***Review Article***

**Recent Advances in Functional Dairy Products Enriched with Herbal Extracts: A Comprehensive Review**

**Abstract**

The global functional food market has witnessed unprecedented growth, with functional dairy products emerging as a significant segment due to their inherent nutritional benefits and consumer acceptance. The integration of herbal extracts into dairy matrices represents a revolutionary approach to creating health-promoting foods that combine traditional dairy nutrition with the therapeutic properties of bioactive plant compounds. This comprehensive review examines recent advances in herbal-fortified dairy products, covering their development, technological implications, nutritional benefits, and market potential. The analysis encompasses various herbal extracts including turmeric, tulsi, ashwagandha, fenugreek, and moringa, along with their incorporation into different dairy product categories such as milk, yogurt, cheese, and frozen desserts. The review highlights the challenges and opportunities in this rapidly evolving field, including technological innovations in microencapsulation, consumer perception studies, and regulatory considerations. The evidence suggests that herbal-enriched dairy products offer significant potential for disease prevention, immune system enhancement, and overall health promotion, positioning them as key players in the future of functional foods.

**Keywords:** Functional dairy products, herbal extracts, bioactive compounds, probiotic enhancement, microencapsulation, consumer acceptance, health benefits

**1. Introduction**

According to the International Food Information Council, functional foods are defined as foods that provide health benefits beyond basic nutrition due to the presence of physiologically active components (Granato *et al*., 2020). These products are designed to deliver bioactive compounds that positively influence physiological functions, immune responses, metabolic processes, and overall well-being (Kussmann *et al*., 2023).

The functional food market has experienced remarkable growth, driven by increasing consumer awareness of the relationship between diet and health outcomes (Siro *et al.,* 2008). the global market was valued at USD 317.22 billion and is expected to achieve a compound analytical growth rate (CAGR) of 9.6% in the forecast period of 2024–2030 (Chhabra *et al* 2025). This growth reflects the expanding recognition of food as medicine and the growing demand for products that support health maintenance and disease prevention (Childs ., 1997).

Functional dairy products constitute a significant and rapidly expanding segment within the functional food market, leveraging the inherent nutritional properties of milk and dairy derivatives as carriers for bioactive compounds (Halder *et al.,* 2021). Dairy products naturally contain high-quality proteins, essential amino acids, calcium, phosphorus, riboflavin, vitamin B12, and various other nutrients, making them ideal vehicles for functional ingredient delivery (Warsewicz *et al*., 2021).

**2. Rising Consumer Demand for Health-Promoting Foods**

This trend has been accelerated by the COVID-19 pandemic, which heightened consumer focus on immune system support and preventive healthcare. 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 (Djaoudene *et al*., 2023).

Aging populations in developed countries are increasingly seeking products that support healthy aging, cognitive function, and disease prevention (Tucker and Buranapin, 2001). The global functional food market reflects this demand, with Functional Dairy Products Market is expected to reach US$ 64.1 billion by 2033, to surge at 4.5% CAGR during the forecast period of 2023-2033 (Jimenez-Ortega *et al.,* 2025).

Consumer preferences have evolved to favor products with natural ingredients, minimal processing, and sustainable production methods. The integration of herbal extracts into dairy products aligns perfectly with these preferences, offering natural alternatives to synthetic additives while providing additional health benefits (Ghosh *et al*., 2024).

**3 Significance of Herbal Extracts in Dairy Fortification**

The incorporation of herbal extracts into dairy products represents a convergence of traditional herbal medicine and modern food technology, creating innovative products that combine ancient wisdom with contemporary scientific validation (Balkrishna *et al*., 2024). This approach offers multiple advantages for both product development and consumer health, positioning herbal-fortified dairy products as a significant innovation in functional food technology (Jaffar *et al.,* 2024).

Herbal extracts provide a rich source of bioactive compounds, including polyphenols, flavonoids, essential oils, alkaloids, saponins, and other phytochemicals that exhibit diverse biological activities . These compounds can enhance the nutritional value of dairy products while providing natural preservation effects, potentially reducing the need for synthetic preservatives and additives (Altemimi *et al.,* 2017). The antioxidant properties of herbal extracts can prevent lipid oxidation, protein degradation, and maintain product quality during storage, extending shelf life and reducing food waste (Blasi and Cossignani., 2020).

Traditional Indian herbs such as turmeric, tulsi (holy basil), ashwagandha, fenugreek, and moringa have been extensively studied for their therapeutic properties and show particular promise for dairy fortification. These herbs possess well-documented health benefits, including anti-inflammatory, immunomodulatory, adaptogenic, and antioxidant properties. Their incorporation into dairy products creates functional foods that can contribute to disease prevention, immune system support, and overall health maintenance (Ashok *et al*., 2024).

**3.1 Functional Dairy Products: An Overview**

Functional dairy products represent a sophisticated category of foods that have been enhanced beyond their basic nutritional profile to provide specific health benefits. These products can be classified into several categories based on their functional components and target health benefits (Granato *et al.,* 2010). The primary classifications include probiotic dairy products, fortified dairy products, and bioactive dairy products, each serving distinct nutritional and therapeutic purposes.

Probiotic dairy products contain live beneficial microorganisms that confer health benefits to the host when consumed in adequate amounts. These products typically contain strains of Lactobacillus, Bifidobacterium, and other beneficial bacteria that support digestive health, immune function, and overall well-being (Jena and Choudhury, 2023). Numerous studies have been advanced to establish a link between gut health and immunological function and to explain how probiotics, prebiotics, nutraceuticals affect the gut microbiota and immune function. The therapeutic potential of probiotic dairy products has been extensively documented, with benefits including improved lactose tolerance, enhanced immune response, and reduced risk of gastrointestinal infections (Kopp-Hoolihan, 2001).

Fortified dairy products have been enhanced with specific nutrients, vitamins, minerals, or bioactive compounds to address nutritional deficiencies or provide additional health benefits. Common fortification ingredients include vitamins D and B12, calcium, iron, omega-3 fatty acids, and various antioxidants (Shahidi and Ambigaipalan, 2016).

Bioactive dairy products contain naturally occurring or added bioactive compounds that provide specific physiological benefits beyond basic nutrition. These compounds include peptides, lipids, carbohydrates, and other molecules that can modulate biological processes such as blood pressure regulation, cholesterol metabolism, and immune function (Ma *et al.,* 2023). The bioactive components in these products often work synergistically with the natural nutrients in dairy to enhance their therapeutic potential.

