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REVIEW ARTICLE

Pumpkin Seed and Watermelon Seed, a Nutraceutical Adjunct for Health-promoting Cheese Spread: A Review

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Abstract

The use of pumpkin and watermelon seeds as nutraceutical adjuncts in cheese spreads boosts the health benefits and adds nutritional compositions. Spreadable cheese, a popular dairy product, is increasingly being considered for functional food development due to its long shelf life and bioactive properties. Pumpkin and watermelon seeds are both nutrient-dense, containing proteins, essential fatty acids, vitamins, minerals, and bioactive compounds with antioxidant, anti-inflammatory, and potential disease-preventing properties. Pumpkin seeds, rich in polyunsaturated fatty acids, minerals like magnesium, and bioactive peptides, have shown health benefits such as reducing the risk of chronic diseases, while watermelon seeds provide high-quality protein, antioxidants, and essential nutrients that promote heart health, improve skin conditions, and help manage diabetes. This review paper consists of an integration of these seeds into cheese spreads can provide a sustainable and innovative solution to meet the growing consumer demand for functional, nutrient-enriched dairy products. By utilizing these underutilized seeds, the dairy industry can develop healthier, value-added products that align with public health and sustainability goals. This approach highlights the potential of functional foods in supporting consumer well-being while diversifying the dairy sector.

Keywords: Pumpkin seeds, Watermelon seeds, Bioactive compounds, Functional, Nutraceutical adjuncts.

Introduction

Milk and dairy products are primary sources of biological calcium, essential for bone mass development. However, the dairy industry faces challenges due to seasonal price variations and high demand, which often lead to economic adulteration of dairy products. Such practices involve the inclusion of undeclared or prohibited ingredients, compromising product integrity. Protecting consumers from fraudulent practices and ensuring fair competition among producers are therefore critical priorities (Karoui & De Baerdemaeker, 2007). Among dairy products, spreadable cheese holds significant importance in Brazil, where its consumption has risen steadily since the 1990s, making it the third most popular dairy product in the country (Anonymous, 2014). Spreadable cheese, a processed cheese originating in Brazil, was traditionally crafted at home using naturally clotted milk, driven by the activity of inherent bacteria. Modern production methods utilize raw or pasteurized skim milk, with or without lactic acid bacteria, to create a soft, white, mildly acidic cheese derived from cow's milk. The distinctive characteristics of spreadable cheese stem from its production process, particularly the acid coagulation induced by lactic acid bacteria (Van Dender, 2014; Cristina *et al*., 2017). Processed cheese, including spreadable varieties, is valued for its extended shelf life and nutritional profile, offering bioactive proteins, lipids, minerals, and vitamins (Henning *et al*., 2006). In contrast to butter, which is less favored due to its poor spreadability, high saturated fat, and cholesterol content, processed cheese spreads are gaining popularity.

In India, cheese production is expanding at a rate of 10–15% annually, with 90% of cheese consumed as processed cheese or cheese spreads. These products provide fat and protein in a pre-digested form, alongside concentrated levels of calcium, phosphorus, riboflavin, and other vitamins. Additionally, they contain conjugated linoleic acid, health-promoting bioactive peptides, and

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lower fat content compared to low-fat table spreads (Giri, 2013). The functional properties of processed cheese and cheese spreads are influenced by the type and quantity of natural cheese, emulsifying salts, and other ingredients used in production (Zehren & Nusbaum, 2000). Cheese-making, an ancient method of food preservation, involves separating and maturing whey, which extends the shelf life of milk-based products. Processed cheese is produced by heating natural cheese to its melting point and blending it with suitable emulsifiers, enhancing palatability and flavor diversity. Globally, natural cheeses such as Swiss, mozzarella, and cheddar, with varying flavors and maturity levels, serve as raw materials for producing diverse processed cheese varieties, including soft, high-moisture, low-acidity cheese spreads and solid, high-acidity, low-moisture cheese blocks (Rifky *et al*., 2018; Mohichehra *et al*., 2024).

