Nutritional Significance of Legume Crops

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Abstract

Legumes and pulses belong to the Fabaceae family which are nutritionally rich and are vital sources of proteins and other nutrients, especially chickpeas, peas, soybeans, and mung beans. Pulses are an excellent source of dietary fibers and resistant starch contributing to its low GI (glycemic index). Pulses are also a major reservoir of bioactive compounds that play an important role in metabolic processes; most of them belong to phenolic acids, flavonoids, and tannins. Pulses are also excellent sources of vitamins and minerals but their bioavailability is low due to co-occurrence of anti-nutritional factors. The consumption of pulses and their products lowers the health implications of severe diseases such as Diabetes, cancer, and neurogenerative diseases. The undigested pulse serves as feed for the gut microbiota; thus, consuming pulses also improves our gut health, which is beneficial for our health.

Keywords: Legumes, nutrition, bioactive compounds, health

Introduction

Legumes, belonging to the Fabaceae (Leguminosae) family, represent approximately 5% of about 400,000 plant species identified on Earth. The word "legume" originates from the Latin term Legumen, which means "beans inside pods." This family includes some of the earliest domesticated plants, known as "founder crops," which were pivotal to the development of early human agriculture. Among these "Big Eight" pioneer crops, four legumes- pea (*Pisum sativum*), chickpea (*Cicer arientinum*), lentil (*Lens culinaris*), and bitter vetch (*Vicia ervilia*) were cultivated as early as 10,000 BC, highlighting their ancient agricultural significance.

Cultivating legumes is essential for the global production of grains used for food and feed. Pulses, the edible seeds of leguminous plants, are crucial due to their high nutritional content. Among the 20,000 varieties of legumes worldwide, the most widely grown grain legumes include common bean, faba bean, pea, chickpea, cowpea, pigeon pea, lentil, peanut, grass pea, and horse gram.

According to the Food and Agriculture Organization (FAO) 2018 statistics, the common bean, also known as the dry bean, is the most widely cultivated grain legume globally, with 34.5 million hectares (mha) under cultivation followed by chickpea (17.8 mha) and cowpea with 12.5 mha. The global production of grain legumes exceeds 92 million tonnes, with significant contributions from countries such as India, China, Brazil, Argentina, Australia, Canada, and the United States. Among the countries, India stands out as the largest producer, contributing a quarter of the world's legume production.

In Europe, the most widely grown legumes are field peas, faba beans, and soybeans. Over the past decade, there has been a notable increase in soybean production, driven by the rising demand for livestock feed. Reports from the European Commission indicate that in 2019, 943,000 hectares were dedicated to soybean cultivation, with an expected increase of 44% by 2030. Despite this expansion, Europe relies heavily on imports, producing only 43% of its domestic legume consumption.

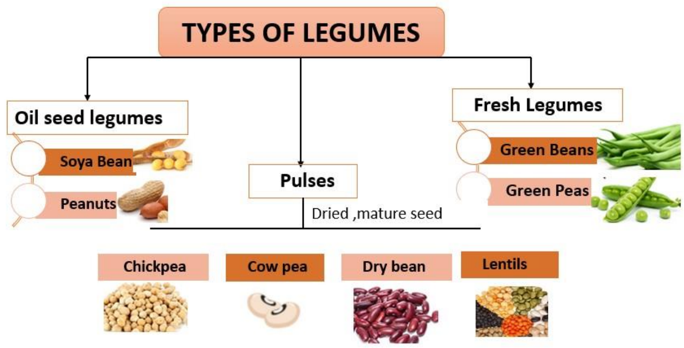

Fig 1: Classification of commonly consumed legumes

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Legumes are rich in protein, carbohydrates, fibers, vitamins, minerals, etc. They also serve as a significant protein source and a typical serving of legumes (1/2 cup of cooked dried legumes) contains approximately 2-4 g of fiber and 7-8 g of protein. Most beans have very low-fat content, generally comprising less than 5% of total energy, except for lupin seeds, and soybeans, which contain fat ranging from 15% to 47% of total energy (Rebello et al., 2014; Banti and Bajo., 2020). Significant amounts of B complex vitamins and important minerals including potassium, calcium, and iron are present in legumes. The proportional amounts of these elements, especially protein and fiber, as well as the makeup of each component, are what essentially define the nutritional value of legumes. The rich macro and micronutrient content of grain legumes makes them an important dietary component. Because of the way that they are composed of amino acids, proteins stand out among these nutrients. Since they help produce a balanced diet. Widely accepted claims highlight the benefits of grain and legume components in treating and preventing a variety of ailments when reevaluating their impacts on human health. When taken as a whole, these claims effectively support the frequent consumption of grain legumes as a means of enhancing health (Duranti 2006).

