Chapter

Herbs and Spices Fortified Functional Dairy Products

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Abstract

Recently, an increased interest in exploiting the functional and medicinal health attributes of herbs and spices has been observed worldwide among the health conscious consumers to preserve and promote the health and nutrition and immunity particularly during the Covid-19 pandemic era. Fortification of dairy products with these herbs and spices so as to exploit the functional and medicinal attributes have also gained momentum. Herbs and spices are rich source of bioactive compounds such as anti-oxidants, vitamins, micro- and macro-minerals, phytochemicals like flavonoids, alkaloids, glycosides, tannins, essential oils, coumarin, organic acids, phenols and saponins. Milk and other dairy products have been popular compatible vehicles for delivering functional, nutritional and other health benefits of phytochemicals of herbs and spices among the consumers. This chapter explores the quality and functional attributes of herbs and spices fortified dairy products such as herbal spiked milk, curd and yoghurts, paneer, cheese and ice creams and other dairy products.

Keywords: bioactive compounds, herbs and spices, dairy products, functional foods, antioxidants, phytochemicals

1. Introduction

Food habits and disease prevention have a clear link; the effects of food on diseases including diabetes, obesity, osteoporosis, hypertension, and cardiovascular disease have been reported in the literature [1]. The indigenous knowledge of traditional medicinal plants are becoming more widely recognized around the world. Since it is the world's largest producer of traditional medicinal herbs, India is considered as the "Botanical Garden of the World" and "Land of spices" [2]. Herbs and their extracts have been used to fortify foods as preservatives, flavorings, medicinal agents, and food additives throughout history [3]. Consumer knowledge and interest in adding herbs to dairy and food products to enhance dietary strategy and balanced nutrition for achieving health benefits from foods beyond providing basic nutrition has increased worldwide as a result of the advent of functional foods, and consequently, the demand for value-added functional foods has grown worldwide [4]. Since India is the world's largest producer of milk, a significant amount of liquid milk is utilized for traditional dairy products. Incorporating herbal bioactives into conventional Indian dairy products facilitate to compete in the global functional food market, which is growing at a rapid pace [5].

2. Herbs and their classification

Herbs and spices are plants or parts of plants, mostly leaves and seeds, that are used for their taste, flavor, aroma, and imparting color in food products, or for medicinal and functional properties. These are cultivated primarily in temperate and tropical climates and harvested to be used as flavorings or seasonings [6]. The diverse phytochemicals and bioactive compounds present in herbs and spices give additional nutraceutical, medicinal and functional health benefits. In addition to leaves and seeds, spices may be derived from different other parts of the plant such as bark, buds and flowers, fruits and seeds, rhizomes and roots, or sometimes the complete whole plant tops [7]. Although, the term 'spice and 'herbs' are used interchangeably, 'herb' is considered as a subset of spice and refers to plants with aromatic leaves with medicinal and functional health benefits. In addition to taxonomic classification, herbs and spices have been classified according to seasonality and lifespan, based on usage and applications and on the basis active principles and functional and medicinal properties present in them. Classification of herbs based on their seasonality and lifespan, usage and bioactive phytochemicals present in them has been presented in **Table 1** [6, 8].

Classification	Properties	Examples
According to the usage		
Medicinal herbs	Curative and healing properties and used as pharmaceutical and therapeutical purposes.	Tulsi, sage, pepper mint, rosemary, thyme, asparagus, *Aloe vera*, garlic, cinnamon leaf, neem, brahmi, ashwagandha, amla, malabar nut, coriander, ginger, onion etc.
Culinary herbs	Have strong flavors and/or imparts color in food and thus used in cooking.	Borage, chives, mint, parsley, basil, dill, thyme, sage, oregano, chervil, paprika, turmeric, saffron etc.
Aromatic herbs	Have pleasant smelling flowers or foliage and used for aroma.	Lemon verbena, clove pink, lavender, bergamot, myrtle, scented geranium, sweet violet, rose etc.
Ornamental herbs	Used for decoration and Ornamental purposes.	Chives, lavender, chicory, yarrow, jewelweed, rosemary, chamomile, thyme, sage, feverfew etc.
According to the active constituents		
Aromatic herbs	Owing to the presence of volatile essential oils, they have a good odor and are widely used both therapeutically and as flavorings. These are of two types:	
	Stimulant Herbs: Increases the body's energy and movements, and most commonly affects the digestive, respiratory, and circulatory systems.	Capsicum, damiana, fennel, garlic, ginger, peppermint, sage, thyme, catnip, feverfew, lemon grass, penny royal etc.
	Nerving Herbs: These are used to relieve and heal the nervous system, but these also have an impact on the digestive, respiratory, and circulatory systems.	Chamomile, crampbark, dong quai, ginger, hops, lobelia, skullcap, valerian, catnip, lady's slipper, and sarsaparilla etc.
Astringent herbs	They have an impact on the digestive, circulatory, and urinary systems because of astringent components including tannins.	Bayberry, comfrey, eyebright, golden seal, peppermint, red raspberry, slippery elm, white oak, white willow, black walnut, crampbark, mullein, and penny royal etc.