**3.2 Common Functional Dairy Examples**

The functional dairy product market encompasses a diverse range of products, each designed to address specific health concerns or nutritional needs. Probiotic yogurt represents one of the most successful examples of functional dairy products, combining the nutritional benefits of yogurt with the therapeutic properties of beneficial bacteria (Sarkar, 2019). These products have been shown to improve digestive health, enhance immune function, and support overall well-being through their impact on gut microbiota composition and activity (Wan *et al*., 2019).

Omega-3 fortified milk has gained significant popularity as a functional dairy product that addresses the widespread deficiency of essential fatty acids in modern diets. These products typically contain EPA and DHA omega-3 fatty acids, which support cardiovascular health, cognitive function, and inflammatory response regulation (Shahidi and Ambigaipalan, 2016). The fortification of milk with omega-3 fatty acids provides a convenient and palatable way for consumers to increase their intake of these essential nutrients (Ganesan *et al*., 2014).

Protein-enhanced dairy products have gained popularity among health-conscious consumers seeking to increase their protein intake for muscle building, weight management, or athletic performance (Padgaonkar, 2009 ). These products often contain added whey protein, casein, or plant-based proteins that enhance their nutritional profile while maintaining the sensory characteristics of traditional dairy products. These benefits include improved digestive health, enhanced immune function, and potential reductions in the risk of certain chronic diseases (Méndez-Galarraga *et al*., 2025).

**4 Herbal Extracts: A Source of Bioactive Compounds**

**4.1 Types of Herbal Extracts Commonly Used**

The selection of herbal extracts for dairy fortification depends on various factors, including their bioactive compound profile, compatibility with dairy matrices, sensory properties, and established health benefits. Among the most commonly used herbal extracts in functional dairy products are turmeric, tulsi (holy basil), ashwagandha, fenugreek, moringa, mint, and various other traditional medicinal plants that have been validated through scientific research (Basu et al., 2023).

Turmeric (Curcuma longa) stands as one of the most extensively studied and widely used herbal extracts in functional food applications. The primary bioactive compound in turmeric, curcumin, exhibits potent anti-inflammatory, antioxidant, and antimicrobial properties. Research has demonstrated that curcumin can help reduce inflammation, support immune function, and potentially reduce the risk of chronic diseases such as cardiovascular disease and certain types of cancer (Razavi *et al.,* 2021).

Tulsi or holy basil (Ocimum sanctum) represents another highly valued herbal extract with extensive traditional and scientific validation. sanctum-infused functional foods exhibited cognitive enhancing properties, adaptogenic qualities, anti-obesity effects, gastro protective, anti-inflammatory, hypoglycemic, and immune - modulatory effects (Thakur and Thapa, 2023).

Ashwagandha (Withania somnifera) is a renowned adaptogenic herb that has gained significant attention in functional food applications. The root extract contains withanolides, alkaloids, and other bioactive compounds that help the body adapt to stress and support overall well-being. Ashwagandha (Singirala et al., 2025),

Moringa (Moringa oleifera) has emerged as a super food ingredient due to its exceptional nutritional profile and bioactive compound content. The leaves contain high levels of vitamins, minerals, antioxidants, and various phyto - chemicals that support immune function, provide anti-inflammatory benefits, and contribute to overall health maintenance. Moringa extract can significantly enhance the nutritional value of dairy products while providing a natural green color (Kaur et al., 2023).

**4.2 Key Bioactive Compounds**

The therapeutic potential of herbal extracts in functional dairy products stems from their rich and diverse composition of bioactive compounds. These compounds include polyphenols, flavonoids, alkaloids, saponins, essential oils, and various other phytochemicals, each contributing unique properties to the final product (Ali *et al.,* 2022).

Polyphenols represent one of the most important classes of bioactive compounds found in herbal extracts. These compounds include phenolic acids, flavonoids, stilbenes, and lignans, which exhibit potent antioxidant, anti-inflammatory, and antimicrobial activities. Polyphenols can help protect against oxidative stress, support cardiovascular health, and potentially reduce the risk of chronic diseases. Their incorporation into dairy products can significantly enhance the antioxidant capacity while providing natural preservation effects (Khan *et al.,* 2019).

Flavonoids constitute a large subclass of polyphenols that includes compounds such as quercetin, kaempferol, catechins, and anthocyanins. These compounds are responsible for many of the health benefits associated with herbal extracts, including their anti-inflammatory, antimicrobial, and cardioprotective properties. Flavonoids can interact with dairy proteins and lipids in ways that may enhance their bioavailability and therapeutic efficacy (Karak, 2019).

**4.3 Health Benefits**

The health benefits of herbal extracts in functional dairy products are multifaceted, encompassing antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory effects (Paswan *et al.,* 2021). These benefits are primarily attributed to the diverse array of bioactive compounds present in herbal extracts, which work synergistically to provide comprehensive health support. The combination of herbal bioactive compounds with the inherent nutritional benefits of dairy creates products that offer enhanced therapeutic potential compared to either component alone (Kanekanian, 2014).

Antioxidant effects represent one of the most significant health benefits of herbal extracts in dairy products. Anti-inflammatory properties of herbal extracts are particularly relevant for addressing chronic inflammatory conditions that underlie many modern health problems (Yatoo *et al*., 2018). Compounds such as curcumin, rosmarinic acid, and various flavonoids can help modulate inflammatory pathways, reduce inflammatory markers, and support the body's natural anti-inflammatory responses.

Antimicrobial effects of herbal extracts provide both health benefits and technological advantages in dairy product applications (Aziz *et al*., 2023). Immunomodulatory effects of herbal extracts can help support optimal immune function through various mechanisms. These compounds can help enhance immune cell activity, support the production of beneficial antibodies, and modulate immune responses to maintain optimal balance. Alkaloids are nitrogen-containing compounds that often possess significant pharmacological activities (Bribi, 2018).

Table 1. Functional foods components with physiologic effects

|  |  |
| --- | --- |
| **Compound** | **Food sources** |
| Allyl sulfur | Garlic, onions, leeks, chives |
| Carotenoids | Fruits, vegetables |
| Flavonoids | Fruits, vegetables, grains, nuts |
| Indoles | Cruciferous vegetables |
| Isothiocyanates | Cruciferous vegetables |
| Inulin/Oligofructose | Bananas, wheat, chicory, garlic |

**5. Incorporation of Herbal Extracts into Dairy Products**

**5.1 Types of Dairy Products Fortified with Herbs**

The successful incorporation of herbal extracts into dairy products requires careful consideration of product characteristics, processing parameters, and consumer preferences. Different dairy product categories offer unique opportunities and challenges for herbal fortification, each requiring specific approaches to optimize the integration of bioactive compounds while maintaining product quality and sensory appeal.

