

COMMON BEANS – CHEMICAL COMPOSITION AND NUTRITIONAL VALUE

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Abstract. The common bean with the scientific name *Phaseolus vulgaris* L is a herbaceous plant that is part of the *Fabaceae* family. *Phaseolus vulgaris* L is one of the most well-known and consumed legumes in the world. Beans are excellent sources of protein, carbohydrates, minerals, vitamins, dietary fiber and omega fatty acids. Following a study conducted by a group of researchers, 16 amino acids were identified by HPLC analysis, namely: aspartic acid, glutamic acid, serine, histidine, glycine, threonine, arginine, alanine, tyrosine, cysteine, valine, methionine, isoleucine, phenylalanine, leucine and lysine. Due to its composition in macro and micronutrients, the nutritional profile is impressive and extremely valuable. Different types of beans are grown worldwide, being consumed mainly in poor countries and playing an important role in the diet. The protein content is 2-3 times higher than in cereals. Beans also contain thiamine, riboflavin, folic acid and have a low fat content. Among the most important minerals found in beans we can list: manganese, iron, zinc, copper, phosphorus and potassium, while other minerals are found in smaller percentage.

Keywords: *Phaseolus vulgaris* L, chemical composition, fatty acids, nutritional value

INTRODUCTION

Beans are among the top ten most widely cultivated legumes in the world, especially for their dry seeds. After wheat, maize and rice, beans are an important crop, especially in underdeveloped or developing countries (JANNAT, S. et al., 2019). Around 1300 species of legumes are cultivated worldwide, of which only 20 species are consumed by humans. Of those 20 species, beans have the largest share in terms of consumption (ALIU, S. et al., 2013).




The common bean, scientifically known as *Phaseolus vulgaris* L, is a herbaceous plant belonging to the *Fabaceae* family. More than 50 species have been reported in the Americas. There are older records of the cultivation of domesticated bean seeds, dating back approximately 3 millennia. In Africa, Latin America and India, the common bean is a major food source (KAZYDUB, N. et al., 2017, KOTUE, T.C. et al., 2018, BEEBE, S. E. et al., 2000) This plant is highly valued by consumers because it is extremely versatile, being successfully used in numerous culinary preparations, but also for its nutritional value (KOTUE, T.C. et al., 2018).




Beans are a rich source of essential amino acids, minerals and vitamins necessary for the human body. It is often referred to as the “concentrate of essential amino acids”. The proteins in *Phaseolus vulgaris* L are easily digestible (KOTUE, T.C. et al., 2018, BEEBE, S. E. et al., 2014).

There are many varieties of beans, some of the most well-known are presented in table 1.

Table 1.