Classification	Properties	Examples
Bitter herbs (phenolics, saponins, and alkaloids)	The presence of phenols and phenol glycosides, alkaloids, or saponins, and are classified into subcategories such as laxative herbs, diuretic herbs, digestive herbs etc.	Aloe vera, blessed thistle, yam root, cascara, licorice, pumpkin, senna, yellow dock, yucca, barberry, gentian, safflowers, and golden seal etc.
Mucilaginous herbs	Polysaccharides give mucilaginous herbs their properties, including a smooth, mild flavor that tastes sweet in water. They aid in the removal of toxins from the digestive system, as well as its regulation and the reduction of bowel transit time.	Althea, aloe vera, burdock, comfrey, dandelion, echinacea, fenugreek, kelp, psylium, slippery elm, dulse, konjak root, Irish moss, and mullein etc.
Nutritive herbs	Provide carbohydrates, and fats, as well as vitamins and minerals.	Banana, barley grass, bilberry, broccoli, grapefruit, hibiscus, lemon, oat straw, onion, red clover, apple, asparagus, banana, barley grass, bilberry, broccoli, cabbage, carrot, cauliflower, spirulina, stevia, wheat germ etc.
According to seasonality and lifespan		
Annuals	Complete their life cycle in one season within a year	Anise, basil, borage, calendula (pot marigold), chamomile, chervil, cilantro/ coriander, dill bouquet, dill dukat, fennel, smoky, marjoram, parsley, shiso, saffron, summer savory etc.
Biennials	Grow for more than one season	Caraway seeds, prime rose, bai zhi, mullein, teasel, viper's bugloss, angelica, caraway, clary, watercress, and parsley etc.
Perennials	Which live for two seasons and only bloom in the second.	Alfalfa, allspice, aloe vera, angelica, avens, bee balm, bay leaves, catnip, chamomile, common thyme, dill, echinacea, fennel, lavender, lemon balm, mint: spearmint/ peppermint/ applemint/ orangemint, marjoram sweet, mitsuba, oregano, rosemary, stevia, salad burnet, sage, tarragon, watercress, yarrow etc.

Table 1.
Classification of herbs based on their usage and applications, active principles in them and their seasonality and lifespan.

3. Functional properties of herbs

Herbs and their extracts have been shown to be beneficial to one's health. Flavonoids, polyphenols, phenolic acid, terpenoids, sulphides, carotenoids, coumarins, lignans, saponins, curcumins, phthalides, and plant sterols are only a few of the natural bioactive compounds found in it. These naturally occurring bioactive compounds shows several biological effects such as antimicrobial, anti-inflammatory, antioxidant, antiallergic and antihypertensive effects [9]. Herbs are very high in natural antioxidants. Antioxidants are substances that inhibit or prevent the oxidation process. Synthetic antioxidants, such as butyl hydroxy anisole or butylhydroxytoluene, are commonly used in the food industry to prevent the deterioration of food quality (including the degradation of lipids, carbohydrates and proteins). Such antioxidants, on the other hand, are volatile and easily decompose at high temperatures, and their ingestion may pose serious health risks. Herbal phytochemical based natural antioxidants are currently in high demand among consumers, owing

Common name	Scientific name	Bioactive components	Functional and medicinal properties
Basil	*Ocimum basilicum*	Phenolic acids (rosmarinic acid & caffiec acid), flavanol glycosides (quercetin & kaempferol), anthocyanins	Anti-asthmatic, anti-stress, gastric anti-ulcer activity, antioxidant, antibacterial, anti-fungal, antiviral, anti-mutagenic, antitumor and immuno-stimulant activities.
Aloe vera	*Aloe barbadensis miller*	Aloin, emodin, lupeol, auxins, gibberellin, Vitamins A, C & E (antioxidants)	Antibacterial, antiviral, antiseptic, analgesic wound healing, anti-inflammatory gastroprotective, antitumor.
Arjuna	*Terminalia arjuna*	Flavonoid and phenolic content, sitosterol	Antioxidant & free radical scavenger activities, heart tonic for healthy cardiovascular system, lowers blood cholesterol.
Sage	*Salvia triloba*	Phenolic acid, flavonoids	Anti-oxidative properties and anti-inflammatory activities.
Ashwagandha	*Withania somnifera*	Steroidal lactones, alkaloids and flavonoids	Antitumor, respiratory stimulant activities and immuo-stimulating effect.
Pudina leaf	*Mentha sp.*	Menthol, mint L-carvone, essential oils	Digestive health, natural coolant and mouth-freshener
Coriander leaf	*Coriandrum sativum*	Essential oils, linalool	Rich in antioxidant, help lower blood sugar, fight infections, and promote heart, brain, skin, and digestive health
Rosemary	*Salvia rosmarinus*	p-cymene, linalool, thymol	Rich source of antioxidants and anti-inflammatory compounds, help to boost the immune system and improve blood circulation.
Origanum	*Origanum vulgare*	carvacrol, β-fenchyl alcohol, thymol, rich in phenolic content	Antibacterial agent, reduction of asthma, cramping, diarrhea, and indigestion.

Table 2.
Some important herbs commonly used for development of functional dairy products, their bioactive components and functional and medicinal properties.

to concerns about the safety of synthetic antioxidants. Antioxidant properties are demonstrated by phenolic compounds found in herbs [10, 11]. Herbal bioactive compounds have also been shown to prevent or reduce the risk of degenerative diseases such as diabetes, cancer, obesity, and cardiovascular disease [12].

Polyphenols are plant secondary metabolites which work as antioxidants, scavenge free radicals and protects against cancer, cardiovascular disease, asthma, infection, and diabetes. Based on the number of phenol rings and the structural elements that hold these rings together, polyphenols are divided into 4 groups; phenolic acids, flavonoids, stilbenes and lignans. Acid fruits contain phenolic acids, which are further divided into hydroxyl benzoic and hydroxyl cinnamic acids [13]. Flavanoids are a form of polyphenol that is abundant in the human diet and is responsible for the attractive colors of flowers, fruits, and leaves [14]. Flavonoids are classified into six classes, as flavonols, flavones, flavanones, flavanols, anthocyanins, and isoflavones. Plant stilbenes are antifungal phytoalexins. Many studies confirms that supplementation of polyphenol-rich herbs with a healthy diet can help prevent coronary heart disease, reduce cancer cell growth, and have anti-diabetic effects [13].