**5.1.1 Milk and Milk Beverages**

Milk and milk-based beverages are ideal vehicles for herbal enrichment due to their liquid form, ease of absorption, and consumer familiarity. Fortified milk products like turmeric (golden milk), tulsi, ginger, and ashwagandha milk have gained popularity for their therapeutic properties, such as immune boosting and stress relief (Ashok *et al.,* 2024).

Herbal integration methods include the addition of powders, liquid extracts, or encapsulated forms. These must consider processing factors like temperature, pH, and homogenization pressure to preserve both the milk quality and the bioactive stability. Additionally, these functional beverages can be designed to cater to specific demographics or health goals, such as stress management or immune support (Gupta *et al*., 2023).

**5.1.2 Yogurt**

Yogurt offers an excellent fermented matrix for herbal fortification. Its acidic environment supports the stability and enhanced bioavailability of herbal compounds (Mehra *et al.,* 2022). The synergy between herbal bioactives and probiotics can amplify therapeutic effects, including digestive health and inflammation control (Curro *et al.*, 2017). Herbal yogurts can be tailored for various health concerns turmeric and ginger for anti-inflammatory benefits or ashwagandha for stress relief. However, taste and texture must be optimized, as certain herbal compounds may introduce bitterness or astringency. Natural sweeteners and fruit flavors are commonly used to enhance sensory appeal (Dwivedi, 2022).

probiotic strained yogurt-like dessert with toasted pearl millet flour and Hibiscus rosa-sinensis extract. The ingredients (pearl millet: 2.5-8%, Hibiscus: 2.5-8%, and sugar: 25-45%) were optimized for probiotic viability, lactic acidity, sensory characteristics, and acceptance using Design Expert software. The best formulation (pearl millet: 4.86%, Hibiscus: 4.4%, and sugar: 29.47%) had a probiotic viability of 7.53 ± 0.33 log10 CFU g−1, over the required threshold (Joshi *et al.,* 2025).

**5.1.3 Cheese and Paneer**

Cheese and paneer provide a dense fat and protein matrix ideal for stabilizing and protecting herbal compounds. Paneer, with its mild flavor and minimal processing, accommodates herbs without compromising texture or palatability, and it retains heat-sensitive compounds effectively (Singh *et al*., 1982).

In cheeses, herbs can be incorporated during curdling, added to the milk beforehand, or applied to the surface. Herbal cheeses not only benefit from the health effects of plant compounds but can also exhibit improved flavor and antimicrobial properties. The influence of herbs on microbial activity during cheese ripening must be carefully managed to avoid undesirable changes in fermentation (Ritota and Manzi, 2020).

**5.1.4 Ice Creams**

Herbal-fortified ice creams combine indulgence with wellness. The cold environment preserves heat-sensitive compounds, and the fat-rich matrix enhances the delivery of lipophilic bioactives like curcumin. Ice creams enriched with turmeric, moringa, or adaptogenic herbs appeal to health-conscious consumers seeking functional desserts (Poonia, 2020).

However, formulation must account for the impact of herbs on freezing behavior and texture. Stabilizers and emulsifiers are often needed. Additionally, masking herbal bitterness with sweeteners and complementary flavors ensures consumer satisfaction in the premium ice cream segment (Mcdonald, 2017).

**5.1.5 Butter and Ghee**

Butter and ghee, with their high fat content, are excellent carriers for fat-soluble herbal compounds. Their use in Ayurvedic medicine forms the basis for modern applications. Herbs can be infused during heating, mixed as oils, or added in powdered form. Ghee fortified with turmeric offers anti-inflammatory effects, while tulsi-infused butter supports immunity (Meshram *et al.,* 2016).

**5.2 Methods of Incorporation**

The successful incorporation of herbal extracts into dairy products requires careful selection of appropriate methods that optimize the delivery of bioactive compounds while maintaining product quality, stability, and consumer appeal. The choice of incorporation method depends on various factors, including the nature of the herbal extract, the target dairy product, processing requirements, and desired shelf life.

**5.2.1 Direct Infusion/Extraction**

Direct infusion is a simple and widely used method that involves adding herbal liquids or infusing herbs directly during processing. It offers control over bioactive concentration and even distribution in dairy matrices (Bellary and Rastogi, 2016). For milk, herbs can be added before or after pasteurization; for yogurt, before fermentation to allow probiotic interaction. Its advantages include low cost and simplicity, but challenges involve potential changes in flavor, color, and stability (Mehra *et al*., 2022).

**5.2.2 Microencapsulation of Herbal Compounds**

Microencapsulation technology represents a sophisticated approach to incorporating herbal extracts into dairy products, offering enhanced stability, controlled release, and improved bioavailability of bioactive compounds (Mehta *et al.,* 2022). Yogurt is a popular dairy product due to its distinct taste and health-promoting effects. Nevertheless, yogurt has been fortified with different natur. This technology involves the encapsulation of herbal compounds within protective matrices that can shield them from environmental factors while facilitating their release under specific conditions (Wazzan *et al*., 2024).

**Spray drying**, common for powdered herbal extracts, enhancing shelf life and handling (Ghosh *et al.,* 2017).

Coacervation involves the formation of liquid-liquid phase separation to create microcapsules containing herbal extracts. This technique is particularly useful for encapsulating oil-soluble compounds and can provide excellent protection against oxidation and degradation. The resulting microcapsules can be incorporated into dairy products without significant impact on sensory characteristics (Carvalho *et al.,* 2022).

**5.2.3 Use of Herbal Powders vs. Herbal Extracts**

The choice between powders and extracts depends on processing compatibility, cost, bioactivity, and sensory impact.

**Herbal powders** retain the full plant matrix, offering fiber, minerals, and broader nutrition, but may alter texture or flavor (Aguilera, 2019).

**Herbal extracts** are more concentrated and easier to blend into smooth dairy products, but may lose some plant compounds during processing (Abd El-Aziz *et al*., 2023a).

Powders tend to be more affordable and stable, while extracts offer stronger bioactivity and easier standardization. Sensory evaluation is key, as powders may impact taste and texture more noticeably than extracts (Abd El-Aziz *et al*., 2023b).

**6. Technological Implications of Herbal Fortification**

**6.1 Impact on Physico-Chemical Properties**

The incorporation of herbal extracts into dairy products can significantly influence their physico-chemical properties, including pH, moisture content, fat content, protein structure, and texture characteristics. The interaction between herbal compounds and dairy components can result in both beneficial and challenging effects that must be carefully managed during product development.

pH modification represents one of the most significant physico-chemical changes that can occur when herbal extracts are incorporated into dairy products. Many herbal extracts are naturally acidic or basic, and their addition can alter the pH of the dairy matrix, potentially affecting protein stability, microbial growth, and overall product characteristics. For example, the incorporation of citrus-based herbal extracts can significantly lower the pH of milk-based products, potentially causing protein precipitation or affecting the activity of beneficial bacteria in fermented products (Rashidinejad *et al*., 2022).

