Nutritional Composition, Utilization, and Processing of Haricot Beans (Phaseolus Vulgaris L): A Comprehensive Review

ABSTRACT

This comprehensive review delves into the nutritional composition, utilization, and processing techniques of haricot beans, also known as common beans or kidney beans. Beginning with an examination of the significance of legumes, particularly in addressing protein deficiencies in underdeveloped and developing regions, the review highlights the pivotal role of haricot beans in Ethiopia's food security and the livelihoods of smallholder farmers. The nutritional analysis covers essential components such as protein, fat, fiber, ash, and carbohydrates, alongside discussions on functional properties and anti-nutritional factors. Furthermore, it explores the incorporation of haricot beans into traditional cuisines and their associated health benefits, including mitigating risks of diabetes, heart disease, and certain cancers. Moreover, the review evaluates various processing methods, including soaking, germination, dehulling, and autoclaving, elucidating their impacts on the nutritional profile and anti-nutritional factors of haricot beans. In conclusion, this review underscores the nutritional significance and versatility of haricot beans, underscoring their role as a sustainable food source with substantial health benefits.

Keywords: Haricot bean, nutritional composition, processing, utilization

INTRODUCTION

“Legumes have a potential to add to the nutritional quality of foods and many options have been suggested for their inclusion in novel food preparation with improved nutritional and functional values”(Carbonaro&Nucara, 2022).“Proteins represent one of the most concentrated nutrients in legumes, and they can be easily used as components in innovative human foods. In addition, legumes have higher protein content than cereals: therefore, they represent a primary source of amino acids for humans”(Carbonaro&Nucara, 2022).“Proteins extracted from legumes are an important font of proteins of plant origin, that can be consumed as an alternative to meat proteins”(Carbonaro, 2021).“Legumes make a significant contribution to diets but are rarely the major focus of attention. It is often referred to as ‘poor man’s meat’ and with few exceptions direct legume consumption tends to drop or at best remain stable with income increases”(Jones et al., 2021).“Statistics show bean consumption in Africa has remained relatively constant over the past 15 years except for significant declines in several countries where beans are a more important element of the diet, such as Rwanda, Burundi, and Kenya”(Kalyebara et al., 2022). “Pulses play a crucial economic role in food and nutrition security in Ethiopia. Recently, the production and supply of pulses have increased due to increased demand in both local and international markets, thus enhancing smallholders’ income”(Shahidur et al., 2021).“Among the different pulse crops grown in the country, the haricot bean accounts for the second largest production share of 17 percent, while other pulses, such as horse beans, chickpeas, lentils, green peas, lupines, and green beans, account for the remaining percentage”(Negash, 2009).“Haricot bean (Phaseolus Vulgaris L), locally known as ‘Boleqe’ also known as a dry bean, common bean, kidney bean, and field bean is a very important legume crop grown worldwide”(Gashaw, 2020).“It is an annual crop which belongs to the family Fabaceae. It grows best in warm climates at temperatures of 18 to $24^{o}C$”(Teshale et al., 2005). Haricot bean is considered the main cash crop and protein source for farmers in many of the low-land and mid-altitude areas of Ethiopia. There is a wide range of haricot bean types grown in Ethiopia, including the mottled, red, white, and black varieties. Through an exploration of the complex web of legume production, consumption, and usage, this review aims to clarify their essential function in forming agricultural landscapes, maintaining livelihoods, and promoting nutritional resilience in the face of changing global problems.

Production of legumes (pulses) in Ethiopia

Pulses are cultivated across various regions of the country following cereals, with their production volumes varying across different areas as documented in Table 1 (CSA, 2009).“In the 2008/2009 period, pulses accounted for 14.4% (approximately 1058 million hectares) of the grain crop area and 11.48% (over 19.6 million quintals) of grain production. Faba beans, haricot beans, field peas, and grass peas occupied 4.81% (more than 538 thousand hectares), 2.38% (over 267 thousand hectares), 2.06% (about 230 thousand hectares), and 1.43% (more than 159 thousand hectares) of the given crop area, respectively. The production from faba beans, chickpeas, haricot beans, and grass peas constituted 4.07% (approximately 6.9 million quintals), 1.82% (around 3.1 million quintals), 1.93% (3.29 million quintals), and 1.18% (2.03 million quintals) of the grain production, respectively”(CSA, 2009).