The antimicrobial properties of herbs can effectively regulate the growth of spoilage and pathogenic bacteria in dairy products. Phenolic compounds are the main antimicrobial compounds found in herbs, and they can be used as effective replacements for artificial antimicrobial agents used in food production. Some pathogenic bacteria (*Salmonella enteritidis, Listeria monocytogenes*, and *Staphylococcus aureus*) and fungi have been found to be inhibited by phenolic compounds such as tea catechins, coumaric acid, ellagic acid, oleuropein, and ferulic acid [15]. Furthermore, the essential oils present in various herbs contains bioactive compounds which shows antimicrobial properties in addition to anti-inflammatory, anticarcinogenic, and a variety of other beneficial health promoting activities [16]. The use of synthetic chemical additives in food processing pose several health risks and these essential oils may be used to substitute these synthetic additives **Table 2** [17].

4. Application of herbs in milk and other functional dairy products

4.1 Milk

Recently the demand for milk fortified with herbs and spices has increased due to their therapeutic effects and health benefits. Kumar Gaur et al. reported that herbal milk containing tulsi juice, turmeric powder and ginger juice) was rich in antioxidants and total phenolic content which enhanced the shelf life of the product in addition to imparting the typical herbal flavor, improved sensory quality and consumer acceptability due to their various potential health benefits such as anticarcinogenic. Cardio-protective, anti-inflammatory and anti-microbial [18]. Pathur et al. reported that tulsi flavored herbal milk has improved sensory attributes and overall acceptability, enhanced keeping quality with good antioxidant properties when compared with normal milk [19]. Jankar et al. developed ready-to-serve turmeric-flavored milk by combining milk and turmeric powder. Turmeric is high in antioxidants and has anti-inflammatory, anticarcinogenic, immunomodulant along with several other medicinal, and nutritional properties. Turmeric blended milk relieves cough and cold symptoms, as well as headache and wound pain [20].

Kamble et al. [21] formulated flavored milk with different varieties of piper betel leaves. *Piper betel* leaves popularly known as Paan in India, are dark green heart-shaped aromatic leaves of the Piperaceae family. The leaves, which are widely used for mastication, are rich in aromatic volatile oils, phenols, and the alkaloid arakene, which act as a stimulant for muscular and mental efficiency. Piper betel leave flavored milk was reported to have good consumer acceptability [21]. Pugazhenthi and Jothylingam developed dietetic herbal flavored milk with 5% aloe vera pulp extract and artificial sweeteners such as aspartame and sucralose. The physico-chemical properties of dietetic herbal flavored milk were within the standard ranges, with a small rise in protein content when aspartame was added. Furthermore, the content of almost all minerals increased slightly, which could be due to minerals found in aloe vera pulp [22]. Kishore et al. tested medicinal herbs like fennel, tulsi, and lemongrass oil in herbal-flavored milk. They reported several functional health benefits of this flavored herbal milk due to tulsi, which decreases the risk of heart disease, soothes fever, headache, and sore throat; and fennel, which aids in blood purification, improves eyesight, lowers blood pressure, and reduces fiber, while lemongrass oil has antioxidant, anti-bacterial, and gastric ulcer-prevention properties [23].

Sawale et al. developed *Pueraria tuberosa* added herbal milk. The content of hydroxy methyl furfural (HMF), ethanol stability, and lightness of the herbal milk decreased, whereas the functional properties of milk, redness and yellowness, and antioxidant activity increased. They reported that the inclusion of *Pueraira tuberosa*

may be ideal for the preparation of low heat-treated functional dairy food products [24]. Similarly, Vaquil et al. formulated a flavored milk with wheat grass juice added at a 12:1 milk-to-juice ratio in double toned milk with good quality characteristics and acceptability. The study indicated that, adding wheat grass juice increased the chlorophyll content and extended the shelf life by up to 15 days [25]. Rathod et al. prepared flavored milk by the inclusion of ginger juice which increased total solids, acidity, solid not fat, and ash content, while protein, fat, moisture, and pH decreased as the amount of ginger juice increased. On the basis of overall acceptability and sensory qualities, it was determined that flavored milk made with 96 parts milk and 4 parts ginger juice with 5% sugar was the most appropriate [26].

4.2 Yoghurt, Dahi and Lassi

Herbal supplemented yoghurts were formulated with potential multifunctional health benefits to consumers. Chowdhury et al. developed herbal yoghurts with a variety of herbal leaves, including tulsi (*Ocimum sanctum*), pudina (*Mentha arvensis*), and coriander (*Coriandrum sativum*). The yoghurt was made by combining pretreated herbal leaves with uniform milk containing *L. acidophilus* and *L. plantarum* strains (1:1 v/v) and incubating at 40°C for 6 hours. They observed that the presence of herbs in yoghurt did not affect the probiotic population and there was not any significant difference in total titratable acidity and in pH during storage. However, as compared to control yoghurt without any herbs, herbal yoghurt had higher -D-galactosidase enzymatic activity. They reported maximum β-D-galactosidase activity in tulsi incorporated yoghurt [27]. Similarly, Ghosh observed that tulsi extract and beetroot extract (level of 5%) with yoghurt had more nutritional benefits than natural yoghurt. They reported that folic acid and riboflavin content were improved in the yoghurt by the addition of tulsi and beetroot. Moreover, tulsi shows better antiradical properties in yoghurt [28].