Moisture content modifications can occur when herbal extracts are incorporated into dairy products, particularly when using liquid extracts or when herbs affect the water-holding capacity of the dairy matrix. Changes in moisture content can influence product texture, shelf life, and microbial stability. Some herbal compounds may act as humectants, increasing water retention, while others may have dehydrating effects that could impact product quality (Wazzan, 2024).

Fat content and fat distribution can be affected by the incorporation of herbal extracts, particularly those containing lipophilic compounds or essential oils. The interaction between herbal lipids and dairy fats can influence the melting properties, texture, and flavor release characteristics of products like butter, cheese, and ice cream. Understanding these interactions is essential for maintaining optimal product characteristics while maximizing the incorporation of beneficial herbal compounds (Kulshrestha *et al.*, 2008).

**6.2 Sensory Characteristics**

The sensory characteristics of herbal-fortified dairy products represent critical factors that determine consumer acceptance and commercial success. The incorporation of herbal extracts can significantly impact flavor, color, aroma, and texture, requiring careful optimization to achieve products that are both functional and appealing to consumers.

Flavor modifications represent the most immediate sensory impact of herbal fortification, with the potential for both positive and negative effects on consumer acceptance. Many herbal extracts contribute distinctive flavors that can range from pleasant and aromatic to bitter and astringent. The key to successful flavor integration lies in understanding the flavor profiles of different herbs and selecting combinations that complement rather than compete with the natural flavor of dairy products (Cashman *et al.,* 2024).

Color modifications resulting from herbal fortification can be both advantageous and challenging for product development. Natural herbal colors can provide appealing visual cues that communicate health benefits and natural ingredients to consumers (Thakur *et al.,* 2011).

Texture modifications resulting from herbal fortification can significantly impact consumer acceptance, particularly in products where specific texture characteristics are expected. The addition of herbal powders can create grittiness or affect the smoothness of products like milk and yogurt, while herbal extracts may affect the viscosity, gel strength, or mouthfeel of various dairy products (Granato *et al.,* 2018).

**6.3 Shelf-Life Enhancement**

One of the significant technological advantages of herbal fortification in dairy products is the potential for shelf-life enhancement through the natural antioxidant and antimicrobial properties of herbal compounds. This natural preservation effect can reduce the need for synthetic preservatives while extending product freshness and safety, providing both economic and consumer benefits. The ability of herbal extracts to inhibit lipid oxidation, protein degradation, and microbial growth makes them valuable functional ingredients for improving product stability (Teshome *et al*., 2022).

Studies on herbal-fortified butter and ghee have shown that the addition of turmeric, rosemary, and other antioxidant-rich herbs can extend shelf life by several weeks compared to unfortified products. The effectiveness of different herbs as natural antioxidants varies significantly, with some herbs providing more potent protection than others (Paswan *et al*., 2021).

Antimicrobial effects of herbal extracts can contribute to shelf-life extension by inhibiting the growth of spoilage bacteria, yeasts, and molds. Many herbal compounds possess broad-spectrum antimicrobial activity that can help prevent microbial contamination and growth during storage. This antimicrobial activity can be particularly beneficial in fermented dairy products, where the control of undesirable microorganisms is crucial for maintaining product quality and safety (Barak and Mudgil, 2022).

**6.4 Challenges in Processing and Stability**

Despite the numerous benefits of herbal fortification, several technological challenges must be addressed to ensure successful product development and commercialization. These challenges include oxidation of sensitive compounds, development of off-flavors, consistency issues, and maintaining the stability of both herbal compounds and dairy components throughout processing and storage.

Oxidation represents one of the most significant challenges in maintaining the stability of herbal compounds in dairy products. Many beneficial compounds in herbal extracts are highly sensitive to oxygen, light, and heat, making them prone to degradation during processing and storage (Dhulipalla *et al.,* 2023).

The prevention of oxidation requires careful attention to processing parameters, including the use of inert atmospheres, reduced oxygen packaging, and temperature control. The selection of appropriate antioxidants and stabilizers can help protect sensitive compounds, while the optimization of processing conditions can minimize oxidative stress (Musakhanian *et al.,* 2022).

Bitterness and astringency development represent common sensory challenges associated with herbal fortification. Many beneficial compounds in herbal extracts, particularly polyphenols and alkaloids, can contribute bitter or astringent flavors that may be unacceptable to consumers. The intensity of these flavors often increases during storage, potentially making products less palatable over time (Lemieux and Simard, 1992).

Physical stability challenges may include precipitation, phase separation, or changes in texture that can occur when herbal compounds interact with dairy components. Some herbal compounds may be incompatible with specific dairy proteins or may undergo chemical changes that affect product stability (Sikorski *et al.,* 2007).

**7. Nutritional and Therapeutic Benefits of Herbal-Enriched Dairy Products**

**7.1 Improved Nutritional Profiles**

The incorporation of herbal extracts into dairy products can significantly enhance their nutritional profiles by increasing the levels of vitamins, minerals, antioxidants, and other beneficial compounds. This nutritional enhancement creates products that provide superior health benefits compared to conventional dairy products while maintaining the familiar taste and texture characteristics that consumers expect (Mehwish *et al*., 2023).

Enhanced antioxidant content represents one of the most significant nutritional improvements achieved through herbal fortification. Many herbal extracts are rich sources of polyphenols, flavonoids, vitamin C, vitamin E, and other antioxidant compounds that can help protect against oxidative stress and reduce the risk of chronic diseases (Vishwakarma *et al*., 2022).

Vitamin and mineral enhancement can be achieved through the incorporation of herbal extracts that are naturally rich in these nutrients. Moringa extract is exceptionally rich in vitamin A, vitamin C, iron, and calcium, making it an excellent fortification ingredient for enhancing the nutritional value of dairy products (Oyeyinka and Oyeyinka, 2018).

The combination of herbal vitamins and minerals with those naturally present in dairy products can create nutritionally complete products that address multiple dietary needs simultaneously. This comprehensive nutritional approach is particularly valuable for populations at risk of nutrient deficiencies, including children, elderly individuals, and those with restricted diets (Shlisky *et al.,* 2017).

**7.2 Studies Linking Herbal Dairy Products to Disease Prevention**

The scientific literature contains numerous studies demonstrating the potential of herbal-enriched dairy products for disease prevention and health promotion. These studies provide valuable evidence supporting the development and consumption of functional dairy products as part of a healthy diet. The research encompasses various types of studies, including in vitro experiments, animal studies, and human clinical trials, each contributing to our understanding of the therapeutic potential of these products (Epstein *et al.,* 2010).

