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

Comment [RM1]: This manuscript uses data from 2005 to 2012. These data may no longer be relevant today.

ABSTRACT

Comment [RM2]: The abstract should explain the conclusions of the research. In the abstract there are no concrete conclusions in accordance with the title. An example of how much the nutritional composition of Haricot beans should be explained

Haricot beans (Phaseolus vulgaris L.), also known as common beans or kidney beans, are important legume crops with high nutritional value. This comprehensive review explores various aspects related to the nutritional composition, utilization, and processing of haricot beans. The review begins by highlighting the significance of legumes in providing supplementary protein, especially in underdeveloped and developing nations. It discusses the production and consumption trends of haricot beans, particularly in Ethiopia, where they play a vital role in food security and income generation for smallholder farmers. The nutritional composition of haricot beans, including protein, fat, fiber, ash, and carbohydrate content, is analyzed, along with their functional properties and anti-nutritional factors. Additionally, the review examines the utilization of haricot beans in traditional dishes and their health benefits, including their association with lower risks of diabetes, heart disease, and certain cancers. Furthermore, various processing methods such as soaking, germination, dehulling, and autoclaving are explored for their effects on the nutritional composition and anti-nutritional factors of haricot beans. Overall, this review provides valuable insights into the nutritional value, utilization, and processing techniques of haricot beans, emphasizing their importance as a sustainable food source with significant health benefits.

Keywords: Haricot bean, nutritional composition, processing, utilization

INTRODUCTION

Legumes are dicotyledonous seeds of plants belonging to the family leguminacese which consist of 600 genera and about 13,000 species. It is considered a rich source of protein throughout the world and contains approximately three times more proteins than cereals (Amjad et al., 2006). Dry legumes constitute one of the richest and least expensive sources of supplementary protein for a major section of the human population, especially in underdeveloped and developing nations. 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. 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 (Rwanda, Burundi, and Kenya) (Kalyebara et al., 2007).

Pulses play a crucial economic role in food and nutrition security in Ethiopia. Recently, the production and supply of pulses, has increased due to increased demand in both local and international markets, thus enhancing smallholders’ income (Shahidur et al., 2010). Among the different pulse crops grown in the country, the haricot bean accounts for the second largest production share of 17 percent, while the other pulses, such as horse beans, chickpeas, lentils, green peas, lupines, and green beans account for the remaining percent (Negash, 2007). 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. It is an annual crop which belongs to the family Fabaceae. It grows best in warm climates at temperatures of 18 to 24oC (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 among the various crops produced in all regions of the country after cereals. Pulses are grown in different volumes across the country as indicated in Table 1 (CSA, 2009). Pulses grown in 2008/2009 covered 14.4 % (1058 million hectares) of the grain crop area and 11.48% (more than 19.6 million quintals) of the grain production. Faba beans, haricot beans, field peas, and grass peas were planted to 4.81% (more than 538 thousand hectares), 2.38% (more than 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 obtained from faba beans, chickpeas, haricot beans, and grass peas was 4.07% (about 6.9 million quintals), 1.82% (about 3.1 million quintals), 1.93% (3.29 million quintals), 1.18% (2.03 million quintals) of the grain production in that order (CSA, 2009). Haricot beans, originating in Peru, were introduced in Africa by Spanish and Portuguese traders during the 15th century. The bean is widely grown throughout the continent, particularly in medium and high-elevation areas. Cultivation of haricot beans is gaining importance 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 to produce and consume.

Haricot beans are among the most important grain legumes produced by small-scale farmers of Ethiopia, both for subsistence and cash. They are usually intercropped with complementary crops such as maize, sorghum, and inset owing to increasing population pressure on agricultural land and paired nutrient needs in the soil. On average, haricot beans account for 16.3 percent of pulse production in Ethiopia (2005-2012) and are mainly produced in the lowlands and in the Rift Valley areas, where they are a source of income, employment, and food. Virtually all bean production is carried out by about 3.1 million smallholder farmers, on small plots with minimal inputs (CSA, 2012). According to the 2009/10 agricultural sample survey result, Oromiya took the lion's share (43%) of haricot bean production in the country, followed by SNNPR (30%), Amhara (24%), Benishangul-Gumuz 2% and finally Tigray region contributing 1% to the country total production.