There is growing experimental evidence for the use of aloe vera as nutraceutical and functional attributes as it contains important nutrients and essential minerals, bioactive compounds with several health benefits and immune modulating effects. Incorporation of aloe vera gel in yoghurt improves the functional properties and therapeutic values. In a study conducted by Govindammal et al. reported that adding 15% aloe vera gel to yoghurt increased overall acceptability based on sensory evaluation. When compared to plain yoghurt, the addition of aloe vera gel increased protein, fiber content, phytonutrients (such as steroids, anthroquinones, saponins, and phlabotannins) and showed an improvement in vitamin C. Aloe vera also served as a stabilizer, lowering the syneresis value of aloe vera yoghurt and improving the texture [29].

The effect of garlic (*Allium sativum*) and cinnamon (*Cinnamomum verum*) in three types of milk (cow, goat, and camel) on the growth and activity of Lactic Acid Bacteria and proteolytic activity during yoghurt fermentation was investigated by Shori and Salihin [30]. The presence of herbs increased the amount of lactic acid bacteria and proteolytic activity in cow, goat, and camel milk yoghurt during fermentation, according to the report. In another study, cinnamon powder fortified yoghurt was found to contain phenolic acids, flavonols, and cinnamaldehyde. The cinnamon-fortified yoghurt contains just 34.7 percent of the total phenolic compounds found in the cinnamon yoghurt water, with the remaining compounds bound to milk proteins. The *in vitro* digestion of cinnamon-fortified yoghurt resulted in the release of phenolic compounds from milk proteins, resulting in a higher amount of phenolic compounds recovered in the cinnamon-fortified yoghurt at the end of the digestion. Furthermore, adding cinnamon to yoghurt increases its radical scavenging behavior significantly. The yoghurt matrix also improves gastrointestinal stability and cinnamon polyphenol bio-accessibility. These findings

demonstrate that cinnamon-fortified yoghurt can be a valuable source of dietary bioavailable polyphenols [31].

Azizkhani and Parsaeimehr indicated that addition of essential oils extracted from herbs such as peppermint, basil and zataria in probiotic yoghurt increases the antioxidant activity, antiradical activity and consumer acceptability [32]. Similarly, yoghurt made with *Rosmarinus officinalis* oil (0.14, 0.21, 0.29, and 0.36 g/L) was found to have improved flavor and texture in addition to microbiological and physicochemical properties [33]. Herbs like ginger and beet root, which contain high antioxidant properties and are beneficial to human health. In another study, the antioxidant role of herbal yoghurt was investigated by Srivastava et al. who observed that adding ginger or beet root extracts (2%) to the goat, cow and buffalo milk yoghurt modified the antioxidant properties of the herbal yoghurt. The highest antioxidant properties were found in ginger rhizome goat milk yoghurt and beet root extract goat milk yoghurt, followed by cow and buffalo milk herbal yoghurt [34]. Herbal yoghurt made by fortification with peppermint (*Mentha piperita*), dill (*Anethum graveolens*), and basil herbal extracts (*Ocimum basilicum*) were found to be rich in antioxidant activity, proteolytic activity, bioactive compounds, and improved angiotensin-1 converting enzyme inhibition (ACE) [35]. Among these herbs, peppermint yoghurt had the strongest inhibitory impact on ACE activity and proteolytic activity during fermentation and storage of yoghurt [35].

Addition of *Moringa oleifera* leaves powder (1.0–1.5% w/v) to yoghurt improved the nutritional profile of the yoghurt indicated by increased protein, fat and total solids content of the herbal yoghurt over the plain yoghurt [36]. However, the overall acceptability of the moringa enriched yoghurt was lesser than the plain yoghurt might be due to bitterness of the moringa leaves [36]. In another study conducted by Elbagory et al., it was observed that pomegranate peel extract and *Moringa oleifera* leaves extract could be used to improve the antibacterial, functional, and nutritional properties of yoghurt. During the storage times, it was discovered that a concentration of 2% of both pomegranate peels and *Moringa oleifera* leaves had the greatest inhibitory effect against the E.coli O111:H2 (EHEC O111:H2) population. They concluded that ethanolic extracts of pomegranate peels and *Moringa oleifera* leaves could be used to preserve yoghurt and enhance its consistency [37]. Similarly, addition of roselle extract to goat milk based yoghurt had significant antimicrobial activity of probiotic in yoghurt which enhanced the ability to inhibit both gram negative and gram positive bacteria due to the presence of peptides [38].

Labneh a concentrated yoghurt, is a traditional Middle Eastern food. According to studies, adding 0.2 ppm of thyme, marjoram, and sage essential oils to labneh increased its shelf life at 5°C. When stored at 5°C, the control Labneh (without essential oil) showed the presence of yeast and mold from the 14th day onwards [39]. Zaky et al. observed that adding 2 μL/100 ml milk of dill and caraway essential oils to labneh enhanced the flavor, shelf life, and organoleptic properties, especially taste and odor. Dill and caraway essential oils are both antioxidant and antimicrobial agents that are safe to use. The use of these essential oils aided in the development of total volatile fatty acids (TVFAs), which gradually increased in treated samples during storage. Furthermore, the contents of acetaldehyde and diacetyl in treated samples reached their highest levels after 14 days of storage, then gradually decreased until the end of the storage period. El-Sayed et al. investigated the antimicrobial properties of *Moringa oleifera* oil-fortified labneh. They observed that *Moringa oleifera* oil has a high percentage of oleic acid, antioxidant activity, and phenol content, and that it has greater antimicrobial activity against Gram-positive bacteria (*Bacillus cereus, Staphylococcus aureus* and *Bacillus subtilis*), Gram-negative bacteria (*Escherichia coli, Yersinia enterocolitica, Salmonella typhimurium, Listeria monocytogenes and Pseudomonas aeruginosa*), Yeast (*Saccharomyces cerevisiae*) and

other three fungal strains. According to the study, adding *Moringa oleifera* oil to labneh increased total solid, fat, total volatile fatty acid, DPPH scavenging activity, tocopherols, and total lactic acid bacterial counts. The sensory properties of labneh samples improved and received higher scores as the ratios of *Moringa oleifera* oil were increased. With the addition of *Moringa oleifera* oil, however, the protein, ash, acidity, and water soluble vitamins content of labneh decreased concomitantly [40].

