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Enrichment of phytochemicals in dairy products: A review

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Abstract

Dairy enrichment will effectively reduce or prevent diseases associated with nutritional deficiencies because of the high rate of usage of these products. Natural antioxidants are beneficial to human health, and a substantial amount of them may be found in plant materials. They also include a large number of vitamins, micro and macro minerals, essential oils, phenols, saponins, and phytochemicals (tannins, flavonoids, and alkaloids). They are essential to the food chain as preservatives, antioxidants, flavorings and even have therapeutic properties. Plant-based materials are abundant in phytochemicals, which have been shown to have numerous positive effects on human health beyond only providing food. In an effort to satisfy growing customer needs, food researchers and producers are becoming more interested in creating unique food products that use phytochemicals, either in their raw or extracted form. Dairy products and milk, which are fundamental commodities for human development, can strengthen consumers oxidative defenses in a number of ways. Food investigators have traditionally used dairy products to gauge customer preferences for product innovation. This will encourage the food and dairy industries to use more plant-based resources and to develop drinks and nutraceuticals. This analysis examined the significant plant-based ingredients found in traditional dairy products from India. Dairy products that have been fortified with various plant sources have greater nutritional and medicinal benefits. Additionally, it makes it possible to create dairy products with added value.

Keywords: Phytochemical, dairy product, fortification, plant based sources, health benefit

1. Introduction

Plants generate substances known as phytochemicals. Since "phyto" means "plant," they can be found in other plants as well as fruits, vegetables, grains, and beans. Phytochemicals are biologically active organic molecules that are found in plants that humans eat and may be good for your health, but no specific human deficit has been linked to them [99]. The consumption of phytochemicals has been linked to a lower risk of several chronic diseases, partly because of their ability to scavenge free radicals and act as antioxidants. Additionally, recent studies have demonstrated their possible contribution to enhanced arterial blood flow and endothelial function [6]. The term "plant chemicals" refers to phytochemicals. Numerous phytochemicals that are present in fruits, vegetables, whole grains, nuts, seeds, and beans have been determined by scientists to number in the thousands. Consuming a diet high in phytochemical-rich plant foods may help prevent at least one in five incidences of cancer and other major illnesses including heart disease. An increasing body of research is demonstrating the health advantages of phenolic phytochemicals, which are prevalent micronutrients found in fruits and vegetables [61]. Bioactive components that maintain or improve health and arise from the nexus of the food and pharmaceutical sectors are known as phytochemicals, and they are important to nutraceuticals.

The term "plant chemicals" refers to phytochemicals. Numerous phytochemicals that are present in fruits, vegetables, whole grains, nuts, seeds, and beans have been determined by scientists to number in the thousands. Consuming a diet high in phytochemical-rich plant foods may help prevent at least one in five incidences of cancer and other major illnesses including heart disease. An increasing body of research is demonstrating the health advantages of phenolic phytochemicals, which are prevalent micronutrients found in fruits

and vegetables [61]. Bioactive components that maintain or improve health and arise from the nexus of the food and pharmaceutical sectors are known as phytochemicals, and they are important to nutraceuticals. There has been some evidence in recent years supporting the involvement of particular phytochemicals found in plant foods in preventing the beginning of diseases including cancer and heart disease. [99]. Although synthetic antioxidants have been added to food as antioxidants, their carcinogenic effects have made them less acceptable [14, 84]. The search for naturally occurring antioxidants in food is gaining popularity as a means of defending the body against free radical damage, delaying the onset of many chronic illnesses, and preventing lipid oxidative rancidity in food [45]. Other natural and secure food antioxidant sources, such as fruits, vegetables, and plants in general, can take the place of artificial antioxidants [82]. The growth of microbes, particularly infections that compromise food safety, and natural deterioration processes are both strongly suppressed and prevented by phytochemicals. [71] Pharmaceuticals, agrochemicals, flavors, scents, coloring agents, biopesticides, and food additives are only a few uses for phytochemicals [76].