Due to its critical role in increasing food security, export earnings, and employment creation for the national economy, the bean sector has received increasing policy attention from successive governments in Ethiopia. The government improved agricultural extension services, issued high-yielding seeds, established agricultural marketing institutions, like the Ethiopian Commodity Exchange, and initiated agricultural marketing centers and information exchange systems at the national level. These efforts resulted in a considerable improvement in the haricot bean production, productivity, and export volume and value. There are two main types of beans, red and white. Smallholder farmers typically grow the red bean types for household consumption, while white haricot beans are produced almost exclusively for the export market (Ferris and Kaganzi, 2008). In Ethiopia, the white bean is considered a break crop in the cereal-dominated cropping system and is often planted on fields previously planted with tef, wheat, barley, and sorghum because farmers believe that the crop does better on soils with low fertility status (Gonbore) compared to other crops (Legesse et al., 2006). According to Lagesse et al. (2006), large-scale commercial production has also started to emerge using white beans as a break crop to manage soil fertility. The white beans are often referred to as white pea beans, due to their small size and round shape; they are otherwise known as navy beans. White beans are popular in industrialized nations, such as the USA and UK, as they are used to prepare pre-cooked canned "baked beans". The baked bean market is growing in many parts of the world, as it is low-cost, nutritious snack food that is easy and quick to prepare. Although many Ethiopians do not consume an important export crop, the white pea bean. White beans are sold almost exclusively for the export markets; the leading white bean varieties include Awash 1, Awash Melka, and Mexican 142. Also, Chercher, Oumer, and Aregene are white haricot bean types Awash-1 was released in 1990 by Melkasa Agricultural Research Center (MARC) and Chercher variety was released in 2006 by Haramaya University.

The planting period of white pea beans should be set so the harvesting period falls during the dry season. The production period ranges from 85 to 120 days. White pea beans usually are not intercropped. The yield of the white pea beans is decreasing through time. The yield in ZiwayDudega woreda (one of the woredas selected by GRAD for white pea beans interventions), as reported by SNV, is only 1.2 MT/ha. The quality of the beans in the area also has become very poor. The main reason is that farmers usually use their seeds for planting. The seeds, in most cases, are mixed with other haricot bean varieties that are not white. National haricot bean production increased approximately twofold between 2005 and 2012/13, from 138 thousand to 413 thousand tones.

Haricot's share of total pulse production grew from 11 percent in 2005 to 16.3 percent in 2012 (CSA, 2012). Over the period (2005-2012/13), the area cultivated with haricot beans increased from 164 to 359 hectares, a 120 percent growth. On the other hand, the average national yield per hectare is low over the same period, with an average of 1.2 tonnes /hectare (CSA, 2012). This situation can be explained by supply-side constraints, including low adoption of improved seeds, limited knowledge of smallholders on production practices and the benefits of diversification, and market-led demand constraints, particularly the price instability in 2008 that led to diminished trust in the pulse sector for small producers after declining market returns.

Additionally, there is insufficient seed in the country owing to an increasing demand from export markets, and there are particular problems in accessing new white bean varieties (Dawit Alemu and Gerdien Meijerink, 2010). However, despite being low, yields improved between 2005 and 2012, with a 68.2 percent increase. The government has increased extension efforts and prices have risen steadily since 2009. Research institutes have also marketed several improved seeds; the Ethiopia Institute of Agricultural Research (EIAR) introduced white haricot beans (Awash 1, Mexican 142) in 2005, red haricot beans in 2006 (Dimtu, Nasir) and speckled high-yielding varieties were introduced in 2007, these having some success in the major producing areas. Within the red bean types, the most favored include Red Melka, a mottled medium-sized red, Red Wolayta, a medium-sized pure light red, and Naser, a small pure dark red variety.