This review focuses on the incorporation of pumpkin seed and watermelon seed as nutraceutical adjuncts in cheese spreads, exploring their potential to enhance the nutritional and functional qualities of these products.

Pumpkin Seed

Pumpkins are members of the Cucurbitaceae family, which includes a number of species with both agronomic and economic significance. Every portion of the pumpkin is edible and packed with healthy nutraceutical ingredients. In addition to lipids (high in PUFAs), which contain necessary and non-essential fatty acids that help prevent a variety of illnesses like cancer and other cardiovascular disorders, pumpkin seeds are a useful source of protein that can aid in the eradication of protein deficiency. Pumpkin seeds may be used as an amazing dietary supplement that helps curb deficiency problems because they are rich in macro minerals (magnesium, phosphorous, potassium, sodium, and calcium) and micro minerals (iron, copper, manganese, zinc, and selenium). Pumpkin seeds are an expansive raw material for the food and pharmaceutical industries because they contain a variety of bioactive substances, including squalene, flavonoids, phytosterols, and polyphenols. Pumpkin seeds are a key treatment for benign prostatic hyperplasia (BHP) and have antidepressant properties. Eating pumpkin seeds on a daily basis can lower the risk of Parkinson's and Alzheimer's disease. Tocopherols are abundant in pumpkin seeds, which can be extracted for edible use and added to other food formulations for later use (Arunima and Vivek, 2024).

Most components of the pumpkin plant can be used for food, including the 78.69% meat, 17.95% peel, and 3.63% edible seeds, which have a rich nutty flavour and chewy texture (Singh and Kumar, 2020). According to Liliana *et al*. (2020), the meat is consumed as a vegetable or utilized in a variety of culinary preparations as components of soups, pies, breads, stews, jam, purees, marmalades, juices, pickles, fermented drinks, food dye, powders, and extracts of bioactive compounds. "Ogiri," a fermented product used as a seasoning in soups and gravies, is made from some of the fluted pumpkin species (Kaur *et al*., 2019). The primary byproducts of processing pumpkins are seeds and peel, and these flat, oval-shaped seeds are typically thought of as a byproduct of the agricultural industry (Syed *et al*., 2019). These days, pumpkin seeds are regarded as super seeds and are utilized as additions in the bread industry or eaten roasted and salted in many countries (S.M. Abou-Zeid *et al*., 2018). Additionally, they are gaining popularity in the snack food sector as a healthy substitute for traditional fried treats. Lipids (37.8–45.4%), carbohydrates (18–25%), proteins (25.2–37.0%), fibre (3–6%), and ash (3–5%) are found in pumpkin seeds. Edible oils can also be extracted from pumpkin seeds (Singh and Kumar,2023). Numerous essential minerals, including, P, Mg, Zn, Na, Se, Fe, Ca, Na, Mn, Se and Cu are stored in them, Phenolic compounds, squalene, phytosterols, tocopherols (α, β, γ, and δ), tocotrienols, carotenoids, flavonoids, and other bioactive substances are also present in them (Singh and Kumar, 2022). Food's natural bioactive ingredients are crucial for both illness prevention and health benefits. Due to their richness of different functional ingredients, pumpkin seeds are classified as functional foods, which have demonstrated the link between diet and health (Pham *et al*., 2016).

Bioactive peptides, which are short chains of amino acids with a variety of health benefits, are found in the proteins of pumpkin seeds. These peptides are known to have the ability to have physiological effects beyond basic nutrition; some of the bioactive peptides from pumpkin seeds may have anti-inflammatory, anti-cancer, antihypertensive, antioxidant, or other health-promoting properties. The physiological activities of these peptides are based on specific amino acid sequences, and they may be released from proteins during digestion, food processing, enzymatic hydrolysis in vitro, autolysis, and microbial fermentation. Several studies have examined the bioactive peptides derived from pumpkin seeds and their effects on a variety of health conditions. Pumpkin seeds are a beneficial complement to a balanced diet since they can supply these bioactive peptides as well as other necessary and physiologically active ingredients (Monika *et al*., 2024).

