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HEALTH-PROMOTING PROPERTIES OF BROAD BEANS (*VICIA FABA* L.)

WŁAŚCIWOŚCI PROZDROWOTNE BOBU (*VICIA FABA* L.)

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Authors' contribution
Wkład autorów:
A. Study design/planning
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C. Data analysis/statistics
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D. Data interpretation
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E. Preparation of manuscript
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Summary

The aim of this work was to review scientific studies on the health-promoting properties of one of the oldest legumes, the broad bean (*Vicia faba* L). A review of the research literature concludes that broad bean seeds are a rich source of plant proteins, complex carbohydrates, essential vitamins, minerals and phytochemicals. The seeds also contain small amounts of lipids. Broad beans are a good source of l-3,4-dihydroxphenylalanine (L-DOPA), a precursor of dopamine, which is used in the treatment of Parkinson's disease. GABA (gamma-aminobutyric acid), present in broad beans, is an amino acid that lowers blood pressure. Bean seeds contain anti-nutritional substances, e.g. vicin and convicin, which exacerbate the symptoms of hemolytic anemia known as favaism. Based on scientific evidence, regular consumption of legumes is potentially beneficial to health, including but not limited to reducing the risk of many chronic diseases. There is currently a growing interest in the use of legume proteins for the production of functional food products. Analysis of the research literature suggests that *Vicia faba* L. seeds can be a functional food ingredient and should be an important part of the diet.

Keywords: health promoting properties, *Vicia faba* L., broad beans, plant protein, chemical composition

Streszczenie

Celem pracy był przegląd opracowań naukowych na temat właściwości prozdrowotnych jednego z najstarszych warzyw strączkowych – bobu (*Vicia faba* L). Na podstawie przeglądu literatury stwierdzono, że nasiona bobu są bogatym źródłem białek roślinnych, węglowodanów złożonych, niezbędnych witamin, minerałów i fitochemikaliów. Nasiona zawierają również niewielkie ilości lipidów. Bób jest dobrym źródłem l-3,4-dihydroxphenylalanine (L-DOPA), która jest prekursorem dopaminy i ma zastosowanie w leczeniu choroby Parkinsona. Obecny w nasionach bobu GABA (kwas gamma-aminomasłowy), jest aminokwasem, obniżającym ciśnienie krwi. Nasiona bobu zawierają substancje antyodżywcze, np. wicynę i konwicynę, które nasilają objawy niedokrwistości hemolitycznej zwanej fawizmem. Na podstawie dowodów naukowych stwierdzono, że regularne spożywanie roślin strączkowych może przynieść potencjalne korzyści zdrowotne, w tym między innymi zmniejszenie ryzyka wielu chorób przewlekłych. Aktualnie istnieje rosnące zainteresowanie wykorzystaniem białek roślin strączkowych do produkcji funkcjonalnych produktów spożywczych. Na podstawie analizy literatury przedmiotu stwierdzono, że nasiona *Vicia faba* L. mogą stanowić funkcjonalny składnik żywności i powinny być ważnym składnikiem diety.

Słowa kluczowe: właściwości prozdrowotne, *Vicia faba* L., bób, białko roślinne, skład chemiczny

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Introduction

Broad bean (*Vicia faba* L.) is a versatile legume that is used worldwide as a food and medicine, among other things. It is a common edible plant in the Middle East, the Mediterranean, China, Ethiopia and Northern Europe [1]. This plant meets the basic nutritional needs of millions of people because it is a valuable source of plant protein, rich in lysine, nutrients, dietary fiber, non-nutritive secondary metabolites and bioactive compounds (antioxidants, phenols and γ-aminobutyric acid) that have health-promoting effects. It is also characterized by its low lipid content. Although broad bean seeds may contain some anti-nutrients, research shows that eating legumes may have potential health benefits. These include reducing the risk of cardiovascular disease, cancer, diabetes, hypertension, lowering LDL cholesterol, among others. Unripe broad bean seeds are most commonly used for direct consumption; the seeds can also be frozen, dried, cooked and canned [2-4]. According to Karataş et al. [5] the seed coat of *Vicia faba* L. is rich in functional nutrients such as, dietary fiber, minerals and phenolic substances. Therefore, consuming the seeds together with the seed coat has additional nutritional benefits and can help reduce the increase of chronic diseases. In addition, pulses flours, concentrates and protein isolates can be added to foods to enhance nutritional value and provide certain desired functional characteristics [6].

