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The importance of lentil, pea and mung beans sprouts in bakery

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Abstract

Legume sprouts are widely utilized across various fields due to their high nutritional value and numerous health benefits. They are recognized as a valuable source of high-quality proteins, vitamins, minerals, and bioactive compounds with antioxidant properties. Consumer orientation towards a rational and healthy diet has led to an increase in the consumption of sprouted products and their introduction into various food products. This review aims to highlight the importance of using legume sprouts in baking and pastry and the nutritional and functional impact on consumers.

Key words: legume, sprouts, functional, bakery, pastry

1. The evolution of legume consumption worldwide and in Romania

The Fabaceae family, commonly known as legumes, represents a group of ancient angiosperm dicotyledonous plants, distinguished by their remarkable diversity, encompassing approximate [1]. Legumes represent a valuable source of high-quality nutrients, offering a viable alternative to animal-derived proteins and serving as a comprehensive source of essential nutrients, particularly beneficial for individuals experiencing nutritional deficiencies [2].

In the past two decades, sprouts derived from legumes have gained significant popularity among consumers and within the scientific research community due to their high nutritional value and remarkable functional benefits. The evolution of consumer preferences highlights a growing trend toward adopting a healthy lifestyle and consuming natural foods, which supports the frequent inclusion of legume sprouts in balanced diets due to their low calorie and fat content. Moreover, recent research underscores the potential of these sprouts in preventing chronic diseases and improving overall health, thereby contributing to long-term well-being promotion [3].

The effects of germination depend on both the plant species and environmental conditions, although the overall process is common to most plants. Germination is a phase of intense metabolic activity, during which water absorption by the seeds triggers metabolic processes that oxidize stored oils and carbohydrates while breaking down storage proteins. This process provides the energy and amino acids necessary for physiological functions and plant growth [4-6].

Germination has also been documented as an effective method for reducing certain anti-nutritional factors present in seeds, such as trypsin inhibitors, phytates, and raffinose oligosaccharides. Some antinutritive components are leached out during soaking, while others are metabolized into secondary compounds within the germinating seed. For instance, trypsin inhibitors, which hinder protein digestion, are significantly reduced, and phytic

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acid, which forms insoluble complexes with essential minerals, undergoes hydrolysis. This hydrolysis enhances mineral bio-availability, facilitating their absorption in the human body [4]. Another noticeable change during germination is the significant increase in moisture content, with sprouts containing substantially higher water levels compared to their raw seeds. For instance, mung bean sprouts consist of 93.2% water, whereas the raw seeds contain only 11% [4, 7].

Lentils (*Lens culinaris*) are one of the oldest cultivated plants, having a history of thousands of years as a staple food for various civilizations. Native to the Fertile Crescent region, which includes the Near East, lentils played an important role in human nutrition and the development of early agriculture [2]. Lentils are a legume known for their numerous health benefits, including a reduced risk of cancer due to their rich content of anticancer compounds such as lectins, glycosidic saponins, bioactive peptides (including protease inhibitors), fermentable fibers, and oligo-saccharides. Additionally, their high polyphenol content exhibits significant antitumor activity. [8, 9].

Vidal-Valverde *et. al.* [10] reported a significant reduction in antinutritional factors, including trypsin inhibitors and phytates, over six days of germination. However, the concentration of tannins and catechins increased in both analyzed varieties. These compounds, known for their antioxidant properties, are commonly associated with chocolate and tea. After six days, catechin levels were measured at 1.0 mg/g and 1.2 mg/g (dry weight basis) for the two varieties Pea (*Pisum sativum* L.) is one of the most widely cultivated legumes worldwide, accounting for 26% of the total legume production in 2014 [11]. Its area of origin and initial domestication lies in the Mediterranean, primarily in the Middle East [12].

The sprouting process of pea seeds leads to a significant increase in bioactive compounds, such as polyphenols and flavonoids, thereby enhancing antioxidant activity and contributing to the improvement of nutritional value [13].