Nutritional Composition

One of the well-researched vegetables that prevents sickness is pumpkin, which is produced in 27 million metric tons worldwide each year. Public and medical expert interest in the role that functional foods play in illness prevention is currently growing. Pumpkin seeds are a rich source of useful functional elements. Functional components in pumpkin seeds are important for preventing disease and promoting human health, even though nutrients are the main metabolites that support life (Joachim & James, 2020). Pumpkin seeds are said to as nutritious powerhouses since

Table 1: Nutritional Composition of Pumpkin Seed (Syed *et al*., 2019)

Principle	*Nutrient Value*	*Percentage of RDA*
Carbohydrates	10.71 g	8%
Energy	559 Kcal	28%
Protein	30.23 g	54%
Total fat	49.05 g	164%
Cholesterol	0 g	0%
Dietary fibre	6 g	16%
Sodium	7 mg	7%
Potassium	809 mg	0.5%
Calcium	46 mg	17%
Copper	1.343 mg	4.5%
iron	8.82 mg	149%
Magnesium	592 mg	110%
Manganese	4.543 mg	148%
Phosphorous	1233 mg	198%
Folates	58 µg	15%
Niacin	4.987 mg	21%
Vitamin C	1.9 µg	2%
Vitamin E	35.10 mg	237%
Vitamin A	16 IU	0.5%
Pantothenic acid	0.750 mg	15%
Pyridoxine	0.143 mg	11%
Thiamine	0.273 mg	23%
Carotene-ß	9 µg	--

they are a great source of nutrients. Pumpkin seeds can be regularly ingested because they have no negative health consequences. (Maheshwari *et al*., 2015). Since pumpkin fruit seeds from various Cameron locations contain 28 to 40% proteins, 44 to 53% fat and 7 to 10% carbohydrates, they can be used as a source of oil and protein. All oilseeds in the Cucurbitaceae family provide protein digestibility and are a rich source of some essential amino acids (Achu *et al*., 2013). Elinge *et al*., (2012) found that potassium was the most abundant mineral at 273 mg/ 100 g, while manganese was the trace mineral with the lowest value at 0.06g/100g. The antinutritional components that are identified from pumpkin seeds include Nitrate 2.27 mg/100 g, hydrocyanic acid 0.22 mg/100 g, phytate 35.06 mg/100 g, and oxalate 0.02 mg/100 g. According to their finding, if used appropriately, pumpkin seeds may be a useful source of minerals. Pumpkin seeds are rich in fatty acids. Because of the presence of double bonds in atoms distant from the terminal methyl group in their chemical structure, omega fatty acids are different from polyunsaturated fatty acids. The fatty acids omega-3 and omega-6 are present in pumpkin seeds. (Arora *et al*., 2023).

According to the studies of Syed *et al*. (2019), shown in Table 1, the nutritional composition of pumpkin seed is higher than compared of other seeds. It gives an energy of 559 Kcal, Protein of 30.23 g, carbohydrate of 10.71 g, etc. It contains a good amount of minerals like sodium, potassium, calcium, copper, iron, magnesium, manganese and phosphorous.

Health Benefits

These days, consumers are more conscious of the importance of eating meals that promote a healthy lifestyle and are keen to have access to foods that are high in nutrients and easy to prepare, as these foods have a beneficial impact on human health. Over time, there has been an increase in demand for nutritious food items (Karam *et al*., 2016). Rich in vital nutrients, pumpkin seeds have a number of health benefits (Adsul & Madkaikar, 2021). While serum HDL cholesterol was dramatically elevated, oils extracted from raw pumpkin seeds significantly decreased serum triglycerides, total cholesterol, LDL cholesterol, uric acid, creatinine, serum transaminases, and urea (Nameni *et al*., 2021). Research on individuals using pumpkin seed oil in a controlled lifestyle by Majid *et al*. (2020) revealed a considerable increase in HDL cholesterol and a significant decrease in endpoint LDL cholesterol. According to their results, pumpkin seed oil may have hypolipidemic and antihypertensive properties because it raised HDL and decreased LDL. Because of their high magnesium content, they are known to help those with diabetes. In an observational study involving more than 127,000 persons, diets high in magnesium were associated with a 34% reduced risk for women and a 33% lower incidence of T2D for men (Arora *et al*., 2023). Tryptophan can be found naturally in pumpkin seeds. One amino acid that encourages sleep is tryptophan. Research indicates that consuming approximately 1 gram of tryptophan each day enhances sleep quality (Halson, 2014). Pumpkin seeds are also a great way to get magnesium. It has also been suggested that the magnesium levels have an impact on sleep (Chollet *et al*., 2001).