Although legumes, including broad beans, are an incomplete source of protein, the functional benefits of *Vicia faba* L. justify making this plant an important part of the diet due to its nutritional value and health-promoting properties.

Aim of the work

Due to the growing interest in the health-promoting properties of vegetable crops, including the search for alternatives to animal protein, the aim of this study was to summarize the most important questions about the health-promoting properties of one of the oldest legumes, *Vicia faba* L.

Methods

The paper was prepared on the basis of a literature review; the literature analysis of the study was thematic [7]. To this end, a comprehensive search of scientific literature in electronic databases was carried out: Wiley Online Library, Elsevier, PubMed, SpringerLink, Taylor & Francis, science portal ScienceAlert, journal publisher platform MDPI, Google Scholar search engine. Scientific journal websites and the United States Department of Agriculture website were also used, applying the following keywords: broad beans, *Vicia faba* L., origin of *Vicia faba* L., botanical characteristics of broad beans, chemical composition, glycemic-index, plant proteins, nutritional value, health-promoting, properties, functional food, anti-nutritional ingredients, diseases of civilization. The data collection period covered the months from April to September 2024. For the literature review, publications and articles in English and Polish (one paper in German) were selected, which were mainly published in recent years. Due to the high merit of the publications, especially with regard to the origin and botanical characteristics of broad beans, publications published between 1970 and 1990 were also analyzed. The titles, abstracts and full texts of the publications were carefully scrutinized when selecting the literature. Literature sources were selected that were directly relevant to the research question.

Literature review results

Origin and more important botanical characteristics of broad beans – Vicia faba L.

Broad beans are one of the oldest cultivated plants in the world [8]. The archeological research carried out by Caracuta et al. [9] using micro X-ray computed tomography showed that a wild variety (*Vicia faba* L.) grew near the Lower Galilee (Mount Carmel, Israel) 14,000 BC – almost three thousand years before the plant was domesticated. In biblical times, broad beans were a valuable food and are mentioned in two books of the Bible: the second book of Samuel (17.27-29) and the book of Ezekiel (4.9) [10].

According to historical sources, the broad bean was a plant that was known and cultivated in ancient Egypt, Palestine, Greece and Rome. Bean seeds were found during the excavations of Troy, and the bean is also mentioned in the Iliad [11]. In Egypt, broad bean seeds were found in the tombs of the pharaohs. In ancient Greece, on the other hand, broad bean dishes were served at funeral ceremonies. In ancient Rome, on the other hand, politicians gave out broad bean seeds for free before elections in a bid to win the favor of the people. The names of many ancient Roman families (Fabia) were derived from the word *faba* (bean).

Pliny the Elder's work *Historia naturalis* (1st century AD) shows that broad beans were one of the most important crops for Roman agriculture. This fact is also evidenced by the numerous culinary footnotes from this period by Gavius Apicius. Archeological work carried out in Biskupin has shown that broad beans were cultivated on Polish soil as early as 500 BC. Both in ancient times and in the Middle Ages, broad beans were among the most important cultivated and medicinal plants [12-14].