Different type of beans

Name	Features
<p data-bbox="371 533 520 555">BLACK BEANS</p> 	<p data-bbox="632 510 1305 629">-it plays an important role in human nutrition, being a valuable source of protein, fiber, vitamins, minerals (high magnesium content) and polyphenolic compounds (phenolic acids, flavonoids and proanthocyanidins) (NGUYEN K.H., 2023, https://www.libertatea.ro/lifestyle/fasole-beneficii-proprietati-tipuri-de-fasole-3462924, RODRÍGUEZ, M. D. et al., 2024)</p> <p data-bbox="632 633 1305 725">-it has good gelling and emulsifying properties, being a food product with potential for use as a supplement in a wide range of food products. Black beans are also used to obtain various protein concentrates (NGUYEN K.H., 2023);</p> <p data-bbox="632 730 1305 801">-dry black bean grains are velvety to the touch and have a sweet taste (https://www.libertatea.ro/lifestyle/fasole-beneficii-proprietati-tipuri-de-fasole-3462924).</p> <p data-bbox="632 806 976 828">-the amino acid profile is well balanced.</p> <p data-bbox="632 833 1305 875">-the polyphenol content may differ depending on the variety, agricultural practices and geographical origin.</p> <p data-bbox="632 880 1305 972">-they have several benefits, the most important of which are: antihypertensive, antioxidant, anti-inflammatory, antimicrobial and anticancer, intervene in the control of lipid metabolism (RODRÍGUEZ, M. D. et al., 2024) .</p>
<p data-bbox="312 1014 580 1037">GREAT NORTHERN BEANS</p> 	<p data-bbox="632 976 1305 1048">-the beans are small, white, kidney-shaped (https://www.libertatea.ro/lifestyle/fasole-beneficii-proprietati-tipuri-de-fasole-3462924)</p> <p data-bbox="632 1052 1305 1095">-the consumption of Great Northern beans is lower compared to other varieties</p> <p data-bbox="632 1099 1305 1142">-it can be used to develop new functional food and beverage products (GUHA, S. & MAJUMDER, K. , 2024)</p> <p data-bbox="632 1146 1305 1218">-it was found that the starch from Great Northern beans, at a temperature of 21°C, had a very good absorption of water and oil (SATHE, S. K.& SALUNKHE, D. K., 1981)</p> <p data-bbox="632 1223 1305 1391">-Great Northern beans are rich in protein, fiber, vitamins (it has a valuable content of B vitamins, including folic acid, vitamin B1 and B6) and important minerals, such as: calcium, phosphorus, manganese, iron, magnesium, potassium and zinc(https://www.verywellfit.com/northern-bean-nutrition-facts-and-health-benefits-5072085, https://be-still-farms.com/blogs/healthy-organic-living-blog/why-great-northern-beans-are-a-must-have-in-your-diet-top-benefits).</p> <p data-bbox="632 1395 1305 1536">-it has multiple benefits, namely: it helps maintain a healthy digestive system and plays a role in keeping blood sugar levels constant, it has a cardiovascular protective effect and reduces the risk of heart disease, it helps lower LDL cholesterol levels (https://be-still-farms.com/blogs/healthy-organic-living-blog/why-great-northern-beans-are-a-must-have-in-your-diet-top-benefits).</p>
<p data-bbox="379 1606 512 1628">LIMA BEANS</p> 	<p data-bbox="632 1568 1305 1639">-Lima beans are semi-flat, kidney-shaped, with a fragrant taste (https://www.libertatea.ro/lifestyle/fasole-beneficii-proprietati-tipuri-de-fasole-3462924, GAVILAN-FIGARI, I.M. et al., 2024)</p> <p data-bbox="632 1644 1305 1785">-It has a high protein content, ranging from 14.24% to 24.92%, abundant in essential amino acids such as: lysine, phenylalanine (2.8–128.3 g/100 g), leucine (1.42–156.7 g/100 g), valine (0.81–98.3 g/100 g), threonine (0.84–102.7 g/100 g), isoleucine (0.77–90.8 g/100 g), and histidine (0.09–62.4 g/100 g) (GAVILAN-FIGARI, I.M. et al., 2024, PALUPI, H.T. et al., 2021, ADEBO, J. A., 2023)</p> <p data-bbox="632 1789 1305 1836">-like other bean varieties, lima beans are rich in vitamins (niacin, riboflavin, and thiamine) and minerals (calcium, iron, zinc, phosphorus, and potassium),</p>