Composition and Nutrition

Legumes possess abundant and inexpensive sources of major nutrients such as proteins, carbohydrates, dietary fibers, antioxidants, vitamins, and minerals and in spite of that they remain underutilized crops. Legumes are a rich source of protein containing a good amino acid profile and also, legume proteins provide a higher amount of essential amino acids especially lysine in our diet (Kumar et al., 2022). Legumes are a source of complex carbohydrates such as resistant and slowly digestible starch, and oligosaccharides. On average per gram of legume provides 60.76 g carbohydrates 23.10 g proteins, and 1.86 g fat. In addition to that, legume also contains ample amount of minerals and 100 gm of legume contains potassium (1244 mg), phosphorus (367 mg), magnesium (177 mg), and calcium (113 mg). In addition to that, legumes also contain several antinutritional factors (ANFs) including α-galactosides, phytates, polyphenols, trypsin and chymotrypsin inhibitors, lectins, that limit their consumption (Fernández et al., 1997; Srivastava and Srivastava 2003). Different processing methods such as cooking fermentation, sprouting, and extrusion, are known to reduce their ANFs and enhance the digestibility and bioavailability of nutrients (Popova and Mihaylova 2019; Wiesinger et al., 2022).

Protein

Pulses provide a rich source of dietary protein. The protein content of pulses (per 100 g) ranges from 19.90 g in adzuki beans to 36.17 g in lupin and protein content in pulses is almost double as in the case of cereals. However, legume protein is deficient in sulfur-containing amino acids (cysteine and methionine) that are prevalent in abundant amounts in cereals. The major portion of legume protein is contributed by Globulins (72%) storage proteins and albumins (25%).

The composition of legume proteins is predominantly globulins (about 72%) and albumins (around 25%). Also, Legume protein content varies significantly based on cultivar, environmental factors, and agricultural practices. This variability influences both the protein content and amino acid profile observed across different legume species, from peas and beans to soybeans and lupins (Affrifah et al., 2023). Overall, legumes play a pivotal role in providing dietary proteins that complement or rival those found in animal products, contributing substantially to the nutritional diversity and protein intake of human diets worldwide.

Carbohydrates

Legumes are a rich source of carbohydrates and it ranges from 40.37 g/100 g in lupin and up to 63.40 g/100 g in lima beans. Also, it is a significant contributor to dietary fiber (soluble and insoluble) ranging from 5% to 37% (Collins 2020).

Starch, the predominant carbohydrate found in legumes, serves as a vital energy source in the human diet, primarily referring to non-structural carbohydrates. Also, legumes contain a high content of resistant starch (RS) and raffinose-family oligosaccharides which exhibit prebiotic activities and in turn, maintain intestinal gut health (Maphosa and Jideani 2017). Starch consists of amylose, a linear glucan with minimal branching, and amylopectin, a larger molecule with extensive branching. Legumes typically contain 30-40% amylose starch, which is 5-10% higher than cereals.

Quantifying resistant starch accurately poses challenges due to the absence of standardized analytical methods. Cooked legumes tend to retrograde or reassociate upon cooling more rapidly compared to cereals, thereby enhancing their resistance to digestion. Furthermore, it is feasible to augment resistant starch content in foods through modifications in water content, pH levels, temperature, and the severity of heating and cooling during processing.

Fibers

In addition to starch, legumes are rich sources of dietary fiber (DF), ranging from 5 to 37 percent. This fiber includes both soluble and insoluble forms, contributing significantly to their role in enhancing dietary fiber intake and supporting a diet characterized by a low glycemic index (GI) (Collins 2020).

Minerals

Legume crops contain significant levels of minerals essential for human nutrition. However, its bioavailability is low due to the presence of phytate that chelates the Zn and Fe Soybeans. Per 100 g, legume grains contain approximately 1,244 mg of potassium, 367 mg of phosphorus, 113 mg of calcium, 177 mg of magnesium, 3.5 mg of zinc, 6.23 mg of iron, 7.9 µg of selenium, and 0.76 mg of copper. These minerals play a vital role in metabolism and cellular processes and function as cofactors in numerous enzymes. Also, legumes are low in sodium which is a desired trait in human nutrition (Hohn et al., 2017).

Vitamins

Vitamins are crucial macromolecules required in small but adequate quantities to maintain optimal human health. Legumes contain significant amounts of B-complex vitamins (folate, thiamin, and riboflavin) and are relatively a poor source of fat-soluble vitamins and vitamin C (Maphosa and Jideani 2017).

Lupin has higher amounts of vitamin B1 (thiamin) and vitamin B2 (riboflavin). Soybean contains the highest levels of vitamin B3 (niacin) and folate, while lentils have a higher concentration of vitamin B6 (pyridoxine). Chickpeas are rich in vitamin C (ascorbic acid). Thiamin levels in most legumes meet the Recommended Dietary Allowance (RDA) for both children and adults (FAO/WHO 2002). Riboflavin levels in mung beans, winged beans, and soybeans are within the RDA for children, whereas the riboflavin level in lupin matches the RDA for adolescents. Additionally, the levels of pyridoxine in chickpeas and lentils fall within the recommended range for children (Bolarinwa et al., 2019).