Haricot beans, originating from Peru, were introduced to Africa by Spanish and Portuguese traders during the 15th century. The bean is widely cultivated across the continent, particularly in medium and high-elevation areas. Cultivation of haricot beans is gaining significance in countries such as Cameroon, Guinea, and Senegal in Central and West Africa. Its short maturity period (less than three months), high nutritional value, relatively long shelf life, and low input requirements justify its importance even for poorer farmers for both production and consumption purposes.

"Haricot beans are crucial grain legumes cultivated by small-scale farmers in Ethiopia, serving both subsistence and cash purposes. They are commonly intercropped with complementary crops like maize, sorghum, and inset, owing to increasing population pressure on agricultural land and paired nutrient needs in the soil. On average, haricot beans contribute to 16.3% of pulse production in Ethiopia (2005-2012), predominantly produced in the lowlands and Rift Valley areas, where they serve as a source of income, employment, and food. Nearly all bean production is undertaken by approximately 3.1 million smallholder farmers, operating on small plots with minimal inputs"(CSA, 2012). According to the 2009/10 agricultural sample survey, Oromiya accounted for the largest share (43%) of haricot bean production in the country, followed by SNNPR (30%), Amhara (24%), Benishangul-Gumuz (2%), and Tigray (1%).

Given its critical role in enhancing food security, export earnings, and employment opportunities for the national economy, the bean sector in Ethiopia has received increasing policy attention from successive governments. Various efforts have been made to improve agricultural extension services, provide high-yielding seeds, establish agricultural marketing institutions such as the Ethiopian Commodity Exchange, and initiate agricultural marketing centers and information exchange systems at the national level. These endeavors have led to significant improvements in haricot bean production, productivity, and export volume and value.

"In Ethiopia, there are two main types of beans: red and white. Smallholder farmers typically grow red bean types for household consumption, while white haricot beans are predominantly produced for the export market"(Ferris and Kaganzi, 2008)."The white bean is considered a break crop in the cereal-dominated cropping system of Ethiopia and is often planted on fields previously used for tef, wheat, barley, and sorghum due to its perceived ability to thrive in soils with low fertility status (Gonbore) compared to other crops"(Legesse et al., 2006).

Large-scale commercial production of white beans has also emerged, primarily using white beans as a break crop to manage soil fertility. White beans, also known as navy beans due to their small size and round shape, are popular in industrialized nations such as the USA and

UK, where they are used to prepare pre-cooked canned "baked beans." The baked bean market is expanding globally as it offers a low-cost, nutritious snack food that is easy and quick to prepare.

“Although white beans are primarily sold for export markets in Ethiopia, with leading varieties including Awash 1, Awash Melka, Mexican 142, Chercher, Oumer, and Aregene, they are not a significant part of the local diet for many Ethiopians. White beans are almost exclusively grown for export purposes, with smallholder farmers typically growing red bean types for household consumption. Various challenges exist in white bean production, including decreasing yields over time, poor seed quality due to mixing with other haricot bean varieties, and difficulties in accessing new white bean varieties”(DawitAlemu and GerdienMeijerink, 2010).

“Despite challenges, there has been a notable increase in national haricot bean production in Ethiopia, rising approximately twofold between 2005 and 2012/13, from 138 thousand to 413 thousand tonnes. Haricot beans' share of total pulse production also grew from 11% in 2005 to 16.3% in 2012”(CSA, 2012).“Over the same period, the cultivated area for haricot beans increased from 164 to 359 hectares, representing a growth of 120%. However, the average national yield per hectare remained low, averaging 1.2 tonnes/hectare over the period”(CSA, 2012).

The low yields can be attributed to various supply-side constraints, including low adoption of improved seeds, limited knowledge among smallholders about production practices and diversification benefits, and market-led demand constraints, particularly price instability in 2008, which eroded small producers' trust in the pulse sector due to declining market returns.

Efforts have been made to address these challenges, including increased extension services, rising prices since 2009, and the introduction of several improved seed varieties by research institutes such as the Ethiopia Institute of Agricultural Research (EIAR). These initiatives have contributed to improvements in haricot bean production, productivity, and export value. Notable varieties introduced include white haricot beans (Awash 1, Mexican 142) in 2005, red haricot beans in 2006 (Dimtu, Nasir), and high-yielding speckled varieties in 2007, which have seen success in major producing areas. Popular red bean varieties include Red Melka, Red Wolayta, and Naser.

