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Effect of fortification on yogurt: A review

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Abstract
Yogurt is a fermented dairy product that is packed with beneficial bacteria that aid in overall wellness. Food fortification is the process of enhancing food by adding additional nutritional ingredients. Yogurt fortification has been done in an inventive way to appeal to the customer for years, and yoghurt acts as an excellent carrier for the fortification process. Yogurt consumption has increased globally as people become more health conscious. So yoghurt fortification and improvisation are still in the works. By fortifying yoghurt with vitamins, minerals, fruits, vegetables, pulses, and other nutrients, it encourages consumption and improves health without compromising the Physico-chemical and sensory properties of yoghurt, which are comparable to standards and acceptable. In this review article different kind of fortified yogurt along with their properties and acceptability will be discussed.

Keywords: Yogurt, fortified, vitamin, physicochemical

Introduction
Fermentation is a process that has been used for thousands of years to extend the shelf life of perishable foods while also improving the flavour and odour of the finished product. Yogurt and other fermented milk products (such as kefir and kumys), traditional alcoholic drinks, vinegar, and pickles are also popular in Middle Asian regions. (Gahruie, H.H *et al*. 2015) [6]
The word "yoghurt" is derived from the Turkish word "yogurmak," which means "Thickening, coagulation, or curdling." (Mauro Fisberg *et al*, 2015) [13]. Most regulatory agencies around the world consider yoghurt (also spelled "yogurt" or "yoghourt") to be a fermented milk product that contains digested lactose and particular, viable bacterial strains, usually *Streptococcus thermophilus* and *Lactobacillus bulgaricus.* Yogurt today is usually milk that has been fermented and acidified with viable and well-defined bacteria, resulting in a thickened, often-flavored product with a long shelf life. In addition to meeting nutritional needs, yoghurt has been linked to a lower risk of gastrointestinal disease, improved lactose intolerance (especially in children), and a variety of other diseases, as well as better dental and bone health and pregnancy outcomes. Yogurt may thus be an attractive dairy substitute for rising nutrient intake, increasing well-being, and preventing diseases in populations (Mauro Finberg *et al*, 2015) [13]
Fortification is the process of that add bioactive component (nutrients or non-nutrient) to edible products (e.g., food, food constituents, or supplements). Fortification can be used to correct or prevent widespread nutrient intake shortfalls and associated deficiencies, to balance the total nutrient profile of a diet, to restore nutrients lost in processing, or to appeal to Consumers looking to supplement their diet (Dwyer, J. T *et al*, 2015) [4]. Several micronutrients, including as riboflavin, vitamins B-6 and B-12, calcium, potassium, zinc, and magnesium, are found in larger concentrations in yoghurt when compared to other dairy products, such as milk.(Tremblay *et al*, 2017) [21].

Fortification with vitamins
Vitamins are being one of the necessary nutrient as they are vital role as precursor of for many for human body. Many research has been conduct on incorporation of vitamins into various foods products like salt, milk, yogurt etc.

Vitamin D
Vitamin A, vitamin D, folic acid, iodine, iron, and zinc oxide are added to yoghurt to give 20-30% of the RDA. Vitamin a (150 µg of retinol) fortification of yoghurt has no effect on pH, titratable acidity, or sensory qualities while refrigerated at 3 °C for 6 weeks. After28 days, adding micro or nanosized iron, zinc, or calcium to yoghurt had no effect on pH or titratable

acidity and even on viscosity. Vitamin D (3 µg of ergocalciferol (D3)) levels in yoghurt have been found to remain constant during manufacturing and storage (Gaur, S *et al.*, 2019) [7]. According to the findings of a fortification meta-analysis, the effect of vitamin D on the improvement of lipid indices in individuals receiving vitamin D from fortified foods was better than in those receiving it through supplementation. As a result, consuming vitamin D supplements with fat-containing foods to improve vitamin D absorption was suggested, which could increase fat intake from foods and negatively affect serum lipid. (Mostafaia *et al*, 2018) [18].

Fortification with minerals

The release of whey was lower in the fat-free plain yoghurts enriched with iron, selenium, and magnesium than in the control. The minerals chromium, magnesium, manganese, and molybdenum were found to have a positive effect on L* (lightness) values. Minerals at 25% of RDA (that are 15 mg of iron, 420 mg of magnesium, 15 mg of zinc, 5 mg of manganese, 200 mg of molybdenum, 200 mg of chromium, 70 mg of selenium per 170 g of yoghurt) were not added to yoghurts and had no effect on Flavour, appearance, or viscosity. (Achanta K *et al*, 2007) [1].

