THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
Jan, 2025 Vol.5(1), 6088−6094

Review Article

Phytochemicals as a functional ingredient in dairy food formulation

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DOI:10.5281/ScienceWorld.14759823

Abstract

Indian ancient system of healing was deeply rooted to plant based medicines. Plants always had a significant role in maintaining physical, mental and spiritual health in human. Phytochemicals or plant derived chemicals are naturally occurring chemical substances that has higher therapeutic functions in human body. Studies estimate that there are almost 10,000 different types of phytochemicals in plant among these only few are studied for their functional property. Incorporating phytochemical plant sources in diet can reduce the chance of occurring chronic disease and oxidative damage. Extraction of those phytochemicals from plant source and optimised incorporation of them can develop different functional dairy products.

1. Introduction

'Phytochemicals' as the name indicates they are the chemicals found in plants. Or they are the secondary metabolites derived from plants. Phytochemicals are biologically active chemical compounds that has a major role in protecting plants from disease, damage, insects and prevent the plant from eaten by herbivorous animals (Chukwuebuka et al.,2015). Apart from the protection phytochemicals helps in providing specific colour and aroma to the plant which helps pollination of plant. Phytochemicals get accumulated in different plant parts such as stem, leaf, root, flower, fruits and seeds. Different range of phytochemicals can be found in fruits, vegetables, whole grains, legumes, herbs, seeds and fungi. The level may vary from plant to plant based on the climatic growing conditions and plant variety. Phytochemicals have various health promoting properties in human body. Plants have been widely used as traditional medicine in ancient times. Now a days phytochemicals are incorporated to daily diet as a functional food as well as nutraceuticals (Sharma et al., 2019). Due to the effective antioxidant property of phytochemical, they are widely used as a natural and secure antioxidant in fat rich dairy products. Addition of phytochemicals in dairy products not only improve

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Published 29/01/2025

its functionality but also enhance the textural quality and make it more visually appealing. Incorporating phytochemicals in a definite formulation to products like yogurt, ghee, cheese or milk can enrich their health promoting ability, potentially aiding in disease prevention and over all wellbeing (Kubade et al.,2024). Different methods have been used for extracting phytochemicals including ultra sound assisted extraction (UAE), pulsed electric field extraction (PEF), liquid gas extraction, Soxhlet extraction, percolation, maceration etc. (Kumar et al.,2023).

2. Classification of phytochemicals

Thousands of phytochemicals are identified in plants, they can be broadly classified into different classes based on their chemical structure and properties. Some of the major classes of phytochemicals which found in common food and their health benefits are listed in the table **1**.

Table 1: Phytochemicals and their health benefits

Class of phytochemical	Major food source	Health benefits
1. Flavonoids		
a. Quercetin	Apple, onion and citrus fruit	Antioxidant property, Anti-inflammatory effect, Improve heart health, Allergy relief
b. Catechins	Green tea	Antioxidant property, Improve heart health, Regulate blood sugar, Promote weight loss and fat metabolism
c. Anthocyanin	Berries. Cherries, red and purple grapes, purple cabbage	Antioxidant property. Anti-inflammatory effect. Cancer prevention. Regulate diabetes.
2. Carotenoids		
a. Beta-carotene	Carrot, sweet potato, pumpkin, spinach, kale	Vitamin A production, improve eye health, antioxidant property, reduce risk of chronic disease
b. Lutine	Orange, Spinach and kale	Improve heart health, Antioxidant property, Promote skin health
c. Lycopene	Red tomato, watermelon, pink grape	Antioxidant property, eye health, anti-cancerous property
3. Inositol	Bran from corn, oats, rice ray and wheat, nuts and seeds, soybean and soy products	Antioxidant property, retard cell growth
4. Isoflavones	Soy milk and soy products	Antioxidant property, inhibit tumor cell growth
5. Isothiocyanates	Broccoli, cabbage, kale, cauliflower	Induce detoxification of carcinogens, work as antioxidants
6. Lignans	Flax seed, sesame seeds, whole grains	Antioxidant property, estrogenic property