Table 1: Area, production and yield of pulses for private peasant holding for meher season

Pulses	**Area in Hectares**	**Production in quintal**	**Yield (quintal/ha)**
Haricot beans	267069.2	3297753.2	12.35

Chick peas	233440.4	3120800.3	13.37
Faba beans	538820.5	6959836.9	12.92
Field peas	230749.2	2670932.5	11.58
Lentiles	94945.5	947734.03	9.98
Grass pea/ Vetch	159731.5	2031255.5	12.65
Soy beans	6236.04	78988.92	12.67
Fenugreek	33773.59	376588.64	11.15
Gibto	20469.4	172411.38	8.43

Source: (CSA, 2009)

Utilization of haricot bean

Haricot beans are highly nutritious, containing significant amounts of calcium, potassium, phosphorus, and iron, making them an essential crop for improving food security (Singh et al., 2020). According to Mekonnen et al. (2018), beans are commonly perceived as "poor man's food" among medium to high-income urban and rural consumers in Ethiopia, leading to limited urban demand. Ferris and Kaganzi (2008) note that many pulse retailers in major Ethiopian town centers choose not to stock haricot beans and other pulses due to low interest from customers in these lower-value products, such as chickpeas, lentils, split peas, and faba beans. Bean consumption in Ethiopia typically ranges from 1 to 16 kg per year (Ferris and Kaganzi, 2008).

The consumption of haricot beans in Ethiopia, calculated as the difference between production and export, has shown a significant annual average growth of 20.3% between 2004 and 2012, increasing from 148 to 320 thousand tonnes. During the same period, production and export of haricot beans experienced growth rates of 13% and 14%, respectively. High transportation and transaction costs associated with haricot bean aggregation and trading contribute to the limited marketable surplus, reinforcing the subsistence orientation of smallholder farmers. However, between 2008 and 2012, on-farm consumption as a share of total production decreased from 82% to 69% in 2012, possibly due to the attractive international prices for haricot beans in recent years.

Haricot beans are rich in starch, protein, and dietary fiber, and are excellent sources of various minerals and vitamins, including iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid. Additionally, haricot beans are used as animal feed and fuel for cooking, but they also contain complex sugars such as raffinose and stachyose, which can cause flatulence, and a toxic compound called phytohaemagglutinin, a lectin that induces nausea, vomiting, and diarrhea when sparingly boiled beans are consumed. However, boiling beans for at least ten minutes at boiling point (100°C, 212°F), germination, fermentation, frying, and dry-heat methods can deactivate this toxic compound (Bad Bug, 2012).

"Health organizations now promote the regular consumption of common beans and other pulses due to their potential to reduce the risk of diseases such as cancer, diabetes, and coronary heart diseases"(Leterme and Munoz, 2002). Common beans are low in fat and cholesterol-free, acting as appetite suppressants due to their slow digestion and low sustained increase in blood sugar. Researchers have found that common beans can delay hunger reappearance for several hours, which can enhance weight-loss programs.

Furthermore, white haricot beans (Navy Beans) can serve as substitutes for red meat, providing protein comparable to that of meat or dairy foods when combined with whole grains such as whole wheat pasta or brown rice, without the high calories or saturated fat. Haricot beans are commonly consumed in traditional dishes, such as nifro (boiled grain) mixed with sorghum or maize, wet (local soup), or with kocho. Fresh beans (mature, whole non-dried grain) are appreciated for their taste and tenderness.

Health Benefits of haricot bean

Regular consumption of pulses is associated with reduced risks of type 2 diabetes, coronary heart disease, and certain cancers, attributed to the soluble fiber content in these legumes. They provide energy, stabilize blood sugar levels, and offer essential nutrients such as iron, copper, manganese, and thiamine (Vitamin B1), which support energy production and antioxidant defenses (Chibbar et al., 2010). Navy beans, also known as white beans, are small, oval, and white in appearance, and they are rich sources of various nutrients including folate, manganese, dietary fiber, protein, and vitamins such as thiamin (Vitamin B1). Consumption of navy beans has been linked to a lower risk of heart attack, improved energy levels, stabilized blood sugar, and antioxidant benefits. These versatile beans are commonly used in baked beans, soups, salads, and chili. However, they may be challenging to digest due to their composition. The name "navy beans" originates from their historical use as a staple food for the U.S. Navy in the 1800s (Kutos et al., 2003). Studies have shown that consumption of baked beans, primarily made from navy beans, can help lower total cholesterol levels and low-density lipoprotein cholesterol, possibly due to the high saponin content in navy beans. Saponins also possess antibacterial and antifungal properties and have been found to inhibit the growth of cancer cells. Additionally, navy beans are the richest sources of ferulic acid and p-coumaric acid among common bean varieties (Ligaya et al., 2013).