Broad bean (*Vicia faba* L. var. major Harz) – the correct botanical name is broad bean vetch, is a plant, with not very high heat requirements, an annual from the broad bean family (*Fabaceae* Lindl.), genus Vetch (*Vicia* L.). Broad beans come in two botanical forms: *Vicia faba* var. *major* – broad bean (edible form) and *Vicia faba* var. *minor* – broad bean (fodder form). Broad beans are a plant with a strongly developed root system – the tap root overgrows the soil to a depth of less than 110 cm. There are numerous root papillae on the roots of broad beans that host the bacteria *Rhizobium leguminosarum* bv. *viceae*, which fix atmospheric nitrogen. Broad beans are therefore a valuable forecrop for subsequent crops, as they leave behind a nitrogen-rich site and their strongly developed root system drains and aerates the soil well. The stem of the broad bean is straight, stiff, smooth, quadrangular and hollow inside. Depending on the variety, it can reach a height of 40 to 125 cm. The sessile leaves vary in shape and size depending on their position on the plant. Butterfly flowers, up to 5 cm long, are white with a purple sail and black spots on the wings. They are usually gathered in clustered inflorescences (2 to 4 flowers each) that grow at the base of the leaves. The plants usually flower in May-July. The fruit of the broad bean is a large, fleshy, green pod, 4-20 cm long, 1.5-3.5 cm wide, cylindrical or flattened, containing 2 to 5 seeds separated by spongy sepals (the pods become leathery and brownish black as they mature). The seeds are very large, lenticular or kidney-shaped, pale yellow or light green in color, possibly brown, and reach about 35 mm in length. Seed color and size is a varietal trait [11,15-16].

Chemical composition and health-promoting properties of Vicia faba L. *seeds*

Broad beans are a vegetable with high nutritional value at a relatively low calorie content; 100g of cooked broad beans provide approximately 110 kcal. Broad beans eaten raw in the form of young seeds have a low glycemic index: GI=40. Cooked seeds, on the other hand, already have twice the glycemic index [17-19].

The nutrient content of *Vicia faba* L. seeds and their bioavailability is influenced by a number of factors, including variety, seed maturity stage, meteorological conditions prevailing during plant vegetation, cropping

systems, and seed storage and processing conditions, including heat treatment [20-23]. The content of essential nutrients in broad beans is shown in Table 1.

Table 1. Essential nutrient content of broad beans (g/100 g)

Details	Protein	Carbohydrates	Lipids
Broad bean seed at milky maturity [12]	5-8	6-14	0.3-0.4
Dry bean seeds [12]	25.6-27.5	50.8-58.7	1.30-1.47
Cooked broad beans (without salt) [18]	7.6	19.6	0.4
Frozen broad beans [24]	6.8	13.4	0.4

Notes: Own elaboration based on Durau [12], United States Department of Agriculture [18], and Kunachowicz et al. [24].

Vicia faba L. is a plant rich in plant protein with a balanced amino acid profile, complex carbohydrates, dietary fiber, vitamins, minerals and antioxidants. In addition, it is characterized by its low lipid content. It contains many bioactive compounds, such as phenolic compounds – mainly flavonoids, with proven antioxidant activity. It is also a good source of l-3,4-dihydroxphenylalanine (L-DOPA), which is a precursor to dopamine and has applications in the treatment of Parkinson's disease. Broad bean seeds also contain anti-nutritional substances such as phytic acid, trypsin inhibitors, saponins, wicin and convicin (fava-inducing compounds), lectins and condensed tannins, which negatively affect the biological value of the seeds. In order to eliminate or minimize the anti-nutritional content, a number of methods are used to process broad beans [1,25-27], and to breed new varieties [28].

Broad beans are one of the main sources of cheap plant protein, especially in developing countries. A glass of cooked broad beans (170 g) provides approximately 12.9 g of protein, which is 26% of the recommended daily intake [4,18,23,29]. In addition, it has a high protein-to-carbohydrate ratio compared to other legumes [30].

Based on solubility, we can classify plant proteins, including *Vicia faba* L. protein, into five main groups. These include albumins, which are well soluble in water, globulins, which are soluble in dilute salt solutions, prolamins, which are soluble in alcohol, glutelins, which are soluble in dilute acids and bases, and residue (insoluble) proteins [31]. In a study by Alghamdi [32], globulins (69.5-78.1%), glutelins (12.0-18.4%), prolamins (1.83-3.57%) and albumins (1.41-3.01%) were the largest fraction of total proteins in thirteen broad bean seed varieties. It should be noted that the amino acid profile of *Vicia faba* L. protein is poor in sulphur-containing amino acids; methionine (48 mg/100 g) and cystine (61 mg/100 g), as well as tryptophan (73 mg/100 g). In contrast, *Vicia faba* L. seeds contain high levels of leucine (536 mg/100 g), lysine (487 mg/100 g), aspartic acid (853 mg/100 g), arginine (682 mg/100 g) and glutamic acid (1144 mg/100 g) [24]. The opposite is the case with cereal grains, which have a low content of lysine and a very high content of sulphur-containing amino acids. Therefore, cereal and legume seeds are considered complementary in plant-based diets [4,6,33].