2. Types of phytochemicals

Although almost 10,000 distinct phytochemicals have been identified, many more are currently unidentified [6]. Foods include hundreds of different phenolic chemicals, including flavonoids and non-flavonoids (phenolic acids, stilbenes, and lignans). [62] Based on the outcomes of experimental models, the primary antioxidants that are advised include flavonoids, carotenoids, ascorbic acid, and tocopherols [78]. [66] Moreover, diets high in flavonoids, carotenoids, and other compounds linked to an increased risk of type 2 diabetes in middle-aged and older women. [69, 104] Regarding flavonoids antioxidant action, the 3-hydroxyl group plays a very important role [39]. Primary metabolites of phytochemicals include proteins, amino acids, common sugars, chlorophylls, and the purines and pyrimidines of nucleic acids. Primary metabolites of phytochemicals include proteins, amino acids, common sugars, chlorophylls, and the purines and pyrimidines of nucleic acids. The remaining plant compounds, known as secondary metabolites, include curcumines, alkaloids, terpenes, flavonoids, lignans, plant steroids, saponins, phenolics, and glucosides. [35] One of the biggest classes of phytochemicals found in crops are polyphenols. Approximately half of the thousands of phenolic structures that have been found are members of the flavonoid class. The subclassification of flavones, isoflavones, flavanones, catechins, and anthocyanins exists within this class. Polyphenols have been studied in a variety of in vitro and in vivo systems. They have biological properties like antioxidant and anti-inflammatory properties. [85, 22, 96] by polyphenols, the biggest subgroup of which are flavonoids; seven flavonoids were found. Carotenoids, polyphenols, isoprenoids, phytosterols, saponins, dietary fibers, and certain polysaccharides are a few of the important phytochemicals. Numerous grains, fruits, and vegetables contain flavonoids.

3. Variety of plant-based foods

Plant-based meals, such as grains, fruits, and vegetables, are rich in bioactive phytochemicals that may lower the chance of developing chronic illnesses. Micronutrients and

phytochemicals are two examples of bioactive dietary components that work synergistically to produce the health benefits linked to phytochemical consumption. The general consensus is that whole plant-based diets, which contain mixtures of several phytochemicals, have higher protective effects than single, isolated phytochemical components [106]. [41] 20,000 of the over 200,000 phytochemicals that are currently known to exist come from fruits, vegetables, and grains. [76] Emphasize the nutritious value of millet and investigate different milk and milk products that have been supplemented with millets, as well as creative dairy cuisine ideas. [54] Phytochemicals, particularly polyphenols found in fruits, vegetables, berries, drinks, and herbal remedies, may adjust dysregulated lipid and glucose homeostasis, lowering the risk of consequences from type 2 diabetes and the metabolic syndrome. [21] Food ingredients like strawberry fruit are frequently added to dairy products in order to boost their functionality and antioxidant potential.

Numerous disorders can be prevented or treated with foods that contain phytochemicals as a constituent (functional foods) or the concentrated form of phytochemicals (nutraceuticals). [55] turmeric, a spice included in baked dishes and dairy products. Curcumin has low light stability but is somewhat cheap and heat stable [98]. Either raw or processed, fruits and vegetables are considered to be one of the main dietary sources of phytochemicals for humans. Storage-related adjustments in basundi supplemented with jaggery were considered by [30, 71]. Often known as phytonutrients, phytochemicals are naturally occurring bioactive substances that are abundant in whole grain products, legumes, fruits, vegetables, tea, nuts, and seeds, and dark chocolate. Only a small percentage of the tens of thousands of phytochemicals present in plants have been extracted and identified [17, 93].

4. Health benefits of phytochemical compounds

Numerous health benefits, such as decreased risks of cardiovascular and renal illness, anti-aging treatments, improved brain function, a lower glycaemic index for diabetics, enhanced satiation, and cancer prevention, have been linked to phytochemicals. The antioxidant qualities of plant extract not only shield the product from deterioration but also inhibit the activity of free radicals in the human body, slowing down the aging process. [97] Green plants differ in color due to the presence of different pigments such as chlorophyll, carotenoid, other pigments, and water content [53]. Phytochemicals have the potential to offer health benefits that stop or postpone the development or progression of chronic diseases in humans and animals, independent of the nutrients they contain [33, 38]. The majority of phytochemicals are characterized by antioxidant properties [31, 4] diets high in fruits, vegetables, and spices have been linked to a decreased risk of degenerative diseases, including diabetes [14].