One of the few studies conducted on pea sprouts examined the effects of germination on mineral levels and their bioavailability. Although soaking prior to germination led to some loss of zinc and magnesium, the study found that the improved bioavailability of these minerals after germination more than compensated for these losses [5]. Furthermore, the study determined that the optimal germination period was four days and that the presence or absence of light during germination had no significant effect on either the mineral levels or their bioavailability [4].

Mung beans (*Vigna radiate*) are widely consumed legumes in China, Korea, Japan, and Southeast Asian countries [14, 15]. Similar to others in this group, the primary essential nutrients in mung bean sprouts are B-complex vitamins [4]. Additionally, beans are a rich source of carbohydrates and fiber, as well as B-complex vitamins and essential minerals such as iron, zinc, calcium, magnesium, and potassium [16]. Although beans are a valuable source of carbohydrates, iron, zinc, B-complex vitamins, and proteins, they also contain anti-nutritional factors, such as phytates, which significantly reduce the bioavailability of mineral cations [16].

bean pea lentil

Figure 1 - Legume sprouts

The launch of products containing sprouted grains has grown exponentially across all food categories since 2006 [17, 18]. Between 2006 and 2011, sprouted grain product launches grew by an average of 14% per year, while between 2012 and 2016 the average annual growth rate reached 26%. According to an analysis carried out based on data available in the Mintel database, [19] which used the terms 'sprouted', 'sprout', 'germinated' and 'freshly sprouted' as filters (excluding products derived from Brussels sprouts, such as sprout powder

or juice), a total of 3613 new products were launched on the market during this period. The geographical distribution of these launches shows a majority concentration in North America, followed by Europe and the Australasia region [20].

The sprouted seed market in the European Union is considered a highly specialized niche segment, with approximately 120 professional production units across the EU [21].

The global bean sprouts market was valued at $4.5 billion in 2023 and is projected to reach $6.3 billion by 2033, growing at a compound annual growth rate (CAGR) of 3.5% from 2024 to 2033 [22].

Global consumption of lentils and peas has shown significant growth in recent years. In the United States, data from the National Health and Nutrition Examination Survey (NHANES) reveals that the percentage of adults consuming lentils and dried peas increased from 3.5% in 2003-2004 to 6.0% in 2017-2018 [23]. Among children, a similar upward trend was observed, with consumption rising from 1.1% to 3.4% during the same period [24]

At a global level, pulses - including lentils and dry peas - account for approximately 100 million metric tons of production annually, with chickpeas, dry peas, and lentils contributing nearly 40% of the total. The international trade of pulses has expanded by 29% since 2015, and projections indicate that the trade volume will reach around 21 million metric tons by 2024 [25].

Per capita intake of legumes varies significantly between countries. For example, daily bean and legume consumption ranges from 1.2 grams in Norway to 122.7 grams in Afghanistan, reflecting diverse dietary habits and cultural influences [26].

In the European Union, the consumption of legumes, including lentils and peas, has increased significantly. In 2017, the total legume consumption in the EU reached nearly 3 million tons, encompassing peas, fava beans, lentils, chickpeas, and soybeans. Although lentils and chickpeas are cultivated on smaller areas, the demand for these products continues to grow. The European Union imports approximately 1 million tons of legumes for food consumption, with chickpeas and lentils being among the most sought-after varieties [27].

In Romania, the consumption of sprouts has gained popularity, especially among health-conscious individuals, due to their high content of vitamins, minerals, and enzymes. Sprouts are valued for their ability to enhance digestion and strengthen the immune system [28]. For those interested in growing their own sprouts at home, the process is simple and requires only high-quality seeds, water, and a suitable environment for germination. This practice not only ensures a steady supply of fresh sprouts but also provides the satisfaction of cultivating healthy, natural food at home [29].

2. Nutritional properties and benefits of sprouts

Lentil, mung bean and pea sprouts are an excellent source of nutrients and bioactive compounds and are considered functional with multiple health benefits. Sprouting these legumes leads to significant changes in their chemical composition, established and available essential nutrients and reduces anti-nutritional factors. During sprouting, the protein and essential amino acid content increase significantly, ensuring an optimal protein profile for balanced diets [30].