Watermelon Seeds

The fruit crop known as watermelon (Citrullus lanatus) is a herbaceous creeping plant that is a member of the Cucurbitaceae family. It grows best in warm climates and is primarily propagated by seeds. Being a tropical plant, it needs enough sunlight and a temperature of over 25^{0}˚C to flourish to its full potential. The ideal growing conditions for watermelon are fertile, well-drained soil that is somewhat acidic. Ghana's coastal regions, the woodland zone and particularly the riverbeds in the northern Savannah regions are suitable for its cultivation (Anonymous, 2011).

For many types of watermelon, the key determinants of quality are sweetness and sugar content. It is well-renowned for being incredibly nourishing and thirst-quenching, yet

having few calories. The juice of watermelon is fermented to produce a cool, mildly alcoholic beverage in Namibia (Okonmah *et al*., 2011). The rind is cut, dried, fried and consumed in various African countries. In various regions of the United States, pickled watermelon rind is a common food. It is well known that the fruit is a good source of carotenoids and lycopene. It aids in squelching the free radicals that fuel diseases, including arthritis, diabetes, atherosclerosis, asthma, and colon cancer. Citrulline, an amino acid the body requires to generate arginine, and fibre are also abundant in it (Oyeleke *et al*., 2012).

One of the underrated byproducts is the seeds of watermelons (Citrullus lantus). Watermelon seeds have a reasonable amount of nutrients, good functionality, and good *in-vitro* digestibility of their proteins with fewer antinutritional components. Their high arginine concentration in their amino acid makeup indicates that they have therapeutic advantages (El Adaway and Taha, 2001). Additionally, Cucurbitaceae oilseeds from various Cameroonian locations had a significant lipid content. Oil makes food more palatable and provides concentrated energy. Because of their high protein and fat content, the seeds may also be used to boost the nutrition of infants (Maynard, 2001).

Watermelon seeds are also regarded as a very nutrient-dense food. They are a well-known source of protein, vitamins B, minerals (such as magnesium, potassium, phosphorous, salt, iron, zinc, manganese, and copper), fat and phytochemicals. The economic benefits of watermelon seeds are well acknowledged, especially in countries where agriculture is growing. For instance, the seeds can be used to produce flour, sauces and snacks. The oil from the seeds is used for cooking and in the production of cosmetics. Watermelon seeds are often discarded after the fruit is eaten, despite the fact that they have a wide range of potential uses (Margret *et al*., 2022).

Nutritional Composition

Several nutrients can be found in watermelon seeds as shown in Table 2. They offer dietary fibre in addition to being high in protein and vitamin B. Numerous minerals are also present, including phosphorous, potassium, and magnesium. Lipids, iron, zinc, manganese, copper and sodium, along with other phytochemicals like alkaloids, phenols, tannins and flavonoids, contain saponins. These substances have anti-inflammatory, anti-cancer, and antibacterial qualities in addition to their bioactive qualities (Gayen *et al*., 2023).

