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Kidney beans (*Phaseolus vulgaris* L.) its nutrient profile, health benefits, value-added products and anti-nutritional properties

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Abstract

Kidney beans, also known as red beans, are widely consumed legumes with a rich nutrient profile and numerous health benefits. This article provides an overview of kidney beans, including their definition, cultivation, worldwide consumption, and nutrient composition. They are an excellent source of macronutrients and micronutrients, with high dietary fiber content and significant protein content, making them a valuable component of vegetarian and vegan diets. Additionally, kidney beans contain antioxidants, vitamins, and minerals that contribute to their health-promoting properties. However, kidney beans also contain anti-nutritional factors, such as Lectins, phytic acid, protease inhibitors, and tannins, which can affect digestion and nutrient absorption. Proper cooking techniques can mitigate the effects of these anti-nutritional factors. The article also explores value-added products derived from kidney beans, such as flour, snacks, protein isolates, and extracts, and their potential applications in the food industry. Furthermore, kidney beans have been found to be beneficial in managing diabetes, promoting cardiovascular health, aiding in weight management, and exhibiting anti-inflammatory and anticancer properties. In conclusion, kidney beans offer significant health benefits and play a crucial role in disease prevention. Future research should focus on understanding the mechanisms underlying their health benefits, optimizing processing techniques, and exploring novel applications to fully utilize the potential of kidney beans in enhancing dietary diversity and improving overall health outcomes.

Keywords: Kidney beans, dietary fiber, vitamins, antioxidants, anti-nutritional, snacks, flour

1. Introduction

Kidney beans, scientifically known as *Phaseolus vulgaris* L, are legumes widely consumed and appreciated for their nutritional value and culinary versatility (Jones *et al.*, 2019; Uusiku *et al.*, 2013)^[9, 32]. They are an integral part of various cuisines worldwide, contributing to dietary diversity and overall well-being. Kidney beans are characterized by their kidney-shaped appearance and are often referred to as "common beans" or "red beans" due to their reddish-brown coloration.

Kidney beans have a long history of cultivation and consumption, dating back thousands of years. Originating in Central and South America, kidney beans were later introduced to other parts of the world through the Columbian Exchange (Gepts *et al.*, 2008)^[11]. Today, kidney beans are cultivated in various regions, including North and South America, Africa, and Asia, making them accessible to a wide range of populations.

Kidney beans boast an impressive nutrient profile, making them a valuable addition to a healthy diet. They provide a balance of macronutrients and essential micronutrients. The macronutrients include carbohydrates, proteins, and a negligible amount of fat. The micronutrients found in kidney beans include vitamins such as folate, thiamine, and vitamin K, as well as minerals like iron, potassium, and magnesium (Drewnowski, 2014; Tsai *et al.*, 2017)^[9, 31].

The consumption of kidney beans has been associated with several health benefits. The high dietary fiber content in kidney beans promotes digestive health by aiding in regular bowel movements and supporting the growth of beneficial gut bacteria (Pereira *et al.* 2013; Tosh *et al.* 2013)^[23, 30]. This fiber-rich legume is also known for its potential in managing weight, improve Glycemic control, and reducing the risk of chronic diseases, such as cardiovascular diseases and certain types of cancer (Bazzano *et al.*, 2013; Aune *et al.*, 2017)^[6, 4].

The processing methods used for kidney beans can impact their nutritional composition. Cooking methods, such as boiling or steaming, can help retain the nutrients present in kidney beans (Mudryj *et al.*, 2014)^[22].

Canning, freezing, and dehydration techniques also preserve the nutritional content to a certain extent (Martínez *et al.*, 2019) [28]. Additionally, soaking and sprouting kidney beans can reduce the levels of anti-nutritional factors and enhance nutrient availability (Aguilera *et al.* 2016; Yadav *et al.* 2020) [2, 35]

The versatility of kidney beans extends to the production of value-added products. Kidney bean flour, derived from grinding dried kidney beans, is gaining popularity for its various applications in baked goods, snacks, and gluten-free products (Bai *et al.*, 2018) [5]. Kidney bean-based snacks and convenience foods are also being developed to cater to consumer demands for healthier alternatives (Yang *et al.*, 2021) [36]. Moreover, kidney bean protein isolates and extracts are being explored for their functional properties and potential use in food formulations (Wang *et al.*, 2020) [34].

Kidney beans play a significant role in promoting health and preventing various diseases. For individuals with diabetes, kidney beans can help manage blood sugar levels due to their low glycemic index and high fiber content (Vigiliouk *et al.*, 2014; Bazzano *et al.*, 2013) [33, 6].