	<p>with a low fat content (0.21-3.12%), but high in carbohydrates (50.44-77.39%) (ADEBO, J.A., 2023) -due to their high dietary fiber content, they help prevent diabetes, cancer, obesity, and cardiovascular disease (PALUPI, H.T., et al., 2021)</p>
<p style="text-align: center;">PINTO BEANS</p> 	<p>-Pinto beans are light brown in color with dark reddish brown spots, with a slightly flattened rhombohedral shape - Pinto beans contain high amounts of bioactive compounds, making them a healthy option for consumers (WIESINGER, J.A. et al., 2021); - it has abundant amounts of minerals, such as: calcium (113 mg/100 g), iron (5 mg/100 g), magnesium (176 mg/100 g), phosphorus (411 mg/100 g), potassium (1393 mg/100 g), sodium (12 mg/100 g), zinc (2 mg/100 g) and vitamins (vitamin C with 6.30 mg/100 g, thiamine with 0.71 mg/100 g, riboflavin with 0.21 mg/100 g, niacin with 1.17 mg/100 g, vitamin B6 with 0.47 mg/100 g, folic acid with 0.53 mg, vitamin E1 with 0.21 mg/100 g and vitamin K with 5.6 µg/100 g) (CÂMARA, C.R.S. et al., 2013); -the shell of the beans has extremely high concentrations of kaempferol 3-glucoside (WIESINGER, J.A. et al., 2021); -among the essential amino acids the most predominant is leucine, and glutamic acid was found in the highest concentration (AUDU, S.S. & AREMU, M. O., 2011) -Pinto beans exhibit anticancer activity, mainly due to the presence of polyphenolic compounds (CÂMARA, C.R.S. et al., 2013)</p>
<p style="text-align: center;">ADZUKI BEANS</p> 	<p>-Adzuki beans are of normal or larger size and reddish-brown in color (https://www.libertatea.ro/lifestyle/fasole-beneficii-proprietati-tipuri-de-fasole-3462924, HONDA, Y., et al., 2020); -nutritional parameters for 100 g edible portion of dry beans are: water with a percentage of 15%; energy with an intake of 324 kcal; proteins, with a content of 21.1 g; fat only 1 g; carbohydrates (found in the largest amount) of approximately 60 g; fibers with 3.9 g; ash with 3.4 g; calcium with a content of 82 g; iron with 6.4 mg; and among the vitamins: thiamine with 0.45 mg; riboflavin with 0.15 mg and niacin with 2.2 mg -Adzuki beans have in their composition 11 different types of phenolic compounds (phenolic acid, tannins and flavonoids), which show resistance to oxidative damage and prevent cell degeneration. -polyphenolic compounds are abundant in Adzuki beans (JAIN, P. et al., 2021) -several studies have shown that, due to the essential compounds, Adzuki beans possess a series of functional properties: antimicrobial, anti-inflammatory, antiallergic, antidiabetic, renal protective, hepatoprotective, antihypertensive, antihyperlipidemic, antiobesity, anti-Alzheimer, anticancer (HONDA, Y., et al., 2020, JAIN, P. et al., 2021)</p>
<p style="text-align: center;">KIDNEY BEANS</p> 	<p>-Kidney beans are red, kidney-shaped, and are the most well-known and widely used type of bean (https://www.libertatea.ro/lifestyle/fasole-beneficii-proprietati-tipuri-de-fasole-3462924) -Red kidney beans are an excellent source of amino acids (lysine-7 g/100g, leucine-7.2 g/100g, aspartic acid-9.5 g/100g, glutamic acid-10.2 g/100g and arginine-6.9 g/100g) and omega 3 fatty acids. -Red Kidney beans have a high level of trace elements such as manganese, potassium, iron, zinc, polyphenolic compounds that help reduce the effects of oxidative stress, carbohydrates, soluble and insoluble fibers, vitamins (mainly from group B). They have a low fat content (KIMOTHI, S. & DHALIWAL, Y.S 2020, AUDU, S.S. & AREMU, M.O., 2011) -the health benefits are multiple, having favorable effects in the action against cancer, regulating blood sugar levels, in cardiovascular and degenerative diseases, and an important role in managing body mass (KIMOTHI, S. & DHALIWAL, Y.S 2020, KAUR J. & ABIRAMI, 2023)</p>

CHEMICAL COMPOSITION

Different types of beans are grown worldwide, being consumed mainly in poor countries and playing an important role in the diet. Beans are excellent sources of protein, carbohydrates, minerals, vitamins, dietary fiber and omega fatty acids. The protein content is 2-3 times higher than in cereals (KIMOTHI, S. & DHALIWAL, Y.S 2020). Beans also contain thiamine, riboflavin, folic acid and have a low fat content (KIMOTHI, S. & DHALIWAL, Y.S 2020; DE BARROS, M. & PRUDENCIO, S.H., 2016).



Fig. 1. Pinto beans, red kidney beans, black beans, great northern

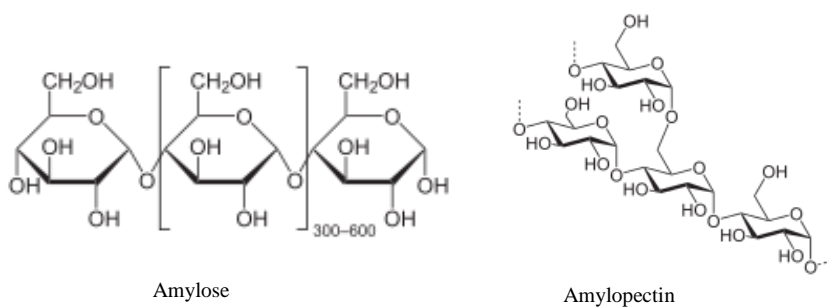
Carbohydrates

A major component of beans is represented by carbohydrates with a percentage of 63-66%, being mainly composed of starch (KOTUE, T.C. et al., 2018; ANINO, C. et al., 2019)

Starch is the major carbohydrate in beans and is found in all varieties of different sizes and shapes. It has a lower digestibility compared to cereal starch. Beans also contain a large amount of fibers such as cellulose, hemicellulose, pectins, oligosaccharides and lignins. These fibers can be partially or even completely fermented at the level of the large intestine, with a major impact on health (HAYAT, I. et al., 2014).