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 have a high nutritional value, are rich in calcium, potassium, phosphorus and iron, and are thus considered a key crop for improving food security. Beans in Ethiopia are traditionally seen as a ‘’poor man’s food’’ by the medium to high income urban and rural consumers, and thus urban demand is low. For instance, pulse retail in many major town centers do not want to keep haricot beans or others pulses (i.e. chickpeas, lentils, split peas, faba beans), implying that their customers were less interested in these low value products. In Ethiopia, common bean consumption ranges between 1-16 kg per year in Ethiopia (Ferris and Kaganzi, 2008).

Haricot bean consumption, calculated as the difference between production and export, registered an annual average growth of 20.3 percent from 148 to 320 thousand tonnes between 2004 and 2012, while production and export grew by 13 and 14 percent, respectively. The bulk of haricot beans (69 percent) are consumed on-farm, with marketable surplus of only 17.6 % (ECEA, 2009). The small share of marketable surplus is partly explained by high transportation and transaction costs incurred in haricot bean aggregation and trading, reinforcing the subsistence orientation of the smallholder farmers. However, between 2008 and 2012, on-farm consumption as a share of total production dropped from 82 to 69 percent in 2012. The driving force behind the increasing share of exports and decreasing share of local consumption may be the lucrative international prices for haricot beans in recent years.

Haricot bean is high in starch, protein and dietary fiber and is an excellent source of minerals and vitamins including iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid. Besides to this, dry leaves, threshed pods, and stalks are fed to animals and used as fuel for cooking. But in addition to the above nutritional composition, haricot bean also has complex sugars such as raffinose and starchyose which are responsible for flatulence and a toxic compound phytohaemagglutinin, a lectin which causes nausea, vomiting, and diarrhea when sparingly boiled haricot beans are consumed. Therefore, this toxic compound can be deactivated by boiling beans; ten minutes at boiling point (100°C, 212°F), germination, fermentation, frying and dry-heat methods (Bad Bug, 2012).

Regular consumption of common bean and other pulses is now promoted by health organizations because it reduces the risk of diseases such as cancer, diabetes or coronary heart diseases (Leterme and Munoz, 2002). This is because common bean is low in fat and is cholesterol free.

It is also an appetite suppressant because it digests slowly and causes a low sustained increase in blood sugar. Researchers have found that common bean can delay the reappearance of hunger for several hours, enhancing weight-loss programs.

Moreover, white haricot beans (Navy Beans) replace red meat; these beans are a good source of protein when combined with a whole grain such as whole wheat pasta or brown rice, provide protein comparable to that of meat or dairy foods without the high calories or saturated fat found in these foods. Haricot bean is consumed in traditional dishes. Dry beans are mostly prepared as nifro (boiled grain), mixed with sorghum or maize and *wet* (local soup) and also with *kocho.* Fresh beans (mature, whole non-dried grain) are popular for their taste and crack ability.

Health Benefits of haricot bean

Consumption of pulses on a regular basis has been associated with lower risks for the development of type 2 diabetes, heart attack risk by the soluble fiber provided from this legume, coronary heart disease and some forms of cancer, gives energy to burn while stabilizing blood sugar, iron for energy, copper and Manganese help with energy production plus antioxidant defenses, maintain your memory with thiamine (Vitamin B1) (Chibbar*et al*., 2010). Navy beans, also called white beans, are small, oval, and white. Navy beans are good sources of folate, manganese, dietary fiber, protein, phosphorus, copper, magnesium, iron, and vitamin B1 (thiamin). Navy beans can lower your risk of heart attack, give you energy, stabilize blood sugar, provide antioxidant benefits, and help maintain your memory. These small white beans are commonly used to make baked beans, but they are also good in soups, salads, and chili. They are relatively difficult to digest. Navy beans are so named because they were a food staple for the U.S. Navy in the 1800s (Kutos *et al.*, 2003).Consumption of baked beans has been shown to lower total cholesterol levels and low-density lipoprotein cholesterol. This might be at least partly explained by high saponin content of navy bean. Saponins also exhibit antibacterial and anti-fungal activity, and have been found to inhibit cancer cell growth. Furthermore, navy bean is the richest source of ferulic acid and p-coumaric acid among the common bean varieties (Ligaya*et al*., 2013).