As Pedersen et al. emphasize [34], high animal protein intake is associated with an increased risk of civilization diseases, while plant proteins show significant protective effects against many chronic diseases. According to Naghshi et al. [35], consumption of plant protein is associated with a lower risk of mortality from any cause and a lower risk of mortality from cardiovascular disease. The study by Bazzano et al. [36] showed that consumption of legumes, which are rich in protein and dietary fiber, lowers serum cholesterol levels and may reduce the risk of ischemic heart disease. According to Martineau-Côté et al. [37], broad bean proteins can be considered as a promising source of bioactive peptides that exhibit antidiabetic, antihypertensive, cholesterol-lowering, anti-

inflammatory and antioxidant activities, indicating the high potential of *Vicia faba* L. for use as a functional food.

Broad beans are becoming a sustainable source of plant protein with high nutritional quality. Flour produced from *Vicia faba* L. is used to enrich the protein content of various food products such as bread, biscuits and pasta. Legume proteins have functional properties such as water retention, fat binding, foaming and gelling, which could expand their potential use in the development of a wide range of food products. The seeds of *Vicia faba* L. are used to produce protein concentrates and isolates, which are further used to produce high-quality protein products [30,38,39]. Bean protein isolates can also serve as promising emulsifiers [40].

Bean seeds contain small amounts of lipids and the fatty acid profiles consist mainly of unsaturated fatty acids (oleic acid and linoleic acid), which have been shown to have health-promoting effects, such as an increase in serum HDL cholesterol, which contributes to the prevention of heart disease [37,41].

As highlighted by Singh et al. [42], the presence of dietary fiber, including resistant starch, which is increasingly included among the components of insoluble dietary fiber, is very important in broad beans [43]. The seeds of *Vicia faba* L. are a rich source of carbohydrates (51-68%); mainly starch, which accounts for about 45% of the total seed weight. Compared to other legumes, *Vicia faba* L. starch has a higher amylose and resistant starch content [44,45]. Resistant starch is defined as a starch and its breakdown products that are not absorbed in the small intestine of a healthy person (they are resistant to the action of digestive enzymes). In contrast, they are fermented in the large intestine by the microflora, inducing health benefits such as reducing inflammation and preventing colon cancer [46]. The presence of resistant starch provides a feeling of satiety and increases the volume of food, while slowing down the digestion of sugars. As glucose metabolism occurs more slowly, insulin secretion decreases. The benefits that result from the consumption of resistant starch also include the prevention and treatment of type II diabetes and weight control [47,48].

In the study by Karataş et al. [5], the total dietary fiber content of whole broad bean seeds was 27.5%, while that of the seed coat was 82.3%. It is therefore recommended to consume broad beans together with the seed coat, which is also a rich source of minerals and bioactive compounds. As highlighted by Mayer Labba et al. [27] and Vidal-Valverde et al. [49], broad bean seeds in their chemical composition contain oligosaccharides from the raffinose family: raffinose, stachyose and verbascose, which can cause bloating and gastrointestinal discomfort.

Broad bean seeds contain also a number of valuable macro- and micronutrients and vitamins (Table 2).