Starch is composed of amylose and amylopectin (figure 2).

Fig. 2. The structure of starch (amylose and amylopectin)



Proteins

Beans are one of the richest plant sources of dietary protein, with an essential role in the diet. Proteins in beans contain lysine, an essential amino acid that is found in small quantities in other cereals (HAYAT, I. et al., 2014). The majority in *Phaseolus vulgaris* L are

globulins with a maximum percentage of 79% and albumins with a percentage of up to 30% (KOTUE T.C., et al., 2018).

There are several factors that influence the concentrations of amino acids in beans, such as: genetic and environmental factors, genotype-environment interaction, crop management, etc. Following a study conducted by a group of researchers, 16 amino acids were identified by HPLC analysis, namely: aspartic acid, glutamic acid, serine, histidine, glycine, threonine, arginine, alanine, tyrosine, cysteine, valine, methionine, isoleucine, phenylalanine, leucine and lysine (FLORES-SOSA, Á.R. et al., 2020)

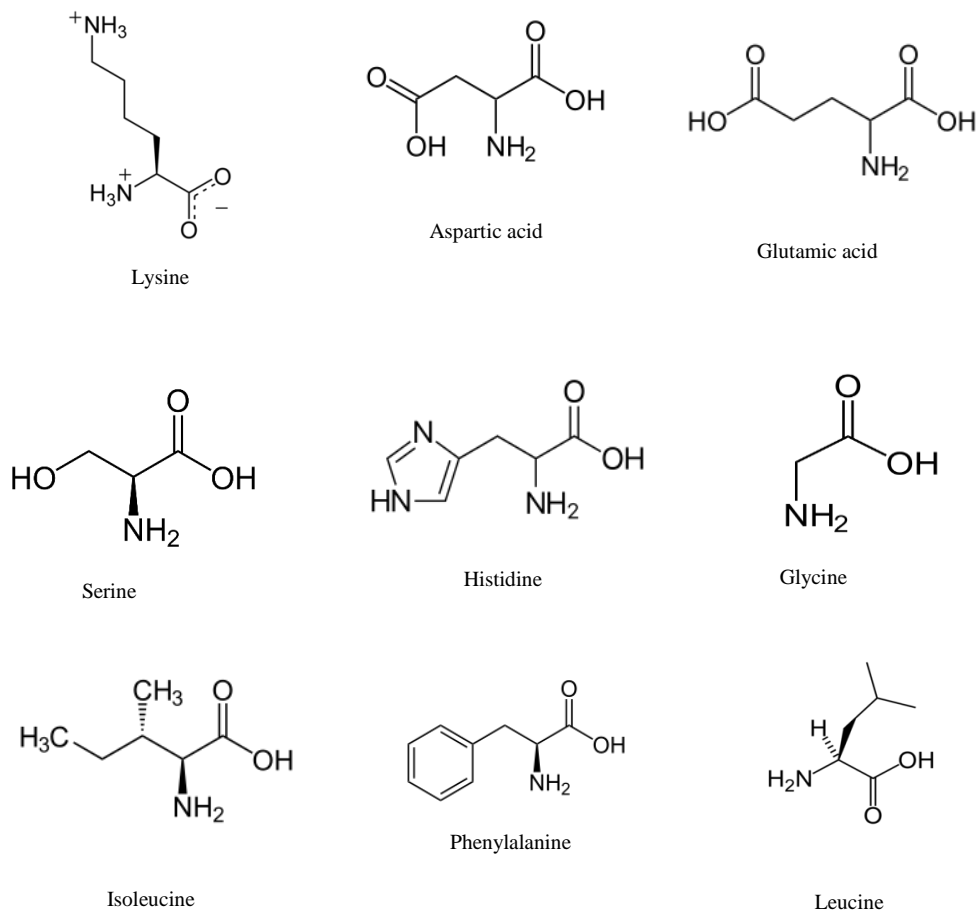


Fig. 3. Chemical structures of amino acids identified in beans

Vitamins And Minerals

Phaseolus vulgaris L is superior to other legumes in terms of micronutrient content, namely vitamins and minerals, having the highest amount of minerals. Among the most important minerals found in beans we can list: manganese, iron, zinc, copper, phosphorus and potassium, while other minerals are found in smaller percentages. Iron is found in the largest amount, 62.0-150 $\mu\text{g/g}$, being present mostly in non-heme form. Beans are also an excellent source of vitamins, such as: B complex vitamins (thiamine, riboflavin, niacin, folic acid, biotin, pyridoxamine), vitamin E

(tocopherols) and in a smaller amount vitamin K. An amount of 400-600 µg of folate is sufficient to satisfy approximately 95% of the daily requirement (HAYAT, I. et al., 2014).