Iron

Each of the whey protein-chelated iron (Fe-WP) and the Fe-Casein complex (Fe-CN) was examined in three different concentrations (10, 20 and 40 milligrams per one kilogram me of milk). After 21 days in the refrigerator, their chemical experiments and organoleptic standards were examined, and the results were published. All of these iron compounds were shown to be appropriate for usage in yoghurt, however two complexes of iron, Fe-WP and

Fe-CN, were preferred of concentration 20 mg (N. Askary *et al*, 2013) [2].

Fortification with fibers

Date fiber

Dairy products are lacking in fiber content. Fiber is one of the component present in cell wall of fruits, vegetables, and cereals, (trowel, 1976) [22]. The impact of Date Fiber (DF) fortification upon quality of fresh yoghurt was explored. The experiment included plain yoghurt, yoghurt fortified with 1.5%, 3%, and 4.5% DF. Although the pH of the yoghurt was raised after fortification with Date Fiber, there were no substantial changes in the acidity. The addition of dietary fibre to yoghurt might enhance its beneficial properties. Plain yoghurt and yoghurt fortified with up to 3% DF had equal firmness, smoothness, sourness, and overall acceptance scores. This study found that fortifying yoghurt with 3% DF resulted in a satisfactory product with possible health benefits. (I. B. Hashim, *et al*, 2009) [8].

Fortification with pulses

Plain yogurt's caloric contribution to daily energy consumption is significantly smaller than its protein and calcium contributions. (Tremblay *et al*, 2017) [21].

Chickpea

Chickpea flour, which is high in protein and dietary fibres but low in fat, was added to yoghurt at various concentrations, and the addition of 1% and 2% chickpea flour improved the viscosity of stored yoghurt while having no effect on the colour values or sensory quality criteria of yoghurt.(Xi Chen, *et al*.2016) [3].

Mung bean

Yogurt fortified with mung bean paste (MBP) at concentration of 5%,10%,15%,20% and 25% were tested for physical, chemical and sensory property. Among the various levels of mung bean pastes, yoghurt supplemented with 10% MBP had higher organoleptic features, such as appearance, Flavour, and overall acceptance. During 28 storage period at 4 °C, yoghurt enhanced with 10% MBP exhibited overall satisfactory preservation ability. Yogurt had an appropriate pH and acidity range, and no signs of growth of yeast, moulds, or Coliform bacteria microbes were seen. (Priyadarshani, W. M. D., et al 2018) [15].

Fortification with dairy powder

Since of rising customer desire for healthy options across product categories, low-fat and fat-free yoghurts have grown in popularity. The texture and Flavour characteristics of low-fat and non-fat yoghurt must be carefully controlled. Skim milk powder (SMP), whey protein isolate (WPI), yoghurt texture improver (TI), and sodium caseinate (NaCn) are all examples of dry dairy powder. WPI fortification resulted in increased viscosity and lumpiness, as well as a lower level of yoghurt syneresis. Yogurts enriched with NaCn or TI, on the other hand, had a high viscosity and little syneresis. Fortification of yoghurts with NaCn and TI has a good effect on sensory Characteristics. (M. Isleten *et al*, 2006) [10].

Fortification with vegetables

Carrot

The encapsulating process was carried out by electrostatic extrusion after the isolation of carotenoids from carrot waste (CW) and thorough characterization. During the final step of yoghurt preparation, two concentrations of properly described CW beads (2.5 and 5 g/100g) were added to yoghurt. During a 28-day storage period at 4 °C, comparative analyses of control and fortified yoghurts were conducted. Yogurt fortified with both concentrations contributes to the necessary daily intake of - carotene. Overall, the enriched yoghurts' physico-chemical and microbiological properties were effectively preserved throughout storage. Because the encapsulating carotenoids significantly increased the antioxidant activity of the yoghurt, it can be used to create fortified yoghurt with high nutritional value. As higher concentration (5g) incorporation of carrot waste bead that has led to more significant yellowness when compared to 2g. (Šeregelj *et al*, 2021) [20].