Watermelon seeds are low in calories and contain vitamins A, B and C, 93.4% water, 0.5% protein, 5.3% carbohydrate,0.1% fat, 0.2% fibre and 0.5% ash. It also includes the following amino acids: arginine, betaine, lycopene ($C_{40}H_{56}$), citrulline ($C_6H_{13}N_3O_3$), amino acetic acid, malic acid, phosphoric acid, carotene, bromine, salt, potassium, sylvite, lysine, fructose, dextrose, and sucrose. The liver uses ammonia and CO_2 to create urea, which is excreted in urine. Citrulline and arginine are involved in this process, high potassium content, which can support the heart and bring blood pressure back to normal. Watermelon seeds contain active chemicals called kukurbositrin, which help activate the kidneys and maintain normal blood pressure. There are over 800 species in the Cucurbitaceae family, and they are primarily used for purposes other than vegetables. Although some people don't think it spread or originated from wild populations in southern Africa, it is a plant that is widely grown in tropical and subtropical regions of the world. (Megha *et al*., 2018).

Table 2: Nutritional composition of watermelon seed (Amrita *et al*., 2023)

Parameters	*Unit (%)*
Ash	2.12
Crude fibre	23.3
Carbohydrate	18.69
Protein	35
Total phenolic content	12.456 mg/100 g
antioxidants	34.71 mg/g

Health Benefits

The vital role of watermelon seeds in a healthy, balanced diet and their potential to become a superfood that enhances our quality of life must be acknowledged. They are a great source of vital nutrients that can improve our health in many ways. These tiny seeds are ideal for use in a variety of culinary recipes because of their mild, nutty flavour and crunchy texture. Lycopene. Vitamin C and vitamin A are among the many antioxidants found in watermelon seeds. According to Miguel *et al*. (2023), these antioxidant molecules aid in defending our cells against oxidative stress, which can harm cells, accelerate aging, and lead to the emergence of chronic illnesses like cancer, heart disease, and neurodegenerative diseases. (Miguel *et al*., 2023).

The sprouting seeds of watermelon, which are high in antioxidants and vitamin C, help to cleanse the skin. Its oil is widely used in many cosmetic products to treat acne and the early signs of aging. Watermelon seeds are a great source of magnesium, which improves the appearance of skin in general. Eczema and other dry-itching skin conditions can benefit from it. Zinc found in seeds has the ability to accelerate protein synthesis, cell division and repair while also slowing down the aging process. Magnesium helps control the metabolism of glucose, which directly affects blood sugar levels. These seeds contribute to the treatment of type 2 diabetes.

Watermelon seeds may be good for a healthy heart because of their anti-inflammatory, antioxidant and

vasodilator qualities. It supplies iron, which is necessary for the body's circulation of oxygen-rich blood. Watermelon seeds are also a good source of zinc, which is important for heart health. It controls how calcium moves through the heart. Watermelon seeds include iron and other elements that help boost the immune system. In this context, the vitamin B complex found in these seeds is also beneficial. Watermelon seeds have a high vitamin C content, which makes them useful for treating asthma symptoms. Vitamin C, a potent dietary antioxidant, can help mitigate the effects of asthma. Although there are studies that give some promise regarding the advantages of watermelon seeds for asthma, further research is still needed. Conversely, watermelon seeds are entirely safe to consume and should be an option for people with asthma (Margret *et al*., 2022).

Conclusion

The potential for developing cheese spreads enriched with pumpkin seed and watermelon seeds as nutraceutical adjuncts offers a compelling opportunity for innovation in functional food products. These seeds are recognised for their exceptional nutritional composition, including high-quality proteins, unsaturated fatty acids, essential vitamins, minerals and bioactive compounds with antioxidant and anti-inflammatory properties. This review has emphasized the viability of utilizing pumpkin and watermelon seeds as nutraceutical adjuncts in cheese spreads. Their integration not only supports consumer demand for healthier, functional dairy products but also aligns with the principles of sustainability by promoting the underutilized plant resources.

In conclusion, the incorporation of these seeds into cheese spreads presents a promising avenue for the development of value-added, nutrient-enriched functional foods. This approach contributes to the diversification of the dairy sector and fosters the advancement of nutraceutical applications, supporting both public health and sustainability goals.

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