Unlike carbs, lipids, proteins, vitamins, and minerals, phytochemicals and zoochemicals are not thought to be necessary for life and are hence classified as quasi-nutrients [28]. A dietary pattern that emphasizes fruits, vegetables, and whole grains is linked to a lower risk of type 2 diabetes. [97] Phytochemicals, or secondary metabolites from plants, are thought to be significant for human health. Advantages include defense against oxidative stress and inflammation as well as a decrease in the risk factors for long-term illnesses like diabetes, cancer, heart disease, and neurological

diseases. [26] Mothers and babies are strengthened and shielded from oxidative damage and associated illnesses by phytochemicals. [96] The main classes of phytochemicals, which include phenolics, tannins, alkaloids, and terpenoids, include antimicrobial, anti-inflammatory, antioxidant, anti-cancerous, detoxifying, immunity-promoting, and neuropharmacological properties. They can also be used to prevent disease. In order for phytochemicals to be beneficial to human health, they must be physiologically significant enough to reach their target areas. [93] Plant foods such as fruits, vegetables, grains, and other plant-based bioactive components called phytochemicals have been associated with a lower risk of major chronic diseases [83].

It has been demonstrated that consuming fruits and vegetables high in antioxidant phytochemicals increases serum and plasma antioxidant capacity. For instance, eating spinach, red wine, strawberries, or vitamin C greatly raised the levels of plasma and serum total antioxidant capacity in older women. [16] phytochemicals with health advantages include preventing diabetes, obesity, cancer, cardiovascular illnesses, and more. Examples of these phytochemicals include carotenoids, polyphenols, isoprenoids, phytosterols, saponins, dietary fibers, and polysaccharides. As a result, phytochemicals are becoming more and more common. Strong antioxidant properties and antibacterial, antidiarrheal, anthelmintic, antiallergic, antispasmodic, and antiviral properties are displayed by phytochemicals [55, 87]. [65] researched and examined the government's dietary recommendations from the past and now.

5. Phytochemicals in dairy industry

There has been a successful description of the functional application of many herbs, spices, fruits, and vegetables in various forms (e.g., powder, fresh, extract, essential oils, etc.) in several dairy products.

5.1 Fermented dairy product

While adding cinnamon did not alter the yoghurt's fermentation process, it did promote the growth of *Lactobacillus* species when stored in a refrigerator [11]. [7] found that adding water extracts of *Allium sativum* and Cinnamon *umverum* to goat, cow, and camel milk did not significantly alter the fermentation-induced acidity. When compared to natural yogurt, [40] discovered that adding cinnamon powder to yoghurt boosted its total phenolic content and radical scavenging activity. [36] included roselle extract and *L. acidophilus* for making yoghurt made from goat milk. [1] shown how the use of herbal extracts increased the acidity of yoghurts and facilitated the fermentation of milk by yogurt bacteria. [94] made stirred dahi with strawberry fortification. [29] A product containing 30% more strawberry cryoconcentrates had increased levels of antioxidant activity and anthocyanins. *Allium sativum* (garlic) and Cinnamomic *verum* (Ceylon cinnamon) aqueous extracts (concentration of 0.1 g/mL) were added to cow and camel milk yogurts, and the results were examined for their impact on *Bifidobacterium bifidum* survival after 21 days of chilled storage and following simulated gastrointestinal digestion [8].

The addition of 2% red ginseng extract to milk and yoghurt increased the levels of radical-scavenging activity and oxygen radical absorption capacity [74]. Probiotic dahi enhanced with herbs and made by [42] using aloe *barbadensis* miller. revealed that yoghurt and fuzhuan brick-tea (FZT)

boosted each other's proteolytic and B-galactosidase activity [57]. The addition of 0.5% Ashwagandha powder to shrikhand improved organoleptic consistency, and at refrigeration temperature, the product remained acceptable for up to 52 days, according to FZT, which also reported reduced syneresis, improved viscosity, and total counts of *Lactobacillus acidophilus* and *Streptococcus thermophilus* [56]. The three herbal lassi varieties with the highest sensory scores were carrot, turmeric, and ginger, at levels of 2%, 1%, and 15% (v/v), respectively. Additionally, it was noted that the lassi fortified with turmeric had the maximum phenolic content when compared to the lassi fortified with ginger and carrot, which had a 9-day shelf life at refrigerator temperature [59].