Proximate Composition of Haricot bean

Moisture content

The moisture content of haricot bean seeds is influenced by harvest timing and environmental factors, making it a crucial parameter to consider. Understanding the relationship between seed morphology, size distribution, and moisture content is essential for designing equipment accurately for tasks such as cleaning, grading, and separation. Harvesting haricot bean seeds with moisture levels exceeding 16% necessitates drying to prevent issues like heating and molding during storage. According to Wang et al. (2009), the moisture content of raw whole haricot beans typically measures 14.2%. Moreover, research indicates that as the moisture content of haricot beans increases, various seed characteristics such as surface area, mass per thousand seeds, sphericity, porosity, terminal velocity, and angle of repose tend to increase (Gharibzahedi et al., 2011). However, it's worth noting that the bulk density decreases with higher moisture content.

Crude protein

“Legume proteins and peptides have been found to serve a broader purpose beyond merely providing amino acids for bodily growth and maintenance”(Carbonaro&Nucara, 2022).“Various proteins (such as enzymatic inhibitors, lectins, and storage globulins) and peptides derived from them (including lunasin and hydrophobic peptides) have demonstrated properties such as anticarcinogenic, hypocholesterolemic, glucose-lowering, antioxidant, antimicrobial, and immunostimulant effects”(Carbonaro&Nucara, 2022).“A deeper understanding of how the structural characteristics of legume proteins influence their digestion in the body and the production of bioactive sequences is crucial for realizing the full nutraceutical potential of these proteins and peptides”(Carbonaro&Nucara, 2022).

Crude fat

The fat content of legumes typically falls within the range of 1-6 percent and is primarily influenced by factors such as variety, origin, geographical location, climate, seasonal variations, environmental conditions, and soil composition (Worthington et al., 1972). Fats present in legumes predominantly consist of neutral lipids, including triglycerides, di- and monoglycerides, free fatty acids, sterols, and sterol esters.According to Wang et al. (2009), the fat content specifically observed in haricot beans is approximately 1.5%.

Crude fiber

Dietary fiber, defined as the sum of lignin and polysaccharides that are not digested by the endogenous secretions of the human digestive tracts (Trowel *et al.*, 1976), is an important component of food. Haricot beans contain 6.6% crude fiber (Wang *et al.*, 2009).“Thermal processing or household cooking may alter the composition of these fibers and thus alter their physiological effects to human body”(Weber and Chaudhary, 1987).

Ash content

“Ash content of haricot beans ranges from 2.9 to 4.3%” as reported by (Wang *et al*., 2009).“The ash content of haricot beans is composed of relatively high levels of Mg, P, Ca, and S. In addition, haricot beans have a low Na and relatively high K contents, with a K: Na ratio of about 33:1”(Amany*et al.*, 2013).

Carbohydrate

Major carbohydrates in legumes are starch and numerous other sugars. Sugars ranges between 6 and 12 percent, whereas starch vary from 24 to 41 percent. Wanget al. (2009) reported that the carbohydrate content of haricot beans ranges from 39.0 to 56.3%.

Functional properties

“The term functional properties refer to the given component present in optimum concentration, subjected to processing at optimum parameters, contributes to the desirable sensory characteristics of the products usually by interacting with other food constituents. They indicate the ability of the pertinacious material to hold oil or fat and water, to emulsify the same and to form products having a firm consistency upon heating and cooling. These include viscosity, dispersibility, emulsify, form gels, foam, produce films and absorb water and/or fat”(Maskus, 2010).

“In order to increase the utilization and consumption of pulses, several researchers have recommended that pulses must be processed into flours and used as ingredients in food product applications. To consider pulses as ingredients, it is necessary to evaluate their functional properties (water absorption capacity, oil absorption capacity, foaming properties and emulsification properties) of the flours for use as ingredients in food product applications”(Maskus, 2010).“Legume flours, due to their amino acid composition and fiber content, are ideal ingredients for improving the nutritional value of bread and bakery products”(Hefnawy*et al*., 2012). Haricot bean flour has potential for traditional and newer product developments with health benefits since it contains about 25% protein, 56% carbohydrate and 1.5% fat. Siddiq et al. (2009) reported that “the water absorption capacity of haricot bean ranged from 2.25 to 2.65 g H_2O/g flour and the oil absorption capacity of haricot beans ranged from 1.23 to 1.52 g oil / g flour.Bulk density is a property of powders, granules, and other "divided" solids, especially used in reference to foodstuff, or any other masses of corpuscular or particulate matter. It is defined as the mass of many particles of the material divided by the total volume they occupy. The bulk density of soaked and dried, dehulled haricot beans were 0.56 gml^{-1} and 0.53 gml^{-1} respectively”.