Dahi and lassi are traditional fermented milk beverages that have gained widespread popularity in India and several other countries. Many studies have found that supplementing lassi and dahi with aloe vera (*Aloe barbadensis Miller*) improves immuno-protective properties, improves growth of a probiotic strain and increases health benefits [41]. Similarly, lassi fortified with ginger (2%), turmeric (1%), and carrot extracts (15%) (v/v) helps to deliver phytochemicals and other nutrients for health benefits in our nutrition food system. The functional benefits of lassi are enhanced by the inclusion of probiotic microorganisms and antioxidant-rich herbal juices, which are the body's primary defense system for neutralizing free radicals and preventing damage [42].

4.3 Butter and ghee

The addition of herbal extract to ghee was influenced by growing customer understanding of food ingredients. Foods fortified with herbs that have inherent antioxidant properties are used in particular for people who suffer from Cardio Vascular Diseases (CVDs) [43]. The most commonly used extracts in ghee, according to Ozcan et al. are Sage (*Salvia officinalis*) and Rosemary (*Rosmarinus officinalis*). Antioxidant properties are higher in sage and rosemary extracts than in synthetic antioxidants [44]. According to Najgebauer et al. adding 2 percent dried herbs (sage or rosemary) to butter made from sour cream improved oxidative stability by delaying lipolysis in butter during storage [45]. Furthermore, Farag et al. observed that butter infused with thyme and cumin essential oils was more effective than the synthetic antioxidant butylated hydroxyl toluene in preventing its oxidation when kept at room temperature [46]. Similarly, Merai et al. found that adding 0.6 percent tulsi (*Ocimum sanctum*) leaf powder to creamery butter ghee resulted in ghee with equal stability to ghee containing 0.02 percent butylated hydroxyl anisole for one week at high storage temperature. Tulsi leaves are also thought to have the potential to extend the oxidative stability of ghee [47].

The effects of sage, rosemary, and oregano extracts on butter stability were investigated by Ahmet et al. They came to the conclusion that these extracts were more effective than BHA at stabilizing butter against oxidation. When stored at 5°C, sage extracts at 0.02–0.05 percent proved to be the most effective in stabilizing butter samples [48]. Renata et al. tested the oxidative stability of butter with added phenolics from rosemary herbs. The study found that rosemary alcoholic extract has the highest antioxidant properties measured in both DPPH radical inhibition and malondialdehyde (MDA) quantification assays, as well as no cytotoxicity. This suggests that using rosemary alcoholic extract as a natural antioxidant is effective, as it achieved the highest oxidative stability of butter when applied to butter at temperatures of 60 and 110°C, with a concentration of 400 mg of phenolic compounds per kg of butter. This reflected at the lowest formation of degraded peroxides from lipids [49].

Currently, the herbs incorporated ghee is advertised as medicinal ghee in India and around the world. In a clinical study conducted by Rajanikant and Patil, it was discovered that incorporating functional attributes of *Terminalia arjuna* in ghee provides beneficial effects against cardiovascular diseases, and that this product had excellent potentiality to act as a free radical scavenger, as well as improved the shelf life of ghee when compared to traditional ghee [50]. According to Parmar

and Khamrui's research, combining 7% arjuna alcoholic extract with ghee made from creamery buffalo butter yielded the highest phytosterol content and sensorial properties [51]. The vasa ghee, which helps to reduce the risk of asthma, is another health-promoting herbal ghee. Vasa ghee is made with the aid of the Malabar nut or vasa (*Adhatoda vasica*). The anti-asthmatic effects of vasa ghee are due to a component called vasicinone, which is an anti- asthmatic agent found in this plant [52].

Using the carotene bleaching assay, DPPH assay, and Rancimat procedure, Nilkanth et al. evaluated the antioxidant activities of ashwagandha (*Withania somnifera*), vidarikand (*Pueraria tuberosa*), and shatavari (*Asparagus racemosus*) extracts in both aqueous and ethanolic forms and compared them to BHA. The phenolic content and antioxidant activities of ethanolic extracts of herbs were found to be higher than those of their aqueous extracts. The ethanolic extracts of the herbs were more effective than the aqueous extracts in preventing the growth of the peroxide value and conjugated diene in ghee. Free radical scavenging activity was improved when ghee was combined with an ethanolic extract of herbs. Vidarikand's ethanolic extract had the highest antioxidant activity of all the plants, followed by ashwagandha and shatavari. Herbs may thus be used as a natural antioxidant because they have health benefits as well as the ability to preserve food [53].

4.4 Ice cream

Trivedi et al. reported that incorporating *Ocimum sanctum* leaf juice extract or freeze dried leaf powder in ice cream mix resulted in very high market acceptability due to potential functional properties. Furthermore, adding basil juice or powder to ice cream had no effect on the amount of overrun [54]. Kumar et al. conducted research to produce ice cream with various levels (2–4%) of tulsi extract. When tulsi extract is added, fat, protein, reducing sugars, non-reducing sugars, and total solids all decrease proportionately but the herbal ice cream has good acceptability among the consumers [55].