Polyphenols

The major bioactive compounds with multiple bioactivities are polyphenols. The main polyphenols in beans are phenolic acids, flavonoids and proanthocyanidins. In general, beans whose beans are colored are rich in polyphenol compounds, mainly in the pigmented seed coat. The concentration of polyphenols is strongly influenced by various factors such as: genotype, environmental and storage conditions, processing method. Also, for the most accurate and correct evaluation of polyphenols in *Phaseolus vulgaris*, analytical methods must be taken into account, including extraction, separation and identification (YANG, Q.Q. et al., 2018).

Fatty acids

Beans are an important source of fatty acids, especially omega fatty acids that include linolenic acid, linoleic acid and oleic acid. These omega fatty acids play a role in strengthening the immune system, protecting against obesity and in preventing cholesterol, developing healthy tissues. The oleic acid and linoleic acid content of common bean varieties was determined to be 13.9% and 12.4%, respectively (<https://www.amazon.com/Food-Live-Adzuki-Sprouting-Pounds/dp/B00JGW35FK?th=1>). According to a research study, linoleic and linolenic fatty acids were predominant in beans. The percentage of oleic acid found in bean oil is 7.8%-13.8%, while linoleic acid had a higher percentage, ranging from 16.7%-25.8% (CELMELI, T. et al., 2018). The predominant fatty acids are unsaturated and represent 72-80% of the total, and saturated fatty acids account for between 20% and 28% of the total.

Regarding monounsaturated fatty acids, two main acids have been reported, oleic acid with 9 percent and cis-vaccenic with 2 percent of the fatty acids in beans.

The fatty acid profile of dry beans consists of 14 fatty acids, the most important in terms of content were: linolenic acid, the majority fatty acid, with an average value of 6.7 mg/g, then linoleic acid with a value of 3.9 mg/g, palmitic acid with 2.9 mg/g and oleic acid 1.5 mg/g (RODRÍGUEZ MADRERA, R. et al., 2024)

NUTRITIONAL ASPECTS

Phaseolus vulgaris L is one of the most well-known and consumed legumes in the world. Due to its composition in macro and micronutrients, the nutritional profile is impressive and extremely valuable. Macronutrients include proteins (with a rich content of essential amino acids), carbohydrates (the main ones are starch and dietary fiber), fats. The amount of fat in beans is low, which makes this legume can be used in diets to maintain body weight. Micronutrients refer to vitamins, predominant in beans are those from the B complex and minerals such as calcium, magnesium, potassium, phosphorus, copper, iron, zinc, manganese and sulfur. *Phaseolus vulgaris* L. is an important source of polyphenolic compounds, which have multiple potential effects on human health, such as: antioxidant, antidiabetic, anti-obesity, anti-inflammatory and anti-mutagenic and anti-carcinogenic properties, protection against cardiovascular diseases, cholesterol reduction (KIMOTHI, S. & DHALIWAL, Y.S., 2020). Also, due to the high content of dietary fiber, the consumption of beans may have digestive benefits, by supporting the development of good intestinal bacteria and helping regular bowel movements.

Different methods of preparing beans can affect their nutritional composition (KAUR, J. & ABIRAMI, 2023).

For poor countries, common beans meet malnutrition requirements and have a protective role against various diseases, including heart disease, cancer, osteoporosis, obesity and diabetes (JANNAT, S. et al., 2019).

CONCLUSIONS

Beans are one of the most widely grown legumes worldwide, being an important source of food especially in poor countries. They provide the necessary protein, dietary fiber, vitamins and minerals. Beans contain 16 amino acids, B vitamins (thiamine, riboflavin, niacin, folic acid, biotin, pyridoxamine), several minerals (iron, copper, manganese, magnesium, etc.), omega fatty acids. Beans also have a valuable nutritional value. They have several health benefits, presenting a series of properties including anti-inflammatory, antioxidant, antidiabetic, etc.

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