Anti-nutritional factors of haricot bean

“The anti-nutrients like trypsin inhibitors, phytic acid, saponins, heamagglutinins and tannins are some of the undesirable components in legumes that could hinder utilization of important minerals including calcium, magnesium, iron and zinc by interfering with their absorption and utilization and thereby contributes to mineral deficiency”(Vasagam and Rajkumar, 2011).“Phytic acid and tannic acid are the two main anti-nutrients present in legumes. Tannins inhibit the digestibility of protein, whereas phytic acid reduces the bioavailability of some essential minerals” (Van der Poel, 1990; Rehman and Shah, 2006). Moreover, haemagglutinins is also toxic protein present in legumes that have the interesting ability to clump or agglutinate red blood cells (RBC) in a fashion similar to antibodies.

Phytic acid

“Phytic acid and its salts represent the majority of the phosphorus in plant legume seeds and monogastric species have a limited ability to hydrolysephytates and release phosphate for absorption. In dicotyledonous seeds such as legumes, phytic acid is found closely associated with proteins and is often isolated or concentrated with protein fraction of this food. Phytic acid or phytate when in salt form is the principal storage form of phosphorus in plant tissues" (Kumar *et al.*, 2008). "Phytic acid has been considered as an anti-nutrient which binds with other nutrients and makes them indigestible. Excessive phytic acid in the diet can have a negative effect on mineral balance because of the insoluble complexes it forms with essential minerals (Cu^{2+}, Zn^{2+}, Fe^{2+},Fe^{3+} and Ca^{2+}), which causes poor mineral bioavailability"(Urbano*et al.*, 2000)."Therefore, phytates have negative impact on enzyme activity and there is an evidence of its negative impact on key digestive enzymes like lipase, α-amylase, pepsine, trypsin and chymotrypsin"(Urbano*et al.*, 2000). However, there are some beneficial effects of phytic acid, such as reduced bioavailability, and therefore toxicity of heavy metals (example, cadimium and lead) present in the diet (Rimpach and Pallauf, 1997).

Tannin

"Tannins are defined as water soluble polymeric phenolics that precipitate proteins"(Haslam, 1989)."Tannins in plant are involved in defense mechanism to environmental attack"(Okuda *et al.*, 1992). It exists in mixtures with many other classes of plant phenolic compounds. Tannins are usually subdivided into two groups: hydrolyzable tannins (HT**)** and proanthocyanidins (PA**)**.Hydrolyzable tannins are more susceptible to enzymatic and non-enzymatic hydrolysis than proanthocyanidins, and usually are more soluble in water.

Haemagglutinins

"Haemagglutinins are proteins in nature and are sometimes referred to as phytoagglutinins or lectins. As in legumes, most cereals commonly consumed by human contain glycoprotein called lectins. Many lectins can bind to intestinal epithelial cells, where they may impair nutrient absorption and cause damage that may allow infiltration of bacteria into the blood stream. Although considerable indications are there and these legume lectins can be harmful to humans, virtually no evidence exits of any significant anti-nutritional effect from cereal lectins"(Jansman*et al.*, 1998). However, the phytohaemagglutinins are heat labile and the normal cooking destroys their specific action.

Minerals content

"Mineral contents of legumes also showed significant reduction (18.99-39.50%) during the process of cooking due to leaching of minerals into cooking water"(Nuzhat*et al.*, 2008).Haricot bean is an excellent source of macronutrients (P, K, Ca, Mg), micronutrients (Fe, Zn, Cu, and Mn), and trace elements (Al, Cr, Ni, Pb, Co, Se, Mo). Amany et al. (2013) reported that "raw white bean seeds contain K, Mg, Ca, Fe and Zn with values 1293, 155.6, 154, 12.55 and 4.86 mg/100 g dry weight respectively but soaked white beans contain K, Mg, Ca, Fe and Zn (1142, 145, 145, 7.98 and 3.38 mg/100 g dry weight respectively)".