Cancer prevention represents one of the most significant areas of research for herbal-enriched dairy products. Many herbal compounds possess anticancer properties that can help prevent the development and progression of various types of cancer (Abdulridha *et al.,* 2020).

Clinical studies have demonstrated that the consumption of herbal-fortified dairy products can help improve various cardiovascular risk factors, including blood pressure, cholesterol levels, and inflammatory markers (Giosue *et al.,* 2022). The effectiveness of these products appears to be related to the specific herbs used, the concentration of bioactive compounds, and the duration of consumption. Long-term studies are needed to determine the optimal formulations and consumption patterns for maximum cardiovascular protection (Biesalski *et al.*, 2009).

**8. Consumer Perception and Market Trends**

**8.1 Consumer Acceptance Studies**

Consumer acceptance is key to the success of herbal-enriched dairy products. Sensory attributes-taste, aroma, and texture- strongly influence purchasing decisions. Products with mild, complementary herbal flavors are preferred over those with strong, medicinal tastes. Consumer familiarity with specific herbs also boosts acceptance (Fiorentini *et al.,* 2020).

Health awareness plays a major role; informed consumers are more open to herbal products, even with sensory trade-offs. Educational efforts and health claims can improve acceptance (Mena *et al.,* 2024). Demographic factors such as age, income, education, and cultural background shape consumer attitudes. Younger, health-conscious, and higher-income groups are generally more receptive (Eze and Mena, 2024).

**8.2 Market Growth Predictions and Opportunities**

The herbal-enriched dairy market is growing rapidly due to rising health awareness, interest in natural foods, and increasing disposable incomes. Global trends show strong expansion, especially in the Asia-Pacific region, where traditional use of herbs aligns with modern health demands (Zamani *et al*., 2025). Developed regions like North America and Europe prefer premium, scientifically backed products, while emerging markets favor affordable options blending traditional and modern nutrition (Enthoven and Broeck, 2021).

Innovation is driving growth, with opportunities in new product development, personalized nutrition, and novel delivery systems. The organic and clean-label segment is expanding, creating space for premium, eco-friendly offerings. E-commerce and direct-to-consumer channels are vital for reaching niche and high-end markets (Peter, 2025).

Targeted products addressing health conditions like diabetes or immune support offer high potential. Technological advancements in extraction, microencapsulation, and digital marketing are enabling more effective product development and consumer engagement. Collaboration between dairy producers, herbal suppliers, and research institutions is crucial for innovation and validation of health claims, boosting consumer trust and accelerating market penetration (Obahiagbon and Ogwu, 2023).

**9. Global trends of the functional foods market**

The global market of functional foods in recent years is growing as is evident in Fig. 1. Steady real term growth of 7.2% is expected to continue to 2017 (Euromonitor, 2013).

Fig. 1 : Global trends of the functional foods market (Euromonitor, 2013).

## 9.1 Future Outlook for Herbal-Fortified Functional Dairy Products

## The future of herbal-fortified functional dairy products appears exceptionally promising, with multiple convergent trends supporting continued growth and innovation. Technological advancements in extraction methods, microencapsulation techniques, and analytical procedures will enable the development of more effective and stable products with enhanced bioavailability and therapeutic efficacy (Mehta *et al.,* 2022). The emergence of personalized nutrition concepts presents opportunities for developing targeted products tailored to specific health conditions and individual nutritional needs (Verma *et al.,* 2018).

Market expansion into emerging economies, combined with increasing global health consciousness and aging populations, will drive demand for functional dairy products that support healthy aging and disease prevention (Halder *et al.,* 2021).

However, realizing this potential requires addressing existing challenges including standardization of herbal extract quality, establishment of evidence-based dosage recommendations, and comprehensive clinical validation of health claims (Mukherjee *et al*., 2022). The development of industry standards, regulatory frameworks, and quality assurance protocols will be essential for ensuring consumer safety and product efficacy (Kabir *et al.,* 2024).

The future success of herbal-enriched dairy products depends on continued investment in research and development, fostering collaboration between industry stakeholders, academic institutions, and regulatory agencies. The establishment of robust scientific evidence through well-designed clinical trials will be crucial for supporting health claims and gaining consumer trust (Tunis *et al.,* 2003). As these challenges are addressed, herbal-fortified functional dairy products are positioned to become integral components of preventive healthcare strategies, offering consumers convenient access to therapeutic nutrition through familiar and appealing food formats (Peckenpaugh *et al*., 2009).

# Conclusion

The integration of herbal extracts into dairy products represents a significant advancement in functional food development, combining traditional therapeutic knowledge with modern food technology. These products offer enhanced nutritional profiles, natural preservation benefits, and proven health-promoting properties including antioxidant, anti-inflammatory, and immunomodulatory effects. While technological challenges such as flavor optimization, stability maintenance, and standardization remain, innovative approaches like microencapsulation and advanced processing techniques show promise for overcoming these barriers. Growing consumer awareness of health and wellness, coupled with increasing demand for natural functional foods, positions herbal-fortified dairy products as a rapidly expanding market segment. The convergence of scientific validation, technological innovation, and consumer acceptance suggests that herbal-enriched dairy products will play an increasingly important role in preventive healthcare and functional nutrition. Future success depends on continued research, regulatory framework development, and industry collaboration to establish quality standards and evidence-based health claims. These products represent a promising pathway toward accessible, therapeutic nutrition that bridges ancient wisdom with contemporary food science for improved public health outcomes.

**Refrences**

Abd El-Aziz, M., Salama, H. H., & Sayed, R. S. (2023). Plant extracts and essential oils in the dairy industry: A review. *Foods Raw Mater*, *11*, 321-337.

Abdulridha, M. K., Al-Marzoqi, A. H., Al-Awsi, G. R. L., Mubarak, S. M., Heidarifard, M., and Ghasemian, A. (2020). Anticancer effects of herbal medicine compounds and novel formulations: a literature review. *Journal of gastrointestinal cancer*, *51*, 765-773.

Aguilera, J. M. (2019). The food matrix: implications in processing, nutrition and health. *Critical reviews in food science and nutrition*, *59*(22), 3612-3629.

Ali, M. A., Kamal, M. M., Rahman, M. H., Siddiqui, M. N., Haque, M. A., Saha, K. K., and Rahman, M. A. (2022). Functional dairy products as a source of bioactive peptides and probiotics: Current trends and future prospectives. *Journal of Food Science and Technology*, *59*(4), 1263-1279.

