probiotics, prebiotics, omega 3 fatty acids, herbs, fruit and vegetables are being incorporated in to the functional foods. This review is done about fortification of yoghurt with many healthy ingredients *viz*., probiotics, vegetables, fruits, whey proteins, cereal fibres, omega 3 fatty acids, phytosterols, iron and different herbs and their functionality was discussed. Physicochemical and sensory properties of fortified yoghurt were also discussed.

Keywords: Probiotic yoghurt, prebiotics, fruits, vegetables, omega3fatty acids, phytosterol, and iron fortification and herbal yoghurt

Introduction
Yoghurt is a fermented dairy product having much health benefits and therefore it is highly focused by dairy researchers. Combined effect of *Lactobacillus delbreuckeii bulgaricus* and *Streptococcus thermophilus* organisms are well defined in yoghurt by its flavor and texture. In addition, these two organisms are probiotic in nature and thereby exert maximum health benefits to consumers. Recent consumers are more interested towards functional food which is not only giving the nutrition; further it should give health benefits *viz*., cholesterol reducing, blood pressure in rhythm, antidiabetic etc. Health benefits of the yoghurt were proven in many of the studies. Still there is high scope to the researchers that yoghurt is ideal vehicle for healthy ingredients such as prebiotics, probiotics, herbs, antioxidants, vegetables, fruits, fibres, etc. Functionality of yoghurt can be improved by addition of fruit concentrates *viz*., apple, strawberry and other fruit yoghurts.

Probiotic yoghurt
Probiotics are generally considered as beneficial microbes which exert maximum health benefits when present into the human gut as live organisms. So far many clinical and *in vitro* studies conducted to prove the clinical effects such as immune modulation, angiotensin converting enzyme inhibition (Chen *et al*., 2007) [6], anti-cholesterol (Sudha *et al*. 2009, Mohamadshahi *et al*., 2014) [46, 33] anticarcinogenic Kailasapathy and Rybka (1997) [29], antiallergic, antidiabetic effect (Ejtahed *et al*., 2011, Y. Singh, 2013) [11, 52], gut disorders, protection of DNA and improvement in skin function etc. (The Harvard Medical School Family Health Guide, 2014) [48]. Still there is a challenge in dairy industry about viability of probiotics in yoghurt during processing and storage. According to FAO/WHO 2001 [13], Probiotic count in the food products at the level of 10^7CFU/ml to provide maximum benefits to the consumers. To make this level in the final product, addition of prebiotics and cryoprotectants is being done by the researchers. Microencapsulation is the best choice to improve the viability of probiotics by protecting them from unfavourable environment. (Mortazavian and Sohrabvandi, 2007, Ding and Shah, 2008 and Jayalalitha *et al*., 2012) [25, 34].
According to probiotic organisms, yoghurt culture itself Probitoic Organisms *viz*., *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. Additionally there are lot of probiotics in lactobacillus, Bifidobacterium species were tried to incorporate based on their beneficial effects. Further prebiotics are always combined with production of probiotic yoghurt to get symbiotic effect.

Fruit yoghurt

Yoghurt is enriched with fruits for nourishing its value according to locally available fruits and their nutritional or functional worth. Fruits are rich source of fibre, potassium, antioxidants, polyphenols and carotenoids. Additionally dietary fibre of the fruits can be acted as prebiotics for the organisms available in yoghurt. Hence combination of fruits and yoghurt combination is considered as functional food for many diseases like type 2 diabetes, cardiovascular disease and gastro intestinal disorders.

Avacodo fruit is rich in vitamin E and fibre content. Avocado pulp was incorporated at different levels and optimized at 8 % level (Gunawardhana and Dilrukshi, 2016). Banana and sapota pulp were attempted in probiotic yoghurt by Meenakshi *et al*., 2018 [49] in the aspect of improving the viability of yoghurt during storage days. They observed that banana yoghurt showed highest viability of probiotic count 21 X 10^8 cfu/ml of after 14 days of storage. Mango pulp was added in the yoghurt prepared with soy milk (Jayalalitha *et al*., 2015) [24]. Mango pulp (15%) masks the flavor of soy milk in yoghurt and improved fibre and protein value of yoghurt.

Baobab fruit is famous for its shelf life and excellent antioxidant which is available in African countries. Aluko *et al*., 2017 [4] studied in Tanzania about the physicochemical properties of baobab enriched yoghurt at different levels of pulp inoculation. He concluded that 10 percent addition baobab is preferred to prepare sensorily accepted yoghurt Joel Ndife, 2014 [28] experimented with different level of coconut cake addition in yoghurt and concluded that 30% of coconut enriched yoghurt had higher overall acceptability. Coconut enriched yoghurt had increased value of carbohydrate (14.62%) fibre (2.18%) and it is well said that nutritionally good quality yoghurt.