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7. Phytosterols	Vegetable oils, nuts, seeds	Cholesterol lowering property

Source:*http://www1.villanova.edu/dam/villanova/studentlife/documents/healthpromotion/Phytochemicals%20-%20Final.pdf, accessed on 20/04/2024*

3. Biological functions of phytochemicals in human body

As mentioned in Table 1. phytochemicals play multiple biological functions in human body. Various health benefits imparted by phytochemicals are discussed below:

a. Antioxidant property: Phytochemicals helps in scavenging free radicals from damaging the cells. Free radicals or reactive oxygen species (ROS) having an unpaired electron are highly reactive in body. They can damage molecules like lipids, proteins present in membrane, mitochondria and DNA (Zhang et al., 2015). It may result adverse health conditions such as tumour, inflammation, diabetes, atherosclerosis, cardiovascular diseases and neuro degenerative diseases. Phytochemicals functions its antioxidant property by donating an electron to free radicals and terminates its action. Consumption of fruits and vegetables having phytochemicals like flavonoids, carotenoids, lignans will result in reduction of occurrence of such diseases

b. Anti-cancerous property. Since they act as an effective antioxidant they will prevent cells from oxidative damage. Phytochemicals like curcumin from turmeric can act as an anti-inflammatory factor which will inhibit chronic inflammation associated with increased risk of cancer. Sulforaphane from broccoli and lycopene from tomato induce apoptosis in cancer cell and leading to cell death. Some phytochemicals like isothiocyanates found in cruciferous vegetables can enhance the detoxification of carcinogens and prevent their harmful effect (Ranjan et al., 2019; George et al.,2021).

c. Anti-diabetic functions: Flavonoids helps in promoting insulin signalling pathways in cells, which helps to improve glucose uptake and utilization. They can also slow down the digestion and absorption of carbohydrates which reduce the blood glucose level (Aba et al., 2018). Antioxidant property of phytochemicals results in reducing the chance of occurrence of diabetic mellitus.

d. Prevention of Coronary Heart Disease (CHD) : Prevention of CHD have also reported by consumption of phytochemicals (Bachheti et al., 2022). CHD is primarily caused by atherosclerosis which block arteries from supplying blood to heart. Phytochemicals such as quercetin, catechin and anthocyanin reduce the LDL (low-density lipoprotein) cholesterol oxidation and inhibit platelet aggregation which eventually prevent chance of atherosclerosis.

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e. Lowering of blood cholesterol: Phytosterols are plant chemicals that structurally similar to cholesterol. They play an important role in lowering blood cholesterol by competing with cholesterol for absorption site in intestinal lining which result in lower the cholesterol absorption.

Carotenoids found in orange and dark green colour vegetables can promote skin health by protecting skin against UV damage and support collagen production. Tannin is another phytochemical present in plants which can inhibit the oxidative phosphorylation of microbial metabolism and there by act as an effective anti-microbial agent (Onyekere et al.,2018). So the effective incorporation of vegetables, fruits, nuts and seed that contain different phytochemicals can support optimal health and disease prevention to a large extend.

4. Incorporation of phytochemicals in dairy foods

Fortification of dairy products using different phytochemicals is a promising route to create functional food. A number of studies have been conducted by adding phytochemicals from different plant source. Traditional dairy products fortified by fruit pulp, berries, herbs extracts and seeds catered nutrient rich and healthier products to modern health trends.