Proximate Composition of Haricot bean

Moisture content

Seed moisture is an important parameter and is a result of harvest time and environmental conditions. The knowledge of morphology and size distribution and their dependence on the moisture content of haricot bean seeds is essential for accurate design of the equipment for cleaning, grading and separation. If haricot bean seed is harvested at moisture contents greater than 16%, it will have to be dried to prevent heating and molding in storage. Wang et al. (2009) reported that the moisture content of raw whole haricot bean is 14.2% and the surface area, one thousand seed mass, sphericity, seed porosity, terminal velocity, and angle of repose increased as the moisture content of haricot beans increased (Gharibzahedi*et al.*, 2011), however, the bulk density decreased as the moisture content increased.

Crude protein

Protein contents of legumes vary between 17 and 34 percent, which include metabolic, structural and storage protein. Legumes are rich sources of protein and the essential amino acid, lysine, but are usually deficient in sulphur containing amino acids, methionine and cystine. Protein concentration of haricot beans reportedly range from 21.1 to 24.5% (Wang *et al.*, 2009).

Crude fat

Lipid content of legume is in the range of 1-6 percent and mainly depends upon variety, origin, location of growth, climate, season, environmental factors and soil type (Worthington *et al.*, 1972). Lipids found in legumes are mainly neutral lipids that mean triglycerides, di and monoglycerides, free fatty acids, sterols and sterol esters. According to (Wang *et al.*, 2009) the lipid content of haricot beans is 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 hydrolyse phytates 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

This review highlights the significance of haricot beans as a vital source of nutrition, income, and food security, particularly for smallholder farmers in various regions. Despite their rich nutritional composition and health benefits, challenges such as anti-nutritional factors necessitate careful processing methods to optimize their nutritional value. Further research and investment in sustainable production and processing techniques are essential to fully harness the potential of haricot beans for improving global food security and nutrition.

Comment [RM3]: The conclusion should explain the results of a comprehensive review of the title. Please add it to the conclusion and also to the abstract.

REFERENCES

Comment [RM4]: add references used recent journals, it is recommended to use theMendeley program

Agbede, J. O. and V. A. Aletor.2005. Studies of the chemical composition and protein quality evaluation of differently processed *Canavaliaensiformis*and*Mucunapruriens*seed flours. J.Food Compos.Anal. 18:89-103.

Amany A. Salem., El-Bostany, A. Nahla., Samia A. Al-Askalany and Hala A. Thabet. 2013. Effect of domestic processing methods of some legumes on phytochemicals content and *in vitro* bioavailability of some minerals. Special Food and Nutrition Department, Food Technology Institute, Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

Amjad I., A.K. Iqtidar, A. Nadia and M.S. Khan. 2006. Nutritional quality of important food legumes, amphidiploids (black gram mung bean) as affected by domestic processing and cooking. Plant Foods for Human Nutrition, 42(2), 117–125. Anti-nutritonal factors and the nutritional value of plant materials with reference to human and animal food. Food Chem. 78(2), 187–205.

Bad Bug Book. 2012. Foodborne Pathogenic Microorganisms and Natural Toxins Handbook: *Phytohaemagglutinin*. Food and Drug Administration. 2012. Retrieved 26 December 2013. Consumers should boil the beans for at least 30 minutes to ensure that the product reaches sufficient temperature

Central Statistical Agency (CSA), 2009. Agricultural sample survey of 2008/2009 (2001E.C). Stat. Bulletin Vol 1, Addis Ababa, Ethiopia

Central Statistical Agency(CSA-2012), Agricultural Sample Survey 2011/2012 (2004 E.C.), Area and Production of Major Crops, Statistical Bulletin, May 2012, Addis Ababa

Chibbar, R.N. Ambigaipalan, P. Hoover, R. 2010. Molecular diversity in pulse seed starch and complex carbohydrates and its role in human nutrition and health.Cereal Chem. 2010, 87, 342–352.