Table 2. Content of major minerals and vitamins (mg/100 g) – frozen broad bean seeds*

Macronutrients	[mg]	Micronutrients	[mg]	Vitamins	[mg]
Phosphorus (P)	49	**Iron (Fe)**	1.6	**Vitamin C**	21.5
Calcium (Ca)	52	**Copper (Cu)**	0.09	**Thiamine (B1)**	0.078
Magnesium (Mg)	21	**Zinc (Zn)**	1.4	**Riboflavin (B2)**	0.052
Potassium (K)	226	**Manganese (Mn)**	0.34	**Niacin (B3)**	2.77
Sodium (Na)	6			**Vitamin B6**	0.05
				Folates	0.1392
				Vitamin A	0.027
				Vitamin E	0.44

Notes: Own elaboration based on Kunachowicz et al. [24].
*The chemical composition of cooked (without salt) broad beans is provided on the United States Department of Agriculture website [18].

Legumes are rich in minerals such as potassium, calcium, magnesium and generally contain a small amount of sodium. Low sodium intake and high intake of potassium, calcium and magnesium are associated with a reduced risk of cardiovascular disease [50,51]. The high potassium content and low sodium content (in ripe broad beans) is also optimal for people suffering from hypertension and in low-sodium diets [1].

Broad beans are a good source of folic acid (folacin, vitamin B9) – a glass (170 g) of cooked broad beans contains about 177 μg of folic acid (which corresponds to about 88% of the daily requirement). It is also a rich source of copper and manganese – 170 g of cooked broad beans is approximately 0.44 mg copper (44% of the daily requirement) and 0.716 mg manganese (36% of the daily requirement) [18].

Broad beans also contain numerous bioactive compounds with health-promoting effects, which, in addition to the protein peptides mentioned earlier, dietary fiber, including resistant starch, include phenolic compounds and natural non-protein amino acids: L-DOPA and GABA [37].

Phenolic compounds serve as a rich source of natural antioxidants and enable the fight against free radicals. They are found in various anatomical parts of plants. They can be divided into several classes: phenolic acids, flavonoids, lignans, stilbenes and tannins [52]. Karataş et al. [5] found that the antioxidant capacity, phenolic content and condensed tannin content of the seed coat of broad beans were significantly higher than those of other pulses.

Broad beans are a rich, natural source of L-Dopa (Latin *levodopum*), a precursor to dopamine, used in the treatment of Parkinson's disease. Etemadi et al. [53,54] found the highest L-DOPA content in fresh leaves, followed by flowers, young pods, mature seeds and bean roots. The accumulation of L-DOPA (l-3,4-dihydroxphenylalanine) in *Vicia faba* has been discussed, among others, by Duan et al. [55]. On the other hand, GABA (gamma-aminobutyric acid, γ-aminobutyric acid), present in broad beans, is an amino acid that lowers blood pressure [56].

Vicia Faba L. also contains a number of antinutritional substances, including: phytates, saponins, lectins, the oligosaccharides mentioned earlier (raffinose, stachyose), vicine and convicin [1]. Vicin and convicin are the main anti-nutritional compounds in *Vicia faba* seeds, which exacerbate the symptoms of hemolytic anemia (called favaism, from the Latin name of the broad bean *Vicia Faba*). Favism or glucose-6-phosphate dehydrogenase deficiency (G6PDD) is a genetic disease resulting from a deficiency of the enzyme glucose-6-phosphate dehydrogenase G6PD. Therefore, people with G6PD deficiency should avoid eating broad beans and being near flowering plants [57-59].

Conclusions

Broad beans (*Vicia faba* L.) are one of the most important legumes with valuable taste, nutritional and health-promoting qualities. Scientific research shows that broad bean seeds are a rich source of plant proteins with a balanced amino acid profile and can be an alternative to animal proteins. They also contain many important minerals and vitamins (especially B vitamins), as well as bioactive compounds that show health-promoting properties. These include: dietary fiber, resistant starch, phenolic compounds, non-protein amino acids (L-DOPA and GABA) and, above all, bioactive peptides. Broad bean seeds may also contain antinutritional sbstances. However, scientific research confirms the preventive effect of the bioactive components found in *Vicia faba* L. against many chronic diseases of the 21st century. Although broad beans have great potential for the development of new nutraceuticals and biofunctional food ingredients due to their richness in health-promoting components, further scientific research is needed to better understand the health-promoting properties of this plant.

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