4.1. Enrichment of fermented dairy products with phytochemicals

Yogurt being a nutritional rich dairy product it is extensively used as a base product for fortification with different berries, fruits and herbs containing phytochemicals to enhance its biological function. Jany et al., (2024) developed functional yogurt by fortification with phytochemicals from pomegranate peel. The study reported a higher concentration of phenolic, flavonoid and anthocyanin content that enriched the physico-chemical, sensory and microbial quality in the final product. Dabija et al., (2018) studied the antioxidant activity and quality attributes of yogurt added with different wild herbs and observed a best result for antioxidant property in yogurt added with herb *marjoram* (*Origanum vulgare* L.). Yogurt fortified with phytochemicals from spices like cinnamon and berries like blue berry having improved antioxidant property have also been developed (Dimitrellou et al., (2020); Helal et al., (2018)). Other fermented dairy products like *Lassi* and *Shrikhand* were also fortified with turmeric, ginger and Tulsi extract to improve their functional properties. The study indicated an increased antioxidant activity due to higher amount of phenolic content in the final product (Maji et al., (2020); Ojha et al., (2018)).

4.2. Enrichment of fat rich dairy products with phytochemicals

Antioxidant property of phytochemicals is the targeted function of an adding phytochemical in fat rich dairy products. Rosemary extract was used in sheep ghee and other fat rich dairy products for inhibiting oxidation process, there by extending storage stability of finished products (Sawale et al.,2020). Other herbs like *Shatavari* (*Asparagus racemosous*) and *Ashwagandha* (Withania somnifera) were also added to fat rich dairy products to improve the shelf life due to their antioxidant

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properties. (Deshmukh et al., 2019). Apart from herbs Manjunatha et al., (2019) used dried powder of orange peel at 2% as nature-derived antioxidant to control the oxidative deterioration of ghee. The bioactive compounds or phytochemicals present in orange peel such as flavonoids acted as a biological antioxidant in ghee. Kubade et al., (2024) conducted a study to determine the effect of adding piper betel leaves containing phytochemicals like eugenol, ascorbic acid and β-carotenoid belonging to propenyl phenol group. The report showed an increased oxidative stability in the developed product compared to control sample added with BHA (Butylated Hydroxy Anisole).

4.3. Enrichment of frozen dairy products with phytochemicals

Addition of fruit and berry pulp to ice cream is a common practice to improve the flavour and colour. Gorya et al., (2015), studied the effect of adding processed *Amla* in to ice cream mix and found an increased number of phytochemicals like phenols and tannin in final product. Ice cream added with pumpkin and carrot pulp containing carotenoids, flavonoids and flavonols had been developed by Hassan et al., (2018). They observed that, ice cream added with carrot and pumpkin pulp found a low melting rate and higher antioxidant property. Studies proved that adding different phytochemical sources such as aloe vera, mint, shredded ginger and curcumin into ice cream could enhance the sensory attributes as well as health benefits (Gabbi et al., 2018; Mahajan et al., 2022)

4.5. Enrichment of dairy beverages with phytochemicals

Several phytochemicals have been explored for their fortification potential in dairy beverages due to their higher medicinal and nutritional value. Dairy beverages added with Tulsi, ginger extract, turmeric powder and aloe vera having antioxidative, anti-inflammatory and antimicrobial property have been developed by researchers (Gaur et al., 2019). Kamble et al developed a flavoured milk formulated by optimized addition of different varieties of piper betel leaves rich in phenols and aromatic vegetable oils. A sweet whey beverage fortified with *Moringa oleifera* leaves powder (MOLP) was developed to study the effect on its nutritional and volatile compounds. MOLP added at three levels (5%, 10% and 15%) showed an increased nutritional value with higher phytochemical content in all blends (Ismael et al., 2016).

5. Conclusion

Phytochemical can exhibit wide range of biological functions having significant effect in human body. Studies reported that the effective application of phytochemicals in different foods can improve its functionality. However, the bioavailability and optimising dosage of each phytochemicals remains areas for future study. Effective utilization and optimisations can make the fortified product even more health beneficial and can also improve their shelf life. Practicing a sustainable sourcing from renewable plant source, agricultural wastes or food waste like citrus peel grape skin extract could

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make this process more efficient. After apprehending the mechanism of action of each phytochemical they can also be used for targeted therapies and as a dietary intervention.

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