Dawit, Alemu and Gerdien, M. 2010. An overview of the Ethiopian Commodity Exchange (ECX). Development Cooperation of Ministry of Foreign Affairs, Wageningen UR, June 2010.

Ferris, S. and Kaganzi, E.2008. Evaluating marketing opportunities for haricot beans in Ethiopia.Improving productivity and Market access (IPMS) of Ethiopian Farmers Project. Working paper 7. ILRI (International Livestock Research Institute), Nairobi, Kenya. 48pp.

Ghavidel, R. A., &Prakash, J. 2007. The impact of germination and dehulling on nutrients, antinutrients, in vitro iron and calcium bioavailability and in vitro starch and protein digestibility of some legume seeds. LWT - Food Science and Technology, 40(7), 1292-1299.

Gharibzahedi, S.M.T., Ghasemlou, M., Razavi, S.H., Jafarii, S.M. and Faraji, K., 2011. Moisture-dependent physical properties and biochemical composition of red lentil seeds. *International Agrophysics*, *25*(4).

Haslam, E.1989. Plant Polyphenols Vegetable Tannins Revisited. Cambridge University Press, Cambridge, U.K.

Hefnawy, T. M. H., El-Shourbagy, G. A., Ramadan, M. F., Impact of adding chickpea (*Cicerarietinum*L.) flour to wheat flour on the rheological properties of toast bread, *International Food Research Journal*, 2012, *19*(2), 521-525.

HotzC., Gibson, RS. 2001. Assessment of home-based processing methods to reduce phytate content and phytate/zinc molar ratios of white maize (Zea mays). Agric. Food Chem. 2001; 49: 692–8.

Jansman, A.J., Hill, G.D., Huisman, J. and Vander Poel, A.F. 1998. Recent advances of research in anti-nutritional factors in legumes seeds. Wageningen. The Netherlands: WageningenPers, p.76.

Kalyebara, R, Andima, D, Xavery, P, Mugabo, J, Njingulula, P, Ngulu, F, Chirwa, R, Kirkby, R and Buruchara, R. 2007. 'Impact of bean R and D technologies in sub-Saharan Africa – evidence from seven countries' PABRA, Kampala.

Kataria, A., Chauhan, B. M., &Punia, D. 1992.Digestibility of proteins and starch (in vitro) of amphidiploids (black gram mung bean) as affected by domestic processing and cooking. Plant Foods for Human Nutrition, 42(2), 117–125.

Kumar, Chandini S., Malleshi, N.G. and Bhattacharya, S. 2008. A comparison of selected quality attributes of flours: Effects of dry and wet grinding methods. International Journal of Food Properties. 11:845- 857.

Kutos, T., Golob, T., Kac, M., &Plestenjak, A. 2003.Dietary fibre content of dry and processed beans.*Food Chemistry, 80*, 231-235.

Legesse, D. G. Kumssa, T. Assefa, M. Taha, J. Gobena, T. Alemaw, A. Abebe, Y. Mohhamed and H. Terefe .2006. Production and Marketing of White Pea Beans in the Rift Valley, Ethiopia.A Sub Sector Analysis.National Bean Research Program of the Ethiopian Institute of Agricultural Research**.**

Leterme, P. and C. Munoz. 2002.Factors influencing pulse consumption in Latin America.British journal of Nutrition 88. Suppl.3, s251-s254.Limbu, F. 1999. Agricultural technology economic viability and poverty.

Ligaya T. Braganza., Maria Divina D. Alcasabas., LevinaDivinagracia T. Ramirez. 2013. Utilization of pea flour as a functional ingredient in bakery products. *European International Journal of Science and Technology Vol. 2.*

Negash R. 2007. "Determinant of adoption of improved haricot bean production package in Alaba special woreda, Southern Ethiopia".*M.Sc.Thesis ,Haramaya University*,Ethiopia.

NuzhatHuma., FaqirMuhammad Anjum., SamreenSehar., Muhammad Issa Khan and ShahzadHussain Effect of soaking and cooking on nutritional quality and safety of Legumes, Nutrition & Food Science Vol. 38 No. 6, 2008, pp 574.