Fortification with fruits

Pomegranate and jacaranda

Conjugated linolenic acids (CLnAs) are abundant in pomegranate (Punica granatum) as well as in jacaranda (Jacaranda mimosifolia) seeds, which are primarily pumice and jacaric acid, respectively. Both CLnAs are known to be powerful ant carcinogens, however they are rarely used in food production. Pomegranate and jacaranda seeds (PS and JS, respectively) and seed oil were described, and seed powder was used to enrich yoghurt with bioactive lipids. PS and JS both had similar fibre and lipid levels. Unsaturated fatty acids dominated the seed oil fatty acid (FA) profile (87–89%), while CLnA concentration ranged from 31 to 69 percent (for JS and PS, respectively). In comparison to JS oil, PS oil had a greater scavenging activity and phenolic

concentration. Yogurt fortified with 0.5 percent (w/v) PS or JS flour had identical nutritional and pH characteristics to the control, but had better antioxidant activities, preferable FA and CLnA contents, and reduced atherogenicity indices. Overall, both bio-fortified yoghurts were well received (Van Nieuwenhove *et al*, 2019) [3].

Apple

In comparison to the control(pH 5.3), adding 1 percent Apple Pomace(AP) (w/w) before fermentation enhanced casein micelle aggregating at an initial stages of fermentation, resulting in one set of gelation at a high pH (5.9).upto 0.5% of AP no effect was noticed. Raising the AP concentration from 0 to 1 percent under cold storage (28 days) resulted in a considerable increase in gel stiffness and cohesiveness, showing that the structural of a undisturbed casein gels was reinforced (Wang, X *et al*, 2019) [24].

Fortification with others

Rose

Rose is added to yogurt in the form of rose petal extract (RPE). RPE has been effectively used in the production of yoghurt as a unique and appealing food addition. The addition of RPE to the fortified yoghurt enhanced various Physico-chemical parameters, including WHC and TPC, as well as lowering syneresis while storage. RPE were added at 0.1, 0.3 and 0.5g/100g of skim milk solution. As of in appearance (colour) there was no significant difference between control and 0.1% RPE enriched yogurt. RPE also boosted the antioxidant capacity indicating that RPE-enriched yoghurt had health-promoting qualities. Furthermore, the addition of RPE to the yoghurt samples had a substantial impact on the scent and taste profiles, and also the sensory scores. Among all the yoghurt samples evaluated, the yoghurt fortified with 0.1 per cent RPE had the maximum sensory scores and the greatest taste profile. (Qi, L et al, 2021) [16].

Aloe Vera

Aloe Vera is indeed one of the world's oldest known therapeutic plants. Aloe Vera, also known as the miracle plant, has numerous names. The major goal was to see how varying doses of Aloe Vera affected the sensory as well as microbiological qualities of yoghurt. Different levels of Aloe Vera were used to make yoghurt (12, 14, 16 and 18 per cent). Completely Randomized Design was used to statistically analyses the data. The yoghurt with 14 per cent Aloe Vera added had the greatest overall sensory acceptance score. (Mukhekar, A, *et al*, (2018) [14].

Red ginseng

Incorporation of red ginseng extract to yogurt with *Lactobacillus acidophilus* and *Streptococcus thermophilus* as culture. Red ginseng extract were added to yogurt at various level (0.5, 1, 1.5, and 2%). The Physico-chemical of yogurt samples were measured such as lactose, protein, total solids, and ash content on first day of fermentation has resulted in increased with increase in level of extract, whereas moisture content and fat content were decreased. Treatable acidity of yogurt has showed increased with storage and pH decreased cause lowering of *L. acidophilus* and *S. thermophiles* cell count. The antioxidant activity was estimated as diverse methods. The red ginseng fortified yogurt had higher activity when compared with plain yogurt. This stating that extract of red ginseng had reduced the fermentation time and increased antioxidant activity (Jung *et al*, 2016) [11].

Lotus leaf

Yogurt enriched with lotus leaf as it is rich in phenolic components. Lotus leaf powder was supplemented with various concentrations (0.2%, 0.5%, and 1%) to yogurt. Effect on Physico chemical properties, total phenolic content (TPC), and antioxidant activity of yogurt were measured. Storage studies were evaluated for 14 days under refrigerated condition. Viscosity of all fortified with lotus leaf powder were more than of control yogurt ($p>0.05$) where 0.2% fortified had highest value of viscosity. Enrichment of lotus leaf powder improved water holding activity (WHC) by 1.5 times than of control. Total phenol content of yogurt increased gradually along with of lotus leaf powder and also increased continuously during storage. 1% enriched yogurt showed highest values on 14th day was 61.94±1.68 mg GAE/g. Increase in the concentration led to increase significant ($p>0.05$) in DPPH radical scavenging activity. These results explained that lotus leaf can be used as a natural ingredient for improving the antioxidant activity and phenolic quality of yogurt (Kim et al 2019) [12].