In addition, sprouting lentils improves the bioavailability of iron and zinc, which are essential for metabolic health and immune system functions. Lentil sprouts also contain significant amounts of polyphenols and flavonoids, compounds that help reduce oxidative stress and prevent chronic diseases [10].

Mung bean sprouts are highly valued for their rich content of plant-based proteins, vitamins (such as vitamin C and B-complex vitamins), and minerals, including potassium, iron, and magnesium. The germination process of mung beans reduces the levels of antinutrients, such as phytates, thereby enhancing nutrient digestibility and absorption. Furthermore, these sprouts are an excellent source of both soluble and insoluble fibers, which contribute to digestive health and help regulate cholesterol levels [31].

Sprouted peas represent another nutritionally valuable legume. The germination process enhances their protein content while reducing indigestible complex carbohydrates such as raffinose. Pea sprouts are rich in vitamin E, vitamin K, and essential fatty acids, and they exhibit remarkable antioxidant properties.

Their consumption can support cardiovascular health and reduce the risk of metabolic disorders [32].

An additional benefit of lentil, mung bean, and pea sprouts lies in their contribution to gut

health. These sprouts are high in prebiotic fibers, which promote the growth of beneficial bacteria within the gut microbiome. Furthermore, they reduce irritating or antinutritional components such as lectins and tannins, thereby improving food tolerance and reducing the risk of digestive discomfort [33].

The nutritional composition of these legume sprouts includes water (70-75%), proteins (20-30%), fibers (5-10%), carbohydrates (5-15%), and moderate amounts of lipids (2-5%). Essential fatty acids such as linoleic acid and linolenic acid are present in balanced proportions, contributing to the health of the nervous and cardiovascular systems. Additionally, these sprouts contain significant amounts of minerals such as calcium, magnesium, iron, and zinc, which are essential for various metabolic functions [34].

Therefore, lentil, mung bean, and pea sprouts serve as versatile dietary options with both nutritional and functional benefits, making them suitable for regular diets as well as specialized regimens aimed at reducing the risk of chronic diseases.

Sprouted grains undergo a natural biochemical transformation during germination, significantly enhancing their nutritional profile and functional properties. This process increases the bioavailabiproteins, amino acids, vitamins (B, C, and E), and minerals (iron, zinc, magnesium, and calcium) while reducing anphytates, tannins, and protease inhibitors. Germination also stimulates thebioactive compounds, including polyphenols, flavonoids, apolyphenols, flavonoids, and antioxidants, which contribute antiinflammatory and cardioprotective effects [35].

Table 1 The nutritional composition of legume sprouts, based on databases and literature sources, per 100 g.

COMPONENT	Unit	Sprouts (medie)/100g	Raw Seeds /100g
Water (H_2O)	%	85 [36]	10 [36]
Energy	Kcal	121 [37]	371 [37]
Carbohydrates	g	13.5 [38]	65 [38]
Total Dietary Fiber (TDF)	g	3.5 [39]	8.5[39]
Total fat Lipid (TFL)	g	0.9 [40]	2 [40]
Protein	g	4.5 [39]	20
Ash	g	0.8 [40]	1.9 [40]
Starch	g	16.2 [41]	55.7 [41]
K	g	40 [42]	100 [42]
Ca	g	20 [37]	50 [37]
Mg	g	15 [43]	25 [43]
P	g	70 [40]	200 [40]
Fe	mg	2.3 [39]	7.5 [39]
Na	mg	5 [39]	10 [39]
Zn	mg	1.1 [44]	2.5 [44]
Cu	mg	0.4 [44]	1.2 [44]
Mn	mg	0.8 [44]	1.5 [44]
Vitamin C	mg	15 [37]	0
Phytates	-	Reduced by ~50%[39]	High[39]
Antioxidant Activity	-	Reduced by ~50%[39]	Baseline[39]

3. Use of sprouts in bakery

Grain legumes, due to their high protein content, serve as a valuable resource for the processing, canning, and food industries. In Eastern countries, approximately 400 different dishes are prepared using legumes, contributing to various physiological benefits for the body [1].