Altemimi, A., Lakhssassi, N., Baharlouei, A., Watson, D. G., and Lightfoot, D. A. (2017). Phytochemicals: Extraction, isolation, and identification of bioactive compounds from plant extracts. *Plants*, *6*(4), 42.

Ashok, G. A., Sandipkumar, B., Santosh, M., and Sudipt, R. (2024). A comprehensive review of herbs utilized in milk products of dairy industry: Insights from Ayurveda. *Pharmacological Research-Natural Products*, 100074.

Balkrishna, A., Sharma, N., Srivastava, D., Kukreti, A., Srivastava, S., and Arya, V. (2024). Exploring the safety, efficacy, and bioactivity of herbal medicines: Bridging traditional wisdom and modern science in healthcare. *Future Integrative Medicine*, *3*(1), 35-49.

Barak, S., and Mudgil, D. (2022). Application of bioactives from herbs and spices for improving the functionality and shelf life of dairy products-A review. *Biointerface Research in Applied Chemistry*, *13*(2), 1-12.

Basu, R., Dasgupta, S., Babu, S. N., and Noor, A. (2023). Medicinal plants in the Indian traditional medicine and current practices. *Bioprospecting of tropical medicinal plants*, 253-286.

Bellary, A. N., and Rastogi, N. K. (2016). Ways and means for the infusion of bioactive constituents in solid foods. *Critical Reviews in Food Science and Nutrition*, *56*(7), 1126-1145.

Biesalski, H. K., Dragsted, L. O., Elmadfa, I., Grossklaus, R., Müller, M., Schrenk, D. and Weber, P. (2009). Bioactive compounds: Definition and assessment of activity. *Nutrition*, *25*(11-12), 1202-1205.

Blasi, F., and Cossignani, L. (2020). An overview of natural extracts with antioxidant activity for the improvement of the oxidative stability and shelf life of edible oils. *Processes*, *8*(8), 956.

Bribi, N. (2018). Pharmacological activity of alkaloids: a review. *Asian J. Bot*, *1*(1), 1-6.

Calder, P. C., and Kew, S. (2002). The immune system: a target for functional foods?. *British Journal of Nutrition*, *88*(S2), S165-S176.

Carvalho da Silva, L., Castelo, R. M., Cheng, H. N., Biswas, A., Furtado, R. F., and Alves, C. R. (2022). Methods of microencapsulation of vegetable oil: Principles, stability and applications-a minireview. *Food Technology and Biotechnology*, *60*(3), 308-320.

Cashman, K. D. (2024). Vitamin D fortification of foods–sensory, acceptability, cost, and public acceptance considerations. *The Journal of Steroid Biochemistry and Molecular Biology*, 106494.

Chaachouay, N. (2025). Synergy, Additive Effects, and Antagonism of Drugs with Plant Bioactive Compounds. *Drugs and Drug Candidates*, *4*(1), 4.

Chhabra, N., Shiriskar, J., and Srinivasan, G. (2025). Current and Future Market of the Dietary Supplements and Nutraceuticals in the Global Economy. In *Dietary Supplements and Nutraceuticals* (pp. 1-48). Springer, Singapore.

Childs, N. M. (1997). Functional foods and the food industry: consumer, economic and product development issues. *Journal of nutraceuticals, functional & medical foods*, *1*(2), 25-43.

Curro, D., Ianiro, G., Pecere, S., Bibbo, S., and Cammarota, G. (2017). Probiotics, fibre and herbal medicinal products for functional and inflammatory bowel disorders. *British journal of pharmacology*, *174*(11): 1426-1449.

Dhulipalla, H., Kommineni, H. K., Archana, V., Devaraj, L., and Syed, I. (2023). Storage and quality degradation of dried herbs, spices, and medicinal plants. In *Drying of herbs, spices, and medicinal plants* (pp. 99-124). CRC Press.

Djaoudene, O., Romano, A., Bradai, Y. D., Zebiri, F., Ouchene, A., Yousfi, Y., Madani, K. (2023). A global overview of dietary supplements: regulation, market trends, usage during the COVID-19 pandemic, and health effects. *Nutrients*, *15*(15): 3320.

Dwivedi, R. S. (2022). Vegetal Taste Modifiers. In *Alternative Sweet and Supersweet Principles: Natural Sweeteners and Plants* (pp. 621-707). Singapore: Springer Nature Singapore.

Enthoven, L., and Van den Broeck, G. (2021). Local food systems: Reviewing two decades of research. *Agricultural systems*, *193*: 103226.

Epstein, J., Sanderson, I. R., & MacDonald, T. T. (2010). Curcumin as a therapeutic agent: the evidence from in vitro, animal and human studies. *British journal of nutrition*, *103*(11): 1545-1557.

Euromonitor. 2013. http://www.portal.euromonitor.com/portal/default.aspx.

Eze, C. C., and Mena, B. (2024). The Role and Importance of Consumer Perception. *Consumer Perceptions and Food*. 7: 3-22.

Fiorentini, M., Kinchla, A. J., and Nolden, A. A. (2020). Role of sensory evaluation in consumer acceptance of plant-based meat analogs and meat extenders: A scoping review. *Foods*, *9*(9): 1334.

Ganesan, B., Brothersen, C., and McMahon, D. J. (2014). Fortification of foods with omega-3 polyunsaturated fatty acids. *Critical reviews in food science and nutrition*, *54*(1): 98-114.

Ghosh, N., Das, A., and Sen, C. K. (2019). Nutritional supplements and functional foods: functional significance and global regulations. In *Nutraceutical and Functional Food Regulations in the United States and around the World*. 14:35. Academic Press.

Ghosh, S., Dutta, S., Kumar Ghosh, P., Bhattacharjee, P., and Das, S. (2017). Design of a polyherbal mix by supercritical carbon dioxide extraction and its encapsulation by spray drying: phytochemical properties and shelf‐life study of the encapsulate. *Journal of Food Process Engineering*, *40*(4): e12505.

Ghosh, S., Sarkar, T., Chakraborty, R., Shariati, M. A., and Simal-Gandara, J. (2024). Nature’s palette: An emerging frontier for coloring dairy products. *Critical Reviews in Food Science and Nutrition*, *64*(6): 1508-1552.

Giosue, A., Calabrese, I., Vitale, M., Riccardi, G., and Vaccaro, O. (2022). Consumption of dairy foods and cardiovascular disease: a systematic review. *Nutrients*, *14*(4): 831.

Gorska-Warsewicz, H., Rejman, K., Laskowski, W., and Czeczotko, M. (2019). Milk and dairy products and their nutritional contribution to the average polish diet. *Nutrients*, *11*(8): 1771.