5.2 Fat rich dairy product

Ghee's shelf life was extended by arjuna bark when it was stored at 8°C in comparison to the control sample [73]. adding 0.6% of pulsi leaf powder (*Ocimum sanctum*) to creamery butter ghee [64]. [52] conducted research on the shelf life of ghee and included 1.5% of betel vine (*Piper betel*) leaves in it. [26] reported that butylated hydroxy toluene was less efficient than thyme and cumin essential oils in preventing the degradation of butter kept at room temperature. [77] successfully increased the ghee's oxidative stability by combining alcoholic and aqueous extracts of the Satavari herb. [75] assessed the ghee's coriander extract's antioxidant capacity. In comparison to the control sample, they believed that coriander extract improved the oxidative stability of ghee during storage.

5.3 Heat acid coagulated dairy product

Assessed the antioxidant potential of ginger (*Zingiber officinale* L.), mint (*Mentha spicata* L.), and beet (*Beta vulgaris*) in a dairy treat called sandesh, which is a heat-desiccated form of coagulated milk protein mass known as chhana. [10] Herbal Sandesh had a longer shelf life after adding herbal coriander, keeping it at 30±1°C and 7±1°C, respectively, for up to 8 days and 30 days [9]. [47] Adding mint and coriander to paneer at a weight level of 10% increased both the product yield and the overall acceptability score. When chilling paneer, adding 0.4% clove essential oil to the chilled water was found to be an effective way to slow down the rate at which the concentration of free fatty acids (FFAs) increased when compared to control paneer [48]. Research on the sensory qualities and process standardization of buffalo milk paneer combined with unrefined turmeric extract (*Curcuma longa* L.) [49] When making paneer paneer, adding cinnamon, cardamom, and black pepper prolonged its shelf life [25].

5.4 Frozen dairy product

Ginger (both juice and chunks) added to ice cream to add taste. Ginger juice was added to the ice cream mixture at ratios of 3, 4, and 5%, along with pieces at 4, 6, and 8%. The resulting ginger ice cream was then compared to a vanilla-flavored control [79]. [63] examined the appropriate amount of curcumin to use as a natural coloring ingredient in ice cream and assessed the finished product's sensory attributes. They discovered that the ideal amount of curcumin powder to add to the ice cream recipe was 0.5%. [12] investigated the impact of varying Piper betel leaf concentrations on the physico-chemical characteristics of ice cream. [34] The structure hardened in strawberry ice cream-

style frozen yogurt simultaneously with an increase in strawberry percentage.^[101] who assessed basil as a flavoring agent for ice cream in two specific forms: juice and powdered dried basil. (0.0, 2, 4, 6, and 8%) basil juice and (0.0, 0.5, 1.0, 1.5, and 2.0%) basil powder were used to make the ice cream.

5.5 Heat desiccated dairy product

Milk contains some flavonoids as well. By preventing lipid peroxidation, these antioxidant components preserve the quality of milk^[110]. In response to growing consumer demand for functional foods, food researchers and producers are becoming more interested in creating novel food products that use phytochemicals, either in their raw or extracted form.^[99, 60] investigated how adding particular plant extracts affected the physicochemical, phytochemical, antioxidant activity, and consumer acceptability of yoghurt. They found that adding the plant extract significantly raised the yoghurts' antioxidant activity, as shown by an increase in polyphenol content.

In order to prepare garden cress seeds Burfi,^[60, 50] investigated how garden cress seeds form. According to^[72], adding 10% of ber powder boosts Burfi's sensory quality, antioxidant activity, and overall phenolic content. Plant components added to yogurt during fermentation are a useful way to boost antioxidant intake and therapeutic value, which may lower the chance of chronic illness development. Reviewing the effects of adding the right plant materials to yogurt in order to create unique functional yogurt with antioxidant characteristics is the goal of this study^[91]. Research has demonstrated that in order to obtain the intended antibacterial effect, the concentration of essential oils in semi-skimmed milk should be about doubled^[46].

The effects of yoghurt fortification with grape seed, thyme, green tea, and mint on physicochemical, rheological, textural, and sensory properties during cold storage had been reported^[15].