Jayalalitha *et al*., 2015 [24] improved the protein (7.12%) and SNF (14.31%) value of yoghurt by addition of 30% soy milk and masking the flavor of soy milk by addition of 15% of mango pulp.

Wibawanti *et al*., 2018 [51] incorporated the extract of exocarp of mangosteen in to goat milk yoghurt. Mangosteen is famous fruit of Indonesia. It improves the antioxidant activity of yoghurt when added at the level of 4%.

Krivorotova *et al*., 2017 [31] analysed the rheological and textural properties of yoghurt enriched with fructooligosaccharides and carbohydrates of artichoke Jerusalem flour. This tuber flour enriched yoghurt exhibited viscoelastic behavior.

Fibre enrichment

Dietary fibers can be incorporated into food for improving properties *viz*., texture, water- binding capacity, gel-forming capacity, sensory characteristics, fat replacer, and thickening effects (Abdul-Hamid and Siew Luan, 2000 and Wang *et al*., 2002) [1, 50]. Generally fibre can be acted as prebiotic in yoghurt and hence promoting the growth of probiotic and LAB present in yoghurt.

Fibers from different sources *viz*., oat, rice, soy, and maize (Fernández-García and McGregor, 1997) [14] apple, wheat or bamboo fibers (Staffolo *et al*., 2004) [44] and (Seçkin and Baladura, 2012) [54] date fiber (Hashim *et al*., 2009 and Gad *et al*., 2010) [19, 15] were used for enriching yoghurt.

Staffolo *et al*. (2004) [44] studied the rheological properties of different fibre enriched yoghurt and concluded that apple fiber fortification decreased yogurt compression values due to the formation of fiber aggregates that interfered with yogurt structure. Yoghurt fortified with wheat and bamboo fiber showed increased compression force and texture sensory scores. Firmness of the fortified yoghurt was preferable to consumers because of insoluble nature of the fibres.

Hashim *et al*., 2009 [19] incorporated the date fibre in to yoghurt and assessed the sensory qualities. He concluded that upto 3% level, date fibre can be fortified in to yoghurt without changing the sourness sweetness, firmness, smoothness and overall acceptability.

Sendra *et al*., 2010 [42] studied the rheological parameters of orange fibre incorporated yoghurt and revealed that increased fibre particle size improves the viscosity of yoghurt and prior pasteurization of fibre improved the gel matrix in yoghurt. Ibrahim and Khalifa, 2015 [21] revealed in their study that addition 4.5% of orange fibre in camel's yoghurt improves the texture, overall acceptability and probiotic growth and survival.

Guven *et al*., 2005 [18] studied the effect of inulin as fat replacer in low fat yoghurt and reported that, addition of inulin at more than 1 g/100 ml increased whey separation, inulin addition caused a decrease in organoleptic scores.

Dabijaa *et al*., 2018 [9] studied about the four fibre incorporation in to yoghurt *viz*., inulin, oat, pea and wheat in different levels. Fibre addition improves the viscosity of the yoghurt and in the aspect of consumer acceptance and texture 2.0% wheat addition followed by 2.5% pea fibre addition was optimized to develop fibre enriched yoghurt.

Vegetable enriched yoghurt

Vegetables are rich in minerals, many vital nutrients and antioxidant substances like Caroteinoids, polyphenols etc. In such a way biological antioxidants will be helpful in preventing chronic diseases by consuming vegetables and fruits.

Salwa *et al*., 2004 [41] developed carrot yoghurt and studied the chemical, microbiological and sensory properties. Consumer acceptance was very good from 5-20% level of inclusion of carrot juice in to yoghurt. Carrot juice addition increase acidity, decreased total nitrogen and total soluble nitrogen ratio and curd tension. Carrot juice prevented the growth of coliforms but there was no change in yoghurt bacteria.

Lejko *et al*., 2014 [53] developed the yoghurt with vegetables having antioxidant substances which reduces the cancer and cardiovascular diseases. Vegetables *viz* carrot, pumpkin, broccoli and red sweet pepper were added in the fermented yoghurt after initial cooling to 15-20 ^{0}C in the amount of 10% w/w. Prior to addition, these vegetables were treated for cooking, homogenizing and pasteurization. Antioxidant activity of the yoghurt was measured by FRAP (Ferric reducing antiradical power) and concluded that broccoli and red sweet pepper had shown highest ability to scavenge free radicals. Vegetables addition did not change the characteristics of the yoghurt and hence it can be enriched with vegetable mash for the sake of Healthy and nutritional point of view.

In general, syneresis value of fruit added yoghurt will be increased during storage days. (Kucukoner and Tarakci, 2003, Salwa *et al*., 2004 [47, 41], Salvador and Fiszman, 2004, Jayalalitha *et al*., 2015, Meenakshi *et al*., 2018) [24, 49].