Purslane

The yogurt was fortified with purslane extract at different level (0.5, 1, 1.5 and 2%). Fortified yogurt was subjected to assessment of physicochemical properties like treatable acidity, pH, syneresis, antioxidant properties and viscosity) and sensory evaluation (colour, odour, taste, texture and overall acceptability). Shelf life studies were conducted at weekly intervals for Physicochemical and sensory properties of yogurt. Statistical analysis found that treatment and storage duration had a significant impact ($p>0.05$) on physicochemical properties and sensory evaluation. The yogurt fortified with 2% of extract had showed lower acidity when compared to others even during storage also has showed significant effect on acidity. With addition of purslane extract to yogurt lowered the syneresis where 1.5% has showed lowest among all levels. Similarly with increase in concentration of extract significantly increased the viscosity. Whereas antioxidant of fortified yogurt with extract had not significantly higher to that of control, only 2% was highest among them. During storage antioxidant activity reduced with time. Sensory evaluation analysis showed that overall acceptability decreased with time. The formulation for fortification of yogurt was 2% extract had considered to be best and also provide good source of functional components for yogurt enrichment (Salehi *et al* 2021) [20].

Table 1: Effect of various component of yogurt

Component	Incorporated concentration	Suggested concentration	Results	Reference
Vitamin D	1000 IU vitamin D	1000 IU	Consumption of fortified yogurt has increased vitamin D levels in body.	Mostafaia *et al*, 2018. [18]
Whey protein chelated Iron	10mg, 20mg and 40mg	20mg	It offer around 15% of the required daily iron intake for women according to United States.	N. Askary *et al*, 2013. [2]
Iron Casein complex	10mg, 20mg and 40mg	20mg	It offer around 15% of the required daily iron intake for women according to United States.	N. Askary *et al*, 2013. [2]
Date fiber	0%, 1.5%, 3%, and 4.5%	3%	The fortified yoghurt produced a satisfactory product with possible health benefits.	I.B. Hashim, *et al*, 2009. [8]
Chick pea	1%, 2%, 3% and 5%	2%	It is possible to increase the protein content of yoghurt without harming the product's quality or sensory attributes.	Xi Chen, *et al*, 2016. [3]
Mung bean	5%, 10%, 15%, 20%, 25%	10%	Showed excellent overall storage capacity throughout 28 days of storage period.	Priyadarshani, WMD, *et al*, 2018. [15]
Carrot	2.5g and 5g	2.5g and 5g	Carrot waste beads fortification in yogurt yield adequate level of βcarotene.	Šeregelj *et al*, 2021. [20]
Pomegranate	0.5%	0.5%	The major CLnA in pomegranate seed is punicic acid along with remarkable health benefits	Van Nieuwenhove *et al*, 2019 [23]
Jacaranda	0.5%	0.5%	Jacaranda seed is a one-of-a- kind source of jacaric acid that is naturally ready for human use.	Van Nieuwenhove *et al*, 2019 [23]
Apple	0.1%, 0.5% and1%	0.5%	In comparison to the others, the yoghurt fortified with 0.5 percent apple pomace had the best stable structure throughout a 28-day storage time.	Wang, X *et al*, 2019 [24]
Rose	0.1g, 0.3g and 0.5g	1%(0.1g)	Suitable for the customers demand, as well as providing health benefits. As it has great consumer acceptance.	Qiu, L *et al*, 2021 [16]
Aloe Vera	12%, 14%, 16% and 18%	14%	From the perspective of health and nutrition, aloe Vera yoghurt is good to society.	Mukhekar, A, *et al*, (2018) [14].
Red ginseng	0.5%, 1%, 1.5%, and 2%	1.5%	Reduced fermentation period and improved antioxidant property even water holing capacity increased.	Jung *et al*, 2016 [11]
Lotus leaf	0.1%, 0.2%, 0.5%, and 1%	1%	Phenolic property and antioxidant property improvised	Kim *et al*, 2019 [12]
Purslane	0.5, 1, 1.5 and 2%	2%	Good source of functional compounds for yogurt	Salehi *et al*, 2021 [19]

Conclusion

In order to reduce the risk of micronutrient deficiency, fortification of food products is necessary. Nowadays, people are more concerned about eating nutritious food products in order to live a balanced and healthy life. The primary goal of developing novel food products is to ensure that they include adequate nutritious components. Since yoghurt is a popular probiotic and prebiotic dairy product that may be ingested on a regular basis, yoghurt innovation will benefit society and the economy both.

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