In order to exploit the medicinal and functional health benefits of aloe vera, particularly fir diabetic patient, Ankush Verma standardized the process of development of ice cream with various levels of aloe vera and mint. The reported that 90 percent of ice cream mix, 10% aloe vera, and 0.05 percent mint extract earned the highest sensory ranking, with the best chemical characteristics (maximum total solids, acidity, protein, carbohydrate, and ash), and the best microbial analysis (SPC and negative in coli type test), suggesting that ice cream has good storage stability [56].

Pinto et al. [57] prepared ginger ice cream with 4, 6, and 8% ginger shreds in the ice cream mix and compared it to a control made with vanilla flavoring. The addition of ginger shreds resulted in a decrease in compositional attributes such as fat, protein, sugars, total solids, and pH, as well as an increase in acidity, which was particularly true at higher levels of shred addition. However, at higher levels of ginger shred addition, acidity, viscosity of ice cream mixes, and melting resistance of ice cream all increased significantly. Among different recipes, 4 percent ginger shredded ice cream had the best appropriate body and texture score as well as the highest acceptability score [57]. Gabb et al. developed ice cream with ginger rhizomes, which were converted into juice, pulp, candy, and powder before being added to the ice cream during the freezing process. The ginger paste and juice reduced fat, total solids, protein, and overrun while increasing antioxidant activity and phenols, while the ginger candy and powder increased solids, crude fiber, antioxidant activity, and phenols while lowering fat and overrun [58].

Sensory evaluation of curcumin (turmeric) powder as natural color for butterscotch flavor ice cream was investigated by Manoharan et al. Turmeric is a bright yellow colorant produced from the roots of the herb *Curcuma longa*, with pigments

including curcuminoids, curcumin, and related compounds responsible for the yellow color. As a result, it's used as a natural colorant in butterscotch ice cream. According to the study, the use of curcumin powder at 0.5 percent in ice cream preparation achieved the highest scores for sensory qualities and overall acceptability [59].

Mint incorporated herbal ice cream had an increased protein and acidity levels and decreased fat and overrun levels. Herbal menthol at 0.5 percent of the ice-cream mix generated the strongest results for the mint flavored ice cream, providing a cooling sensation without altering the sensory and physical properties of the dessert [60]. Similarly, Jana et al. investigated the development of herbal ice cream with 3.50 percent and 2.50 percent lemon grass distillate and curry leaf distillate, respectively and lemongrass powder and curry leaf powder at 0.75 percent and 0.70 percent, respectively. They reported that, the herbal ice cream made with herbal distillates and, especially lemon grass distillate was due to its highest sensory score than herbal ice creams made with herbal powders [61].

4.5 Cheese

Mohamed et al. reported an improved shelf life and consistency of cream cheese (an acid-curd soft cheese with a short shelf life) on addition of *Moringa oleifera* ethanol extract at different ratios of 2.00, 3.00, and 4.00 g/100 g skimmed UF-retentate. According to the findings, the ethanolic extract of *M. oleifera* had the high total phenols and antioxidant activities, as well as a broad range of antimicrobial properties against various pathogenic strains and the largest inhibition region. The ethanolic extract was found to be more effective against gram positive, gram negative, and fungi strains. Furthermore, raising the concentration of *M. oleifera* extract resulted in an increase in probiotic strains and counts, especially with *Lactobacillus plantarum* and improved taste, odor, acidity, total solids, fat/dry matter, soluble nitrogen/total nitrogen, diacetyl, acetaldehyde, total volatile fatty acid, total phenol content, and antioxidant activity. The result suggested the use of *M. oleifera* extract as a natural preservative for cream cheese [62].

Bakheit and Foda developed spicy Mudaffara cheese by adding three different spices (clove, black cumin, and black pepper) with good consumer acceptability. The results suggested that, spicy Mudaffara cheese could be stored at room temperature for 4 to 6 weeks with good taste, depending on the spices used, while its shelf life increased to 8 weeks when kept refrigerated. Clove Mudaffara cheese, on the other hand, had the highest antioxidant activity, followed by black cumin and black pepper cheese [63]. Similarly, Hamid and Abdel developed traditional herbal Sudanese white cheese called Gibna cheese by adding 0.02 percent fenugreek, cinnamon, and cardamon powder to coagulated goat's milk curd. Adding spices to cheese significantly increased fat, protein, and ash content during storage, but total solids and acidity were not affected. The flavor, odor, and consistency of goat's milk cheese were all enhanced by using these spices [64]. Marinho et al. tested semi-hard cheese made from pasteurized and raw Holstein cow milk, coating it with and without lard and rosemary, and ripening it for 60 days. The cheese made from raw milk and coated with lard and rosemary was found to be the most acceptable, giving the final products a higher moisture content, as well as preferred color and texture characteristics [65].

The properties of fresh and ripened herby cheese samples were investigated by Zekai et al. Herby cheese, also known as Otlu peynir – a traditional cheese of eastern Turkey, is made from sheep milk, is widely produced and consumed. Herby cheese is made with around 25 different types of herbs, such as Allium spp., Thymus spp., Ferula spp., Anthriscus nemorosa, and so on. Coskun and Tuncturk also investigated the impact of the herb Allium sp. on biochemical changes in Turkish herby cheese. They observed that, by growing the herb ratios up to 3%, the herby cheese after

ripening greatly raises the levels of lipolysis, Water-soluble Nitrogen, TCA-soluble Nitrogen, and PTA-soluble Nitrogen, which are indicators of proteolysis degrees [66].