Betalains and anthocyanins are used as colorants for fruit preparations, dairy products, ice creams, confectionery, pet-foods, soups, sauces, beverages, and drinks.^[99, 83] observed incorporation of 0.09% (w/v of milk) heartwood extract during the preparation of khoa, increases the shelf life of peda. Tocopherols are used as antioxidants in butter oil (ghee), anhydrous milk fat spreads made of dairy fat and blended spreads, with a 500 mg/kg maximum^[5]. Natural plant-based antioxidants, including phenolic compounds, tocopherols, ascorbate, rosmarinic acid, and catechin, have been employed extensively in food manufacturing. However, peptides and protein hydrolysates from fermented dairy products are now considered to be natural antioxidants^[92]. created a healthier appeal for the consumer by utilizing green tea extracts to prepare dairy products including fried snacks, ice cream, confections, and quick noodles^[109, 44]. Dietary polyphenols are just one of the many endogenous and exogenous substances that the whey proteins can bind with^[108].

The impact on production metrics and milk efficiency in dairy cows of dietary phytochemicals (tannins and species of *Capsicum*) as rumen modifiers^[32]. The majority of the isoflavone-rich soy protein's nutraceutical uses are in dairy-type goods including milk-soy, soy drinks and beverages, yogurts, and dairy desserts.^[99] The purpose of this study is to compare the phytochemical-rich crude pomegranate juice to more widely used fruits like mango and strawberry in

terms of how they affect the properties of yoghurt drinks^[3]. A burgeoning corpus of nutritional science elucidates the intricate mechanisms and pleiotropic pathways behind the varied cardiometabolic impacts of dietary components. Among them, the fields of dairy, which includes milk, yogurt, and cheese, and flavonoids, which are bioactive phytochemicals included in plant foods, are seeing some of the most fascinating developments.^[68] Following their extraction from a variety of sources, phytochemicals are widely used in the creation of nutraceuticals and functional foods^[90].

5.6 Cheese

Using the (DPPH) free radical scavenging assay, researchers evaluated the lipid peroxidation and antibacterial properties of five spice and herbal extracts (cinnamon stick, oregano, clove, pomegranate peel, and grape seed)^[86, 8]. They also ascertained the antioxidant activity of individual spices, such as black pepper, black cumin, and clove. These spices were combined to create a unique cheese called Mudaffara.^[58] investigated how *Nigella sativa* oil added at 0.1% and 0.2% (w/w) affected the reduction of food-borne pathogens inoculated in cheese during storage. Raw cows' milk was used to make the cheese, and all cheese groups were matured for 90 days.^[19] determined the influence of herb (*Allium* sp.) on biochemical changes of herby cheese containing 0, 0.5, 1, 2, and 3% herb made in Turkey^[88].

All samples of broccoli-cheese powder blended contained more total polyphenols than the plain conventional cheese powder.^[23] As the concentration of spinach powder grew, so did the samples of cheese in terms of total solids, protein levels, and acidity.^[67] When compared to the control sample, cheese that contains carrot paste has higher quality, antioxidant activity, vitamin A content, and Na/K ratio.^[20] As the concentration of grape extract increased, the syneresis of milk gels decreased, producing cheese with a high moisture content.^[13] investigated the antibacterial activity of five extracts from spices and herbs (clove, oregano, grape seed, pomegranate peel, cinnamon stick, and oregano) against room-temperature strains of *Salmonella enterica*, *Listeria monocytogenes*, and *Staphylococcus aureus* in cheese.

6. Conclusion

In a conclusion, a variety of phytochemicals, such as some vitamins, flavonoids, terpenoids, carotenoids, phenolics, phytoestrogens, minerals, and antioxidants found in plant materials, may be employed as substitute preservative agents in the food and dairy industries to control postharvest physiological disorders or microbial pathogen injuries of fresh fruit and vegetables. Additionally, registered dietitians and other healthcare professionals consistently advise consuming a balanced diet that consists of a variety of fruits, vegetables, legumes, whole grains, and legumes. The focus of much of the study on phytochemicals found in fruits, vegetables, and cereals has been on their potential to prevent diseases brought on by oxidative stress. These phytochemicals have anti-oxidant properties, scavenge free radicals, and may prevent apoptosis or cell death. The goal of this review article is to identify the food additive of plant materials that has an impact on the phytochemical, antioxidant, physiochemical, and sensory properties of dairy products. These antioxidant components prevent lipid peroxidation and maintain milk quality. Functional milk

products have the potential to expand the application of endangered species of plant food material in the dairy industry.

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