2. Nutrient profile and Health benefits

2.1 Macronutrients and Micronutrients in Kidney Beans

Kidney beans are known for their rich macronutrient and micronutrient content. They are an excellent source of plant-based protein, providing approximately 20 grams of protein per 100 grams (Bhatty, 2016) [7]. Protein is essential for tissue repair, immune function, and enzyme production (Jukanti *et al.*, 2012) [15]. Additionally, kidney beans contain complex carbohydrates, which are slowly digested and provide a steady release of energy (Pilbeanu *et al.*, 2017) [24].

In terms of micronutrients, kidney beans are particularly high in folate, iron, potassium, and magnesium. Folate is crucial for DNA synthesis and cell division, making it important for pregnant women to support fetal development (Bhatty, 2016) [7]. Iron is essential for oxygen transport and plays a vital role in preventing iron deficiency anemia (Graham and Peterson, 2017) [13, 0]. Potassium is important for maintaining fluid balance and proper functioning of the nervous system and muscles (Jukanti *et al.*, 2012) [15]. Magnesium is involved in numerous biochemical reactions in the body, including energy production and muscle function (Pilbeanu *et al.*, 2017) [24].

2.2 Dietary Fiber and its impact on digestive health

Kidney beans are a great source of dietary fiber, with both soluble and insoluble fiber present in their composition. Soluble fiber forms a gel-like substance in the digestive tract, which can help reduce cholesterol levels and improve heart health (Li *et al.*, 2017) [17]. Insoluble fiber adds bulk to the stool, promoting regular bowel movements and preventing constipation (Rebello *et al.*, 2014) [26]. Adequate fiber intake has been associated with a lower risk of chronic diseases such as heart disease, diabetes, and certain types of cancer (Bazzano *et al.*, 2013) [6].

2.3 Antioxidants and their potential health benefits

Kidney beans contain various antioxidants, including flavonoids and phenolic compounds, which contribute to their potential health benefits. Antioxidants help neutralize free radicals, unstable molecules that can damage cells and contribute to chronic diseases (Luthria *et al.*, 2006) [20]. Research suggests that the antioxidants in kidney beans may

have anti-inflammatory and anticancer properties, protecting against conditions such as cardiovascular disease and certain types of cancer (Lima *et al.*, 2016) [18]. However, further studies are needed to fully understand the mechanisms and potential health effects of these antioxidants.

2.4 Vitamins and minerals present in kidney beans

Kidney beans are a rich source of vitamins and minerals that are essential for overall health and well-being. In addition to folate, iron, potassium, and magnesium, they also contain other important nutrients such as vitamin B6, vitamin C, and zinc (Graham and Peterson, 2017) [13]. These vitamins and minerals play various roles in the body, including supporting immune function, promoting collagen synthesis, and aiding in wound healing (Bhatty, 2016) [7].

Inflammation is associated with the development of chronic diseases, including cancer, and the antioxidants found in kidney beans can help combat oxidative stress and inflammation in the body (Aparicio-Fernández *et al.*, 2017) [3]. Additionally, the dietary fiber in kidney beans may promote a healthy gut microbiome, which plays a crucial role in maintaining immune function and reducing the risk of certain cancers (Gibson *et al.*, 2017) [12].

3. Anti-Nutritional Properties of Kidney Beans

3.1 Lectins: Types, effects, and their impact on digestion

Lectins are carbohydrate-binding proteins found in kidney beans and other legumes. They play a role in plant Defense mechanisms but can have adverse effects on human health if not properly inactivated during cooking. Lectins can bind to the lining of the digestive tract, potentially leading to digestive disturbances and nutrient malabsorption (Ricardo-da-Silva *et al.*, 2019) [27]. However, thorough cooking and soaking of kidney beans can significantly reduce Lectin levels and mitigate their negative effects on digestion.

3.2 Phytic acid: On mineral absorption

Phytic acid, also known as Phytate, is a naturally occurring compound found in kidney beans and other plant-based foods. It acts as a storage form of phosphorus but can inhibit the absorption of essential minerals, such as iron, zinc, and calcium (Lestienne *et al.*, 2005) [16]. This can potentially lead to mineral deficiencies in individuals consuming high amounts of kidney beans or relying heavily on plant-based diets. Soaking, fermenting, or sprouting kidney beans can help reduce the phytic acid content and enhance mineral bioavailability.

3.3 Protease Inhibitors: Impact on protein digestion

Kidney beans contain protease inhibitors, which are compounds that interfere with the activity of digestive enzymes involved in protein breakdown. These inhibitors can inhibit the activity of enzymes like trypsin and chymotrypsin, impairing the digestion and utilization of dietary proteins (Pusztai *et al.*, 1993) [25]. However, cooking kidney beans thoroughly can help inactivate protease inhibitors and improve protein digestibility.