Shan et al. [15] observed that cinnamon stick, oregano, clove, pomegranate peel, and grape seed extracts were effective against three foodborne pathogens in cheese (*Listeria monocytogenes, Staphylococcus aureus, and Salmonella enterica* in cheese at room temperature (23°C)). Treatment with these extracts reduced lipid oxidation and improved cheese stability. Clove extract had the strongest antioxidant and antibacterial properties among all the extracts tested and recommended to be used as natural preservatives [15]. These results were in conformity with the findings of Vrinda Menon and Garg, who reported that investigated the clove oil at 1% concentration in cheese can effectively prevent *Listeria monocytogenes* growth in food at both at 30°C and 7°C temperatures [67].

Hassanien et al. [68] found that supplementing cheese with 0.1 percent or 0.2 percent black cumin seed oil, w/w, has important inhibitory effects against certain pathogenic bacteria (*Escherichia coli ATCC 8739, Listeria monocytogenes Scott A, Salmonella enteritidis PT4* and *Staphylococcus aureus ATCC 6538*). The addition of black cumin seed oil to cheese has an antimicrobial effect during cold storage [68].

Josipović et al. developed a new herbal cottage cheeses with fresh or dried parsley, dill, pepper, garlic, and rosemary. The herbal cottage cheeses had optimal sensory properties, improved biological value, and extended shelf life. Foodborne pathogens such as *E. coli, Staphylococcus aureus, Salmonella typhimurium,* and *Listeria monocytogenes* were effectively minimized by the herbal extracts tested *in vitro* and *in situ*. Due to high mass fractions of flavones and phenolic diterpenes, as well as high mass fractions of caffeic and rosmarinic acids, dry rosemary had the highest antioxidant and antibacterial activity among these herbs. Consumers prefer fresh plants, but according to this study, dry plants contribute more to biological benefit and antioxidant properties. As a result, these plant extracts have the ability to serve as natural preservatives and antioxidants [69].

4.6 Shrikhand

Ashwagandha herb powder (0.5%) enriched shrikhand (an Indian dairy product made from lactic fermented curd) was developed by Landge et al. They observed that adding ashwagandha powder to shrikhand improved the organoleptic properties, consistency and extended the shelf life of the product to 52 days when kept refrigerated [70]. Nidhi Ojha investigated the effects of tulsi and turmeric powder in herbal shrikhand. They reported that adding 0.4 percent tulsi powder and 0.5 percent turmeric powder on the basis of Chakka in Shrikhand improved the product's sensory, microbiological activity, and nutritional value [71]. Similarly, Himanshu et al. developed tulsi extract (0.9%) incorporated functional herbal shrikhand without compromising the physicochemical properties of the product [72].

4.7 Other dairy products

Neethu et al. developed Origanum vulgare (also known as oregano, Spanish thyme and wild marjoram) incorporated in paneer made from malic acid coagulated milk. The sensory acceptability of malic acid was higher when it was combined with oregano spiced paneer. In comparison to industrial paneer, the growth of microorganisms was found to be less in this herbal paneer [73]. Shweta et al. reported that 0.6 percent turmeric can be used as a preservative to prolong the shelf life of paneer. When stored at 7 ± 1°C the shelf-life of the herbal paneer was increased to 12 days, compared to 7 days for control paneer [74]. Similarly, Bullerman and Gourma claimed that the compound Oleuropein, derived from the olive tree, can inhibit the

Dairy products	Herb(s) and spice(s) used	Targeted functional benefits	References
Milk	Tulsi juice (25%), ginger juice (3%) and turmeric powder (0.1%).	Anti-carcinogenic. Cardio-protective, anti-inflammatory. Anti-pyretic and anti-microbial.	Gaurav Kumar [18]
	Tulsi	Good antioxidant and iron-chelating properties	Palthur et al.
	Turmeric powder	Immunity booster.	Jankar [20]
	Piper betel leaves	Stimulant for muscular and mental efficiency, carminative, an antiseptic and an expectorant.	Kamble et al. [21]
	Aloe vera pulp (5%)	It is nutrient-dense and aids in the prevention of the several diseases.	Pugazhenth and Jothylingam [22]
	Fennel, tulsi and lemon grass oil	Lowers blood pressure, reduces the risk of heart disease, relieves fever, headaches, and sore throats, helps in blood purification. It also has antioxidant, anti-bacterial, and ulcer-prevention properties.	Kishore [23]
	Pueraria tuberosa	High antioxidant activity	Sawale et al. [24]
	Wheat grass juice	Anti-inflammatory, anti-oxidant, and antibacterial properties.	Vaquil et al. [25]
	Ginger juice	Antioxidant. Improve sensory and keeping quality.	Rathod et al. [26]
Yoghurt	Tulsi leaf	Greater β-D-galactosidase enzymatic activity.	Chowdhury et al. [27]
	Tulsi extract and beet root extract	Antiradical properties	Ghosh [28]
	Aloe vera gel	Antiviral, antimicrobial activity, adjuvant cancer care, ulcer remedy.	Govindammal et al. [29]
	Essential oils from peppermint, basil and zataria	Antioxidant activity	Azizkhani and Parsaeimehr [32]
	Moringa olifera leaf powder	Antimicrobial.	Kabuo et al. [36]
	Beet root and ginger extract	Higher antioxidant properties	Srivastava et al. [34]
	Garlic, cinnamon and peppermint	Antimicrobial and proteolytic activity	Bakrm and Salihin [30]
	Cinnamon powder	Intensify gastro intestinal stability	Ahmed Helala and Davide Tagliazcchi [31]
	Rosmarius officinalis oil	Improved functional properties	Ghalem and Zouaoui [33]
	Peppermint, dill and basil	Enhances inhibition of ACE activity.	Amirdivani and Baba [35]