Due to the health benefits of germinated seeds, various studies have explored their incorporation into different food formulations, such as: biscuits [9, 45, 46], drinks [9, 47], baby smoothies [9, 48], muffins [9, 49, 50] and yogurt [9, 49, 50] and yogurt [9, 51, 52].

In the study conducted by Patel *et al*. [45], the effect of adding untreated, roasted, and germinated black gram (*Phaseolus mungo*) flour on the physicochemical properties of dough and the characteristics of biscuits made from soft wheat flour was investigated. The

results indicated that as the proportion of black gram flour increased, the diameter and spread ratio of the biscuits decreased, while their thickness increased. These changes were attributed to the increased protein and fiber content in the black gram flour, which influenced the dough rheology and the final product properties and by study, Polat *et al*. [46] formulated functional crackers enriched with germinated lentil extract. The addition of germinated lentil extract significantly enhanced the content of bioactive compounds and the antioxidant activity of the crackers without compromising sensory acceptability. Thus, the incorporation of germinated lentil extracts represents an effective strategy for developing bakery products with enhanced functional benefits.

Germinated mung beans represent a notable example of a nutritionally enhanced food. They are rich in protein, fiber, vitamins, and essential minerals. The germination process improves the bioavailability of these nutrients, particularly proteins and minerals such as iron and zinc. Furthermore, germination promotes the synthesis of bioactive compounds, including flavonoids and phenolic acids, which exhibit antioxidant and anti-inflammatory properties [53].

As bread is a fundamental component of the daily diet, efforts have been made to improve its quality by incorporating flour from germinated legumes. The inclusion of these germinated legumes in bread formulations has influenced the rheological properties of the dough and altered the physico-chemical and sensory characteristics of the final product [9]. Sprouts are plant-based foods rich in phytonutrients, such as glucosinolates, phenolic compounds. Numerous studies have demonstrated that sprouts also contain high concentrations of vitamins and minerals [54, 55].

The incorporation of sprouts into food formulations can be an effective strategy for enhancing the nutritional value of widely consumed products worldwide. In this context, scientific literature has been reviewed to identify studies assessing the impact of incorporating germinated grains on both the nutritional profile and sensory attributes of various food products. Most studies have focused on replacing wheat flour with sprouted cereal flour in food formulations. The favorable outcomes observed in these products were closely linked to the type of sprouts used and the proportion of wheat flour substitution. This review provides a concise overview of the nutritional benefits and sensory acceptability of food products enriched with sprouts [55].

Wheat flour is the most widely utilized flour worldwide, serving as the primary or partial ingredient in the majority of bakery and pastry products. In recent years, growing consumer awareness regarding dietary choices has driven the bakery and pastry industries to continuously enhance product quality. Consequently, various methods have been explored and continue to be investigated to improve the nutritional profile of bakery products while also developing functional foods that cater to a diverse range of consumers [56].

Lentil and bean flours are increasingly used to enhance the nutritional properties of food products. For this reason, recent studies frequently examine the effects of germination to assess its potential in improving the sensory profile of food products.

Germination enhances the protein and amino acid profile of flours used in baking while increasing the content of vitamins B, C, and E, which support metabolism and immune function. Additionally, it boosts antioxidant levels and bioactive compounds such as polyphenols, known for their anti-inflammatory properties [57].

Bakery products made with germinated flour exhibit a softer texture, improved water retention, and increased volume. The taste becomes more complex with a subtle sweetness due to the conversion of starch into simple sugars during germination. Additionally, the bread crust develops a more uniform color, while the crumb gains enhanced elasticity and aeration [18].

Conclusions

The growing consumer interest in natural and functional foods has driven the increased market presence of sprouted grain and legume-based products worldwide. Scientific studies support the potential of these ingredients in promoting long-term health by reducing the risk of chronic diseases and improving overall dietary quality. As a result, the integration of germinated legume flours in food formulations represents a promising approach for enhancing both nutritional value and consumer acceptance in modern food production.

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