Okuda, T.,Yoshida, T and Hatano, T. 1992. Antioxidant effects of tannins and related polyphenols. In Okuda, T.,Yoshida, T and Hatano, T. (Eds). Phenolic Compounds in Food and their Effects on Health II, p. 87-97. Washington D.C.: American Chemical Society.

Reddy, N.R., M.D. Pierson, S.K. Sathe and D.K. Salunkhe, 1985. Dry bean tannin: a review of nutritional implication. J. Am. Oil. Chem. Soc., 62: 451-549.

Rehman, Z.U., Shah, W.H. 2006.Thermal processing effects on antinutrients, protein and starch digestibility of food legumes. Food Chem. 91, 327–331.

ReihanehAhmadzadehGhavidel, and JamunaPrakash. Effect of germination and dehulling on functional properties of legume flours.Journal of Science of Food and Agriculture.Volume 86, Issue 8, pages 1189–1195, June 2006.

Rimpach, G. And Palluaf, J. 1997. Cadimium accumulation, zinc status,and mineral bioavailabilty of growing rates fed diets high in inc with increasing amounts of phytic acid. *Biological tace element research 57, 59-70.*

Shahidur, R., Chilot,Y., Befekadu B.,and Solomon L.2010. *Pules value chain in Ethiopia;constraints*and*opportunities for enhancing exports*. International Food Policy Research Institute.

Shimelis, A.E. and Rakshit, S.K. 2005. Proximate composition and physico-chemical properties of improved haricot bean (*Phaseolus vulgaris* L.) varieties grown in Ethiopia. *Journal of Food Science and Technology* (LWT), 38: 331-338.

Siddiq, M., Ravi, R., Harte, J.B., Dolan, K.D. 2009.Physical and functional characteristics of selected dry bean (*Phaseolus vulgaris* L.) flours.LWT- Food Science and Technology.

Teshale, Assefa., Girma,Abebe., Chemeda,Fininsa., Bulti,TessoandAbdelrahman M. Al-Tawaha. 2005. Participatory Bean Breeding with Women and Small Holder Farmers in Eastern Ethiopia. *World Journal of Agricultural Sciences,* 1: 28-35.

Trowel H, Southgate DAT., Wolever,TMS., Leeds AR, Gassull, MA and Jenkins DJA. 1976. Dietary Fiber redefined. *Lancet* 1:967

Urbano, G., Lopez-Jurado, M., Aranda, P., Vidal-Valverde, C., Tenorio, E.J. and Porres, E. 2000. The role of phytic acid in legumes: anti nutrient or beneficial function. *Journal of Physiology and Biochemistry 56, 283-294.*

Vasagam, K. P. K. and M. Rajkumar.2011. Beneficial influences of germination and subsequent autoclaving of grain legumes on proximate composition, antinutritionalfactors and apparent digestibility in black tiger shrimp, *Penaeusmonodon*Fabricius. Aquacult.Nutr.17 (2):188-195.

Vidal-Valverde and J. Frias, “Changes in Carbohydrates during Germination of Lentils,” Vol. 194, No. 5, 1992, pp. 461-464.

Wang, N., Hatcher, D.W., Tyler, R.T., Toews, R. and Gawalko, E.J. 2009.Effect of cooking on the composition of beans (Phaseolus vulgaris L.) and chickpeas (Cicerarietinum L.). Food Research International.

Weber, FE and Chaudhary VK. 1987. Recovery and nutritional evaluation of dietary fiber ingredients from a barley by-product. *Cereal Foods World* 32:548-550.

Worthington, R.E., Hammons, R.O. and Allison, J.R. 1972. ‘‘Varietial difference and seasonal effects of fatty acids composition and stability of oil from 82 peanut genotypes’’, Journal of Agricultural and Food Chemistry, Vol. 20 No. 4, pp. 727-30.

Yu-Haey, K., Pascale, R., Fernand, L., Juana,F.andConcepción,VV.2004. Effects of different germination conditions on the contents of free protein and non-protein amino acids of commercial legumes.