Herbal yoghurt

"Food thy medicine" concept is emerging in consumers and

hence there is an arise of fortification of natural herbs in food. These kinds of yoghurt may not be consumed by all type of consumers due to deviation in colour, flavor and nutritional value. Though consumer acceptance is important to the needy people, researchers concentrated in different aspects *viz*., sensory qualities, consumer acceptance beyond the therapeutic effect of the herbal yoghurt.

Herbs are tried in to the yoghurt in many studies concentrated on delivering antioxidant activity, beta Galactosidase activity and any other significant clinical effect. In general, herbs are having the antimicrobial activity and may inhibit the growth of culture and probiotic bacteria. It is an advantage of that prevention of growth of pathogenic bacteria like coliforms.

Chowdhury *et al*., 2008 [7] experimented the probiotic yoghurt with different herbs *viz*., tulsi leaf (*Ocimum sanctum*), Pudina leaf (Mentha arvensis) and coriander leaf (Coriandrum sativum), separately and a 1:1 (v/v) mixture of the yoghurt mix for analyzing the beta Galactosidase activity. They found that among all the herbs tulsi exhibited the maximum beta Galactosidase activity.

Srivastava *et al*., 2015 [38] studied the antioxidant activity of the herbal yoghurt prepared with ginger rhizome and beetroot at varying levels from 0.5 to 2.0%. They concluded that ginger rhizome showed highest antioxidant activity (ferric reducing capability) in goat milk followed by Buffaloe milk and cow milk.

Govindammal *et al*., 2017 [16] incorporated aloevera gel in to yoghurt and observed the increased value of vitamin C content, phytonutrients, protein and fibre content. Further physico chemical properties and sensory evaluation studies revealed that aloevera incorporated yoghurt was good. Since aloe vera gel acted as stabilizer, syneresis value of aloe vera yoghurt was reduced and the texture of yoghurt improved. Panesar and Shinde 2012 [55] found that aloe vera gel incorporation improved the probiotic viability (10^9cfu/ml) in storage periods of yoghurt.

Kabuo *et al*., 2018 [3] enriched yoghurt with moringa olifera dried powder and optimized the level of addition as 1.0% w/v based on the sensory score and nutritional value. 1.5% addition of dried Moringa leaves powder in to yoghurt improved protein (49.85%), fat (2.5%) and total solids (21%) over the control yoghurt. General acceptability score for the moringa enriched yoghurt was recorded as 7.75 which was lesser than the control yoghurt and this may might be due to bitterness of the moringa leaves.

Azizkhani and Parsaeimehr, 2018 [5] developed the probiotic yoghurt supplemented with essential oils prepared from herbs *viz*., peppermint, basil and zataria for assessing the probiotic viability, antiradical activity and consumer acceptability. Their findings reported that all the essential oils improved the antiradical activity but in the sensory qualities peppermint and basil are good. Viability of the probiotics was not disturbed except Bifidobacterium species.

Ghosh, 2019 compared the tulsi and beetroot incorporated yoghurt at the level of 5% v/v. Though tulsi showed better antiradical activity, beetroot compromises both antiradical activity and sensory acceptance. It is observed that riboflavin and folic acid content were also improved by the addition of tulsi and beetroot in the yoghurt.

Protein enrichment in yoghurt

Yoghurt is always enriched with extra proteins to improve the textural properties and nutritional value. It improves the quality of low fat yoghurt by adding milk proteins, whey proteins as whey protein concentrates (WPC), Whey protein hydrolysates (WHC) etc. Protein source varied in different studies from milk, sea weed, spirulina and legume etc.

Roumanas *et al*. 2016 [40] assessed the biofunctional and rheological qualities of the yoghurt enriched with whey protein concentrates and whey protein hydrolysates. Fortification of whey protein concentrates did not affect the antioxidant properties in yoghurt, whereas whey protein hydrolysates enriched yoghurt showed the higher ACE (Angiotensing converting enzyme) inhibitory activity up to 21 days of storage. Water holding capacity of yoghurt enriched with WPC was higher when compared to yoghurt fortified with WHC throughout the storage.

Spirulina is rich source of protein and minerals and it can be consumed 10g/day (Henrikson, 1989) [20]. Spirulina can be used as food supplement for its Phycosyanin content which prevents the leukemia cell growth. Priyanka, 2011 [39] studied spirulina enrichment in ice cream and yoghurt with different level of addition from 0 to 0.5% and revealed that increased the value of protein, carbohydrate and iron value of yoghurt. Spirulina improves the viability of yoghurt cultures over the storage periods upto 15 days at 5 ^oC. 0.2-0.3% addition of spirulina gives the optimum sensory scores. Agustini *et al*., 2017 [2] studied physicochemical, microbial and sensorial properties of yoghurt enriched with Spriulina platensis. He inferred that 1% spirulina added yoghurt showed good sensory scores and had improved value of protein, viscosity and lactic acid bacteria count. Ihsanuddin, 2014 [22] also got high protein content in yoghurt with spirulina enrichement.