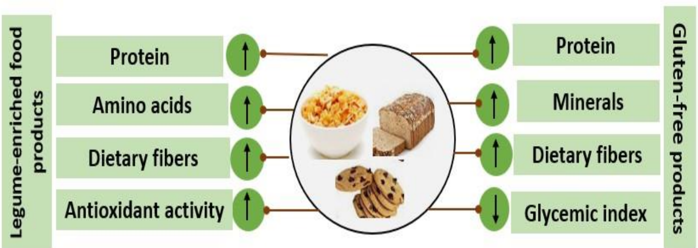

Fig 2: Nutrient enrichment in legume-based food products

Bioactive compounds

Legumes are an excellent source of bioactive compounds and they offer a huge health benefit. Bioactive compounds include antioxidants, oligosaccharides, saponins, phytic acid phenolics, peptides, peptides, and carotenoids (Maphosa and Jideani 2017; Wiesinger et al., 2022). Previously these compounds were called anti-nutritional having a role in the sequestration of nutrients and reducing nutrient bioavailability.

(Pedrosa et al., 2021) recognizes these compounds have an important role in nutrition and these factors lower the health implications such as coronary heart disease (CHD), type II diabetes, neurodegenerative, and obesity. These compounds also possess Anti-inflammatory, antioxidant, and antimicrobial activities. Moreover, Phenolics play a crucial role in regulating metabolism, homeostasis, and cell proliferation (Conti et al., 2021).

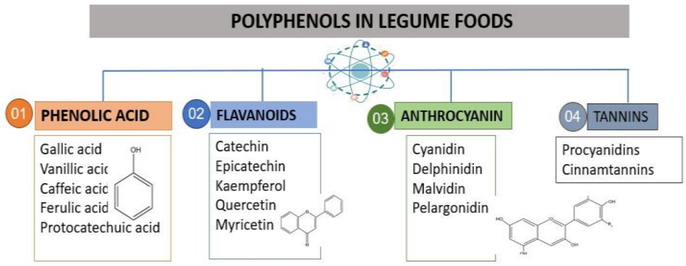

Fig 3: Various types of polyphenols present in food legumes

Challenges in legume nutrition

Anti Nutritional Factors

Antinutritional factors are compounds or substances generated by the normal metabolism of species in natural foodstuffs that reduce nutrient intake, digestion, absorption, and utilization, while also producing various other adverse effects. These factors, which can be heat-stable or heat-labile, include saponins, tannins, phytic acid, gossypol, lectins, protease inhibitors, amylase inhibitors, antivitamin factors, metal-binding ingredients, and goitrogens. Present in the seeds of cereals and legumes, these substances contribute to nutrition-related problems and can pose harmful effects to human health.

Antinutritional factors play a crucial role in determining the use of plants for human consumption by reducing nutrient utilization and/or food intake from plants or plant products. Plants have evolved these compounds to protect themselves from being eaten. However, in a monotonous diet, these toxins can accumulate in the body to harmful levels, and some vitamins in food may be destroyed by antinutritional substances. To fully maintain the nutritional value of food substances, these antinutritional factors must be inactivated or removed (Samtiya et al., 2020; Abbas and Ahmad 2018).

Plants that produce seeds rich in energy supplies, such as carbohydrates, lipids, and proteins, often accumulate potent chemical defense compounds. This is particularly true for grain legumes, which have large, protein-rich seeds that frequently contain substantial amounts of antinutritive factors (ANFs). These include lectins, protease inhibitors, non-protein amino acids (NPAAs), alkaloids, cyanogenic glycosides, pyrimidine glycosides, saponins, tannins, isoflavones, oligosaccharides, erucic acid, and phytates. The presence and concentration of anti-nutritional factors in different food substances vary depending on the type of food, its propagation method, chemicals used in crop growth, and those used in storage and preservation (Thakur et al., 2019).

Health Benefits of Legumes

There are numerous health benefits of legumes and it is an excellent source of protein, complex carbohydrates, dietary fibers, minerals, and vitamins. The slow digestibility of legumes makes it a satiety food as compared to cereals which leads to a surge in blood glucose levels after consumption. The dietary fiber present in legumes significantly contributes to the gut microbiome and is also believed to reduce the health risk of chronic diseases such as diabetes, cancer, and heart disease. RS, dietary fibers, and oligosaccharides digestibility enzymes are lacking in humans, and undigested products serve as nutrient sources for resident probiotics.

Conclusion

Pulses have been consumed as a nutrient and energy source over thousands of years. Pulse production is both environmentally and economically sustainable. Besides, pulses are rich sources of proteins, starch, dietary fibers, vitamins, and minerals that are essential for maintaining human health. Besides this, it is also a good source of polyphenol bioactive compounds that possess the properties of antioxidants and prevent from occurrence of severe diseases such as cancer, diabetes, hypertension, neurodegenerative, cardiovascular diseases, and obesity. With the sudden surge in the human population and prevailing malnutrition around the globe, the Consumption of pulses could prevent hidden hunger and malnutrition deficiency.

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