3.4 Tannins: Antinutrient Effects and potential health risks

Tannins are polyphenolic compounds found in kidney beans that contribute to their astringent taste. While tannins have antioxidant properties, they can also have antinutrient effects

by binding to proteins and inhibiting digestive enzymes (Marinangeli *et al.*, 2017) ^[21]. High levels of tannins in kidney beans can lead to decreased protein digestibility and nutrient absorption. However, cooking kidney beans effectively reduces tannin levels, making them safe for consumption.

Proper preparation methods, such as soaking, cooking, and fermentation, can help reduce the levels of anti-nutritional compounds in kidney beans and improve their digestibility and nutrient bioavailability. It is important to note that the presence of anti-nutritional factors should not overshadow the overall nutritional benefits of kidney beans when consumed as part of a balanced diet.

4. Value-Added Products

4.1 Kidney bean flour: Production and applications

Kidney bean flour is derived from dried kidney beans that have been ground into a fine powder. It is gaining popularity as a gluten-free and nutrient-rich alternative to traditional wheat flour. The production process involves thoroughly cleaning the kidney beans, removing any foreign materials, and grinding them into a fine powder. The resulting flour can be used in various culinary applications, such as baking, as a thickening agent in soups and sauces, or as a nutrient-rich addition to smoothies and beverages (Wang *et al.*, 2017) ^[34]. The high protein content and dietary fiber in kidney bean flour make it a valuable ingredient for individuals seeking to boost the nutritional profile of their baked goods or incorporate plant-based protein into their diet.

4.2 Kidney bean-based snacks and convenience foods

Kidney beans are increasingly being utilized as a key ingredient in the development of healthy and nutritious snacks and convenience foods. These products offer a convenient way to incorporate the nutritional benefits of kidney beans into everyday diets. Kidney bean-based snacks can include roasted or seasoned kidney beans, bean chips, or even bean-based protein bars. These products not only provide a savory and crunchy texture but also deliver a good amount of protein, dietary fiber, and essential nutrients (Ros *et al.*, 2019) ^[28]. They offer a healthier alternative to traditional processed snacks by providing sustained energy and satiety, while also contributing to the overall nutrient intake.

4.3 Kidney bean protein isolates and their uses

Kidney bean protein isolates are obtained through a process that involves extracting proteins from kidney beans and separating them from other components. These isolates are rich in essential amino acids and can serve as a valuable plant-based protein source in various food applications. They can be used to fortify food products, such as beverages, protein bars, and meat analogues, to enhance their protein content and improve their nutritional profile (Liu *et al.*, 2021) ^[17]. Kidney bean protein isolates offer a sustainable and allergen-free alternative to animal-based protein sources, making them suitable for individuals with dietary restrictions or those following a vegetarian or vegan lifestyle.

4.4 Kidney bean extracts and their functional properties

Kidney bean extracts are concentrated forms of bioactive compounds derived from kidney beans. These extracts contain a variety of phytochemicals, including phenolic compounds, flavonoids, and antioxidants, which contribute to their functional properties. Kidney bean extracts have been found

to possess antioxidant, anti-inflammatory, and antimicrobial activities (Abd El-Hack *et al.*, 2021) ^[1]. These properties make them potentially useful in the development of functional foods, nutraceuticals, and natural preservatives. Additionally, kidney bean extracts may have potential applications in the pharmaceutical industry for their therapeutic properties, such as their potential to reduce the risk of chronic diseases or serve as natural antimicrobial agents (Abd El-Hack *et al.*, 2021) ^[1].

The development of value-added products using kidney beans opens new opportunities to incorporate their nutritional benefits into a wide range of food applications. These products not only provide consumers with convenient and nutritious options but also contribute to sustainable food production and promote the utilization of kidney beans as a versatile and valuable ingredient.

5. Summary

Kidney beans are nutrient-rich legumes that offer numerous health benefits. They are a good source of protein, dietary fiber, vitamins, and minerals. Consuming kidney beans has been associated with improved blood sugar control, reduced risk of heart disease, and enhanced weight management. The presence of bioactive compounds, such as phenolic compounds and antioxidants, contributes to their health-promoting properties. However, kidney beans also contain anti-nutritional factors that can interfere with nutrient absorption and digestion. Proper cooking methods can reduce these factors and enhance the nutritional value of kidney beans. Further research is needed to understand the mechanisms of kidney beans' health benefits, optimize processing techniques, and explore potential applications.

6. Conclusion

Kidney beans are an important component of a healthy diet, offering a wide range of nutrients and health benefits. They can contribute to meeting nutrient requirements and promoting overall health. However, their anti-nutritional properties should be addressed through appropriate cooking practices. Future research should focus on unraveling the mechanisms of kidney beans' health benefits, refining processing methods, and developing innovative applications. By doing so, kidney beans can be further utilized to improve health outcomes and enhance dietary diversity.

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