Chick pea water extract is added at 10% level in to the yoghurt and observed that antioxidant property was improved (Shori Amal Bakr, 2013) [43].

Omega 3 fatty acid enrichment

Omega-3 fatty acids are having health benefits *viz*., reducing risk of coronary heart disease, normal function of human brain and treatment against many diseases Consumption of fish oil is highly recommended and there is a necessity to fortifiy omega-3 fatty acids in regular foods. But the difficulty in fortification is poor water soluble nature of fish oil. Hence there is recommendation of nanoemulsion technology for fortification of omega fatty acids as fish oil in to foods. Though severe efforts taken to prepare omega 3 fatty acid enriched yoghurt, consumption vegetarian people is questionable.

Jinfeng Zhong *et al*., 2018 [27] fortified fish oil and oryzanol in to yoghurt by nanoemulsion technology and analysed the physico chemical properties. Fortification of fish oil improved the texture and reduces the syneresis value. This nanoemulsion technology lowered the peroxide value 0.28mmol/L after 21 days.

Estrada *et al*., 2011 [12] developed strawberry flavoured yoghurt fortified with microencapsulated solmon oil (2% W/V). This fortification of solmon oil did not disturb the pH and syneresis value of the yoghurt. But LAB count was reduced during the storage periods.

Iron fortification

Since milk products are having less or no iron content researchers are aimed to improve the iron value in dairy products. Calcium and iron will inhibit the absorption by each other. Fortification of iron in dairy products is highly complicated in the aspect of bioavailability due to the presence of high calcium. To avoid such inhibition and negative impact on sensory acceptability of the yoghurt, microencapsulation is necessary.

Jayalalitha *et al*., 2012 [25] fortified iron molecules and vitamin C in microencapsulated form. Vitamin C promotes the absorption of iron. Subash *et al*., 2015 and Nkhata *et al*., 2015 [45, 36] fortified encapsulated ferrous sulphate molecules in to yoghurt and pasteurized milk and revealed that no sensory attributes were changed but TBA values peroxide value were increased in fortified yoghurt.

Phytosterol fortification

Phytosterol is plant sterols which is having cholesterol lowering properties generally available as white colour powder, insoluble in water, soluble in alcohols and having melting point ranged from 100 to 215^{0}C in human studies. Consumption of phytosterols and/or Phytostanols @ 1.5-3.0 g/day reduced upto 10% of blood LDL-cholesterol (Katan *et al*. 2003; Demonty *et al*. 2009) [30, 10]. Nguyen 1999 [35] reported that 2-3 g of phytosterols esters per day consumption reduced total serum cholesterol and LDL cholesterol upto 6.4 and 10.1 %, respectively. But there are some adverse effects of phytosterols fortification in food *viz*., high melting temperature and chalky taste. Oil water emulsion based technology was used in studies where fortification done with phytosterols.

Volpe *et al.* 2001 [56] tested the effect of 1-2 g phytosterols per day as fortified low fat yoghurt based drink on patients suffering from hypercholesterolaemia. A total of 8 weeks period of study significantly reduced the cholesterol level. Clifton *et al*., 2004 [8] studied the effect of phytosterol fortification in different food for reducing the cholesterol using human subjects *viz*., milk, bread, cereal and yoghurt. They inferred that phytosterols in low fat milk and yoghurt was the best choice of fortification than bread and cereal. Since low fat yoghurt may be suitable vehicle for this functional ingredient, Izadi *et al*., 2015 Lee *et al*., 2007 Noakes *et al*., 2005 [23, 32, 37] focused phytosterol fortification in yoghurt. These are insoluble in water in nature and hence distribution of phytosterols was not uniform in to yoghurt.

Conclusion

Yogurt is healthy food having nutrients such as calcium, magnesium and potassium which protects from heart disorders and nerve related defects. It is best suited for developing immunity, for stronger bones and natural flora helps digestion. When yogurt enriched with active ingredients such as fruits, herbs, probiotics and prebiotics etc, it can be called super food with functional properties suitable for healthy life. Researchers keep on focusing yoghurt to develop it as low fat, low sugar/with artificial sweetener to keep attracting all type of consumers. Yogurt is highly growing product in dairy industry. This can be concluded that the yogurt is ideal vehicle for probiotics, prebiotics, fruits, vegetables, omega fatty acids, phytosterols, carbohydrates and other proteins. It could be served as a cheap and better food supplement of future.

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