Granato, D., Barba, F. J., Bursac Kovacevic, D., Lorenzo, J. M., Cruz, A. G., and Putnik, P. (2020). Functional foods: Product development, technological trends, efficacy testing, and safety. *Annual review of food science and technology*, *11*(1): 93-118.

Granato, D., Branco, G. F., Cruz, A. G., Faria, J. D. A. F., and Shah, N. P. (2010). Probiotic dairy products as functional foods. *Comprehensive reviews in food science and food safety*, *9*(5): 455-470.

Granato, D., Santos, J. S., Salem, R. D., Mortazavian, A. M., Rocha, R. S., and Cruz, A. G. (2018). Effects of herbal extracts on quality traits of yogurts, cheeses, fermented milks, and ice creams: a technological perspective. *Current Opinion in Food Science*, *19*: 1-7.

Gupta, A., Sanwal, N., Bareen, M. A., Barua, S., Sharma, N., Olatunji, O. J., and Sahu, J. K. (2023). Trends in functional beverages: Functional ingredients, processing technologies, stability, health benefits, and consumer perspective. *Food Research International*, *170*: 113046.

Halder, T., Mehta, P., and Acharya, N. (2021). Trends in the functional food market and nutraceutical product development. In *Nutraceuticals for aging and anti-aging*. 16: 26. CRC Press.

Jaffar, H. M., Ambreen, S., Al-Asmari, F., Hussain, I., Rahim, M. A., Fawzy Ramadan, M., and Zongo, E. (2024). Antioxidant activity, microbial viability, and sensory attributes of traditional-yogurt enriched with silymarin. *Cogent Food and AgriCulture*, *10*(1): 2417838.

Jena, R., and Choudhury, P. K. (2023). Bifidobacteria in fermented dairy foods: a health beneficial outlook. *Probiotics and Antimicrobial Proteins*, 13: 1-22.

Jimenez-Ortega, L. A., Gonzalez-Gomez, J. P., Quiñónez-Angulo, P., Valdez-Baro, O., and Heredia, J. B. (2025). Global Market of Bioactive and Functional Compounds from Marine Resources and Wastes. *Bioactive Compounds Extraction from Marine Resources and Wastes*. 5: 31-48. Singapore: Springer Nature Singapore.

Joshi, M., Meena, K. K., Kumar, A., & Meena, S. (2025). Optimization of a novel probiotic-fermented pearl millet-based strained yoghurt-like functional dessert: physicochemical, microbial and sensory characterization. *Sustainable Food Technology*. DOI: [10.1039/D5FB00001G](https://doi.org/10.1039/D5FB00001G)

Kabir, M., Rana, M. R. H., and Debnath, A. (2024). The Role of Quality Assurance in Accelerating Pharmaceutical Research and Development: Strategies for Ensuring Regulatory Compliance and Product Integrity. *Journal of Angiotherapy*, *8*(12): 1-11.

Kanekanian, A. (2014). The health benefits of bioactive compounds from milk and dairy products. *Milk and dairy products as functional foods*, 1-22.

Karak, P. (2019). Biological activities of flavonoids: An overview. *Int. J. Pharm. Sci. Res*, *10*(4), 1567-1574.

Kaur, S., Chauhan, P. N., Harwansh, R. K., Chakma, M., and Kaur, S. (2023). Nutraceutical potential and processing aspects of Moringa oleifera as a superfood. *Current Nutrition & Food Science*, *19*(4), 357-376.

Khan, I. T., Nadeem, M., Imran, M., Ullah, R., Ajmal, M., and Jaspal, M. H. (2019). Antioxidant properties of Milk and dairy products: A comprehensive review of the current knowledge. *Lipids in health and disease*, *18*, 1-13.

Kopp-Hoolihan, L. (2001). Prophylactic and therapeutic uses of probiotics: a review. *Journal of the American Dietetic Association*, *101*(2), 229-241.

Kulshrestha, R., Gupta, C. P., Shukla, G., Kundu, M. G., Bhatnagar, S. P., and Katiyar, C. K. (2008). The effect of water activity and storage temperature on the growth of Aspergillus flavus in medicinal herbs. *Planta medica*, *74*(10), 1308-1315.

Kussmann, M., Abe Cunha, D. H., and Berciano, S. (2023). Bioactive compounds for human and planetary health. *Frontiers in nutrition*, *10*, 1193848.

Lemieux, L., and Simard, R. E. (1992). Bitter flavour in dairy products. II. A review of bitter peptides from caseins: their formation, isolation and identification, structure masking and inhibition. *Le Lait*, *72*(4), 335-385.

Ma, W., Li, N., Lin, L., Wen, J., Zhao, C., and Wang, F. (2023). Research progress in lipid metabolic regulation of bioactive peptides. *Food Production, Processing and Nutrition*, *5*(1), 10.

McDonald, S. T. (2017). Concepts of flavor creation in novel nutraceuticals and functional food formulations. In *Developing New Functional Food and Nutraceutical Products* (pp. 231-247). Academic Press.

Mehra, R., Kumar, H., Rafiq, S., Kumar, N., Buttar, H. S., Leicht, K., and Korzeniowska, M. (2022). Enhancing yogurt products’ ingredients: preservation strategies, processing conditions, analytical detection methods, and therapeutic delivery—an overview. *PeerJ*, *10*, e14177.

Mehta, N., Kumar, P., Verma, A. K., Umaraw, P., Kumar, Y., Malav, O. P. and Lorenzo, J. M. (2022). Microencapsulation as a noble technique for the application of bioactive compounds in the food industry: A comprehensive review. *Applied sciences*, *12*(3), 1424.

Mehwish, A. U., Manzoor, M., Aleem, K., Shafi, F., Shamoon, F., and Rani, A. (2023). *Rohail (2023) A review exploring the incorporation of microalgae to enhance the nutritional profile and health benefits of dairy products. Agrobiol Rec 13: 92–100*.

Mena, B., Sîrbu, A., and Eze, C. C. (2024). Global Consumer Perception Towards Healthy Foods: Influencing Factors and Current Trends. *Consumer Perceptions and Food*, 15: 605-623.

Mendez-Galarraga, M. P., Curutchet, A., and Arzuaga, M. R. (2025). Hybrid Yogurts: Exploring the Functional, Sensory and Nutritional Potential of Dairy-Plant Protein Combinations. *Food Reviews International*, 26: 17.

Meshram, B. D., Poonam, D., Wasnik, P. G., Adil, S., and Datir, R. (2016). Application and Uses of Herbs in Milk and Milk Products. *Int. J. Pure App. Biosci*, *4*(5): 226-235.

Milner, J. A. (2002). Functional foods and health: a US perspective. *British journal of nutrition*, *88*(S2): S152-S158.