Effect of processing on nutritional composition, Functional Properties and Anti-nutritional factors of haricot beans

Grain legumes contain various anti-nutritional factors which impair their nutritional quality; these factors may be removed by different processing methods such as soaking, dehulling, autoclaving, boiling, hydration, fermentation and germination which are used to inactivate the anti-nutrients (Shimelis and Rakhshit, 2007) in the plant based foods thus enhances the nutritional value of isolated protein (Agbede *et al.*, 2005).Reihaneh and Jamuna (2006) reported that the dehulled legume flours had a higher protein solubility compared with germinated and control samples. The bulk densities of germinated and dehulled legume flours were lower compared to raw legume flours. On dehulling, the fat absorption capacities of legume flours were reduced.

Soaking

"Soaking cereal and most legume flours (but not whole grains or seeds) in water can result in passive diffusion of water-soluble Na, K, or Mg, phytate, which can then be removed by decanting the water"(Hotz and Gibson, 2001). Soaking in simple water and salt solution is a common practice to soften texture and hasten the cooking process (Silva *et al.*, 1981). It is often performed before or in conjunction with other processing steps such as germinating, fermenting, cooking and canning. Soaking means exposure of the sample to water and salt solutions with or without additive to encourage ANF loss.Soaking of legumes for 2 hrs before cooking in acetic acid and sodium bicarbonate solutions reduced higher amount of phytate than soaking in simple water and maximum tannin was reduced when haricot bean is soaked in acetic acid solution (Nuzhat*et al*., 2008).

Germination

Germination causes important changes in the biochemical, nutritional and sensory characteristics of legumes. These changes depend on the type of legume and the sprouting conditions, such as time, temperature, the presence or absence of light during the sprouting process or the composition of the soaking and rinsing media. Germination is an inexpensive and effective technology for improving the quality of legumes by reducing the content of anti-nutritional factors such as protease inhibitors (Ghavidel and Prakash, 2007) and decrease in storage proteins and enzyme inhibitors of seed is commonly observed during germination. Heat stable compounds in cereal and legumes such as tannins and hydrates are easily removed after germination (Reddy *et al*., 1985).Germination is inexpensive and effective technology for improving the quality of legumes by enhancing their digestibility (Reddy *et al*., 1985), increasing the level of amino acids and reducing the content of anti-nutritional factors (Vidal-Valverde and Frias, 1992). In haricot beans and peas, free protein amino acids increased after germination (Yu-HaeyKuo*et al*., 2004).Protein and starch digestibility (Kataria, Chauhan, &Punia, 1992) increased, whereas phytic acid decreased during germination of legumes. The phytate is utilized as a source of inorganic phosphate during seed germination and the inorganic form becomes available for purposes of plant growth and development.

Dehulling

Proper dehulling of legumes for human nutrition essentially relates to efficient separation of the seed coat from the cotyledons. Dehulling reduces cooking time, anti-nutritional factors, and improves protein quality, palatability, and digestibility of pulses. An efficient and improved method of dehulling pulses is of vital importance in reducing dehulling losses. Wang and Hatcher, (2009) reported that dehulling (removal of seed coat) resulted in a significant increase in protein, starch, resistant starch, K, P, phytic acid, stachyose and verbascose content, however, a significant decrease in soluble dietary fiber, insoluble dietary fiber, trypsin inhibitor activity, Ca, Cu, Fe, Mg, Mn and tannin content was observed.

Autoclaving

Hefnawy, (2011) reported that there were no significant differences in total protein and moisture contents between cooked treatments (boiling, autoclaving and microwave cooking) of haricot bean seeds. However, there was significantly decreased of non-protein nitrogen, ash and fat contents.

CONCLUSION

In conclusion, this comprehensive review underscores the significance of haricot beans as a crucial source of nutrition, income, and food security, notably for smallholder farmers across diverse regions. Despite their abundant nutritional composition and associated health benefits, challenges such as anti-nutritional factors underscore the importance of employing meticulous processing methods to enhance their nutritional value. Moreover, this review emphasizes the imperative for further research and investment in sustainable production and processing techniques to fully unlock the potential of haricot beans in addressing global food security and nutritional challenges. As a result of leveraging their nutritional richness and versatility, haricot beans can play a pivotal role in fostering healthier diets and livelihoods worldwide.

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