Dairy products	Herb(s) and spice(s) used	Targeted functional benefits	References
Labneh	Thyme, marjoram and sage essential oils	Deliver phytochemicals and other nutrients for health benefits	Otaibi and Demerdash [39]
	Dill and caraway essential oil	Antioxidant and antimicrobial activity	Zaky et al. [79]
	Moringa oliefera oil	Antimicrobial activity	El-Sayed et al. [40]
Lassi	Ginger, turmeric and carrot extract	Rich in antioxidant and provides nutrients	Soma Maji et al. [42]
Shrikhand	Ashwagandha powder.	Respiratory stimulant activities and immuno-stimulating effect	Landge et al. [70]
	Turmeric and tulsi powder	Increased functional properties	Nidhi Ojha [71]
	Tulsi extract	Increased flavor and health benefits	Himanshu et al. [72]
Butter	Sage and rosemary	Increases oxidative stability.	Najgebauer et al. [45]
	Sage rosemary and oregano extracts	Increases oxidative stability.	Ahmet et al. [48]
	Rosemary extracts	Increases oxidative stability.	Renata et al. [49]
	Thyme and cumin essential oils.	Prevent deterioration of butter	Farag et al. [46]
	Rosemary	High antioxidant properties	Santos et al. [49]
Ghee	Sage and rosemary	High antioxidant properties	Ozcan [44]
	Terminalia arjuna	Protective against cardiovascular diseases	Rajanikant and Patil [50]
	Tulsi leaf powder	Increases oxidative stability	Merai et al. [47]
	Vidarikand	Antioxidant properties	Nilkanth Pawar [53]
Ice cream	Basil juice and freeze dried powder	Anti-stress, antioxidant, antibacterial, anti-fungal, antiviral and immuno-stimulant activities.	Trivedi et al. [54]
	Aloe vera and mint	anti-inflammatory gastro protective, antimicrobial and improve storage stability	Ankush Verma [56]
	Shredded ginger	Improves melting resistance	Pinto et al. [57]
	Curcumin powder	Improves sensory attributes and health benefits	Manoharan et al. [59]
	Pudina	Cooling sensation	Patil et al. [60]
	Lemon grass and distillate	Improves flavor and sensory attributes	Janu Atanu et al. [61]

Dairy products	Herb(s) and spice(s) used	Targeted functional benefits	References
Cheese	Cinnamon stick, oregano and clove	Effective against food borne pathogens. (Antimicrobial)	Shan et al. [15]
	Clove oil	Antimicrobial	Vrinda and Garge [67]
	Lard and rosemary	Flavor, color and texture	Marinho et al. [65]
	Black cumin seed	Inhibit food borne pathogens (Antimicrobial)	Hassanien et al. [68]
	Rosemary	High antioxidant property	Josipovic et al. [69]
	Moringa oliefera	High total phenolic content and antioxidant activities	Mohamed et al. [62]
	Black pepper	High antioxidant property	Bakcheit and Foda [63]
	Fenugreek, cinnamon and cardamom powder	Enhance flavor, color and consistency	Hamid and Abdelrahman [64]
	Oregano, thyme	Antimicrobial	Govaris et al. [80]
	Garlic	Antimicrobial	Shan et al. [15]
	Black cumin seed oil	Antimicrobial	Hassanien et al. [68]
	Rosemary essential oil	Antimicrobial	Moro et al. [81]
Paneer	Origanum vulgare	Reduction in asthma, diarrhea and indigestion.	Neethu et al. [73]
	Turmeric powder	Improved texture and keeping quality	Shweta Bunch et al. [74]
Peda	Ginger powder	Increases texture and flavor	Desale et al. [77]
Burfi	Stervia powder and safed musli powder	Superior in physic-chemical, microbial and quality attributes	Goyal and Samsheer [78]

Table 3.
List of some herbal dairy products formulated by incorporating different herbs for their functional and medicinal health benefits.

development of aflatoxins, and that this property of oleuropein may be useful in products like chhana and paneer, where mold growth contributes to the production of mycotoxins, which can be harmful to one's health [75].

Turmeric, coriander, curry leaf and spinach were incorporated separately at the 10% level to manufacture sandesh, a heat-desiccated product of coagulated milk protein mass or chhana [76]. Incorporation of herbs did not significantly affect the overall acceptability of sandesh. According to numerous reports, sandesh combined with coriander leaves has high sensory acceptability as well as high neutraceutical, antimicrobial, and antioxidant properties. When opposed to non-herbal sandesh, herbal sandesh had a longer shelf life [76].

Desale et al. investigated the use of ginger powder in the preparation of peda. Peda is a healthy indigenous milk sweet made by heating a mixture of khoa and sugar until it reaches the desired granular, hard texture and flavor. The product was made with buffalo milk and 30 percent sugar by weight of khoa, along 2–6% ginger powder by weight of khoa. Fat, protein, and moisture content in the finished product decreased significantly compared to regular non-ginger khoa, while total solid, total sugar, and ash content increased significantly. Furthermore, peda made with ginger powder had a twice-as-long shelf life than regular peda [77]. A comprehensive list of some herbal dairy products formulated by incorporating different herbs for their functional and medicinal health benefits is presented in **Table 3** [78].

5. Conclusions

The growing popularity of functional foods has led to the fortification of dairy products with natural herbs that have medicinal properties promoting nutrition and immunity in the body and resulting in promising health benefits that are free of side effects. Herbs in dairy products not only serve as a functional food, but also as a natural preservative that can replace synthetic preservatives that have been linked to negative human health effects. Moreover, the herbal dairy product shall adhere to all regulatory requirements in terms of protection, effectiveness, quality testing, and marketing authorization. Despite the fact that systematic scientific studies and modern techniques are required to determine food constituents, bioavailability of functional components in herbs, new procedure for optimized extraction and refining separation methods of herbs and their impact on human health need to be considered.

Conflict of interest

The authors declare no conflict of interest.

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