Mukherjee, P. K., Banerjee, S., Gupta, B. D., and Kar, A. (2022). Evidence-based validation of herbal medicine: Translational approach. *Evidence-based validation of herbal medicine.* 15*:* 41). Elsevier.

Musakhanian, J., Rodier, J. D., and Dave, M. (2022). Oxidative stability in lipid formulations: a review of the mechanisms, drivers, and inhibitors of oxidation. *AAPS PharmSciTech*, *23*(5), 151.

Obahiagbon, E. G., and Ogwu, M. C. (2023). The nexus of business, sustainability, and herbal medicine. In *Herbal Medicine Phytochemistry: Applications and Trends.* 16: 42.

Oyeyinka, A. T., and Oyeyinka, S. A. (2018). Moringa oleifera as a food fortificant: Recent trends and prospects. *Journal of the Saudi Society of Agricultural Sciences*, *17*(2), 127-136.

Padgaonkar, S. V. (2009). Functional foods with protective benefits. *PFNDAI Bulletin April*.

Paswan, V. K., Rose, H., Singh, C. S., Yamini, S., & Rathaur, A. (2021). Herbs and spices fortified functional dairy products. *Herbs and spices-new processing technologies*.

Peckenpaugh, N. J. (2009). *Nutrition Essentials and Diet Therapy-E-Book: Nutrition Essentials and Diet Therapy-E-Book*. Elsevier Health Sciences.

Peter, S. M. (2025). International Business Strategies for Natural Pet Foods: Responding to Consumer Demand, Ethical Sourcing, and Regulatory Challenges.

Poonia, A. (2020). Herbal Food Product Development and Characteristics. In *Herbal Product Development* (pp. 37-53). Apple Academic Press.

Rashidinejad, A. (2022). Green Tea Catechins: Functionality, Addition to Food, and Bioavailability. In *Tea as a Food Ingredient* (pp. 33-69). CRC Press.

Razavi, B. M., Ghasemzadeh Rahbardar, M., and Hosseinzadeh, H. (2021). A review of therapeutic potentials of turmeric (Curcuma longa) and its active constituent, curcumin, on inflammatory disorders, pain, and their related patents. *Phytotherapy Research*, *35*(12), 6489-6513.

Ritota, M., and Manzi, P. (2020). Natural preservatives from plant in cheese making. *Animals*, *10*(4), 749.

Sarkar, S. (2019). Potentiality of probiotic yoghurt as a functional food–a review. *Nutrition & Food Science*, *49*(2), 182-202.

Shahidi, F., and Ambigaipalan, P. (2016). Beverages fortified with omega-3 fatty acids, dietary fiber, minerals, and vitamins. *Handbook of functional beverages and human health*, 801-813.

Shlisky, J., Bloom, D. E., Beaudreault, A. R., Tucker, K. L., Keller, H. H., Freund-Levi, Y., and Meydani, S. N. (2017). Nutritional considerations for healthy aging and reduction in age-related chronic disease. *Advances in nutrition*, *8*(1), 17-26.

Sikorski, Z. E., Pokorny, J., and Damodaran, S. (2007). Physical and chemical interactions of components in food systems. In *Fennema's food chemistry* (pp. 861-896). CRC Press.

Singh, R. P., Raju, P. N., & Jana, A. (1982). Food technology. *Institute of Food Technologists*, *36*(2), 87-91.

Singirala, S. K., Dubey, P. K., and Roy, S. (2025). Extraction of Bioactive Compounds From Withania somnifera: The Biological Activities and Potential Application in the Food Industry: A Review. *International Journal of Food Science*, *2025*(1), 9922626.

Siro, I., Kápolna, E., Kápolna, B., and Lugasi, A. (2008). Functional food. Product development, marketing and consumer acceptance—A review. *Appetite*, *51*(3), 456-467.

Teshome, E., Forsido, S. F., Rupasinghe, H. V., and Olika Keyata, E. (2022). Potentials of natural preservatives to enhance food safety and shelf life: A review. *The Scientific World Journal*, *2022*(1), 9901018.

Thakur, A., and Thapa, D. (2023). Holy Basil (Ocimum sanctum): A comprehensive review of traditional uses, phytochemical composition, medicinal properties and future directions. *Just Agric*, *3*, 136-151.

Thakur, L., Ghodasra, U., Patel, N., & Dabhi, M. (2011). Novel approaches for stability improvement in natural medicines. *Pharmacognosy reviews*, *5*(9), 48.

Tucker, K. L., and Buranapin, S. (2001). Nutrition and aging in developing countries. *The Journal of nutrition*, *131*(9), 2417S-2423S.

Tunis, S. R., Stryer, D. B., and Clancy, C. M. (2003). Practical clinical trials: increasing the value of clinical research for decision making in clinical and health policy. *Jama*, *290*(12), 1624-1632.

Van Doorn, J., and Verhoef, P. C. (2011). Willingness to pay for organic products: Differences between virtue and vice foods. *International Journal of Research in Marketing*, *28*(3), 167-180.

Verma, M., Hontecillas, R., Tubau-Juni, N., Abedi, V., & Bassaganya-Riera, J. (2018). Challenges in personalized nutrition and health. *Frontiers in Nutrition*, *5*, 117.

Vishwakarma, S., Dalbhagat, C. G., Mandliya, S., and Mishra, H. N. (2022). Investigation of natural food fortificants for improving various properties of fortified foods: A review. *Food Research International*, *156*, 111186.

Wan, M. L., Ling, K. H., El-Nezami, H., and Wang, M. F. (2019). Influence of functional food components on gut health. *Critical reviews in food science and nutrition*, *59*(12), 1927-1936.

Wazzan, H. (2024). Fortification of dairy products using plant-derived bioactive compounds. *Current Research in Nutrition and Food Science Journal*, *12*(2), 561-571.

Witkamp, R. F. (2022). Bioactive components in traditional foods aimed at health promotion: A route to novel mechanistic insights and lead molecules?. *Annual Review of Food Science and Technology*, *13*(1), 315-336.

Yatoo, M. I., Gopalakrishnan, A., Saxena, A., Parray, O. R., Tufani, N. A., Chakraborty, S., and Iqbal, H. M. (2018). Anti-inflammatory drugs and herbs with special emphasis on herbal medicines for countering inflammatory diseases and disorders-a review. *Recent patents on inflammation & allergy drug discovery*, *12*(1), 39-58.

Zamani, S., Fathi, M., Ebadi, M. T., & Mathe, Á. (2025). Global Trade of Medicinal and Aromatic Plants. A Review. *Journal of Agriculture and Food Research*, 101910.