Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/ne5xjs46

COMPARATIVE STUDY OF PHYSICOCHEMICAL AND NUTRITIONAL CHARACTERISTICS OF RAW AND SPROUTED LEGUME BEANS FLOUR

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Received: 29-06-2024 Accepted: 26-07-2024 Published: 27-08-2024

ABSTRACT

Legumes are low-cost sources of plant-based proteins with various biological and nutritional attributes, making them potent to be the main functional food ingredients. Consumption of legumes and their sprouts has become popular among people who are interested in improving and maintaining their health status by changing dietary habits. The sprouting of legumes improves the nutritional, functional, and biological properties of legumes by altering the content and composition of nutrients and bioactive compounds. Aim of the study is to prepare raw and sprouted beans flour (black grams, mung beans, red kidney beans and white kidney beans) and analyzed the nutritional comparison between raw and sprouted legume beans flour. The raw and sprouted flours was analyzed for physiochemical, antioxidants, compositional and minerals contents. Results were subjected to appropriate statistical analysis to determine level of significance. The results for antioxidants, minerals and physiochemical properties was highly significant. The calcium content of raw legumes beans ranged from 0.26 to 0.59mg/100g and increased during sprouting of legumes because sprouting reduced the phytic acid which binds the minerals, calcium content of sprouted legumes beans ranged from 0.61 to 1.29mg/100g. Similarly the results regarding TPC and TFC of raw kidney beans ranged from 0.32±0.03 to 0.58±0.03 mgGAE/g and 0.34±0.02 to 0.55±0.03mgRE/g respectively and increased during sprouting of legumes ranged from 0.44±0.03 to 1.92±0.02mgRE/g and 0.40±0.02 to 0.57±0.02mgRE/g respectively.

Key Words: Legumes, Beans, Sprouting, Phytic Acid

Introduction

The history of using legume crops to suit human nutritional needs and create agricultural techniques is extensive and varied. The domestication history of these food crops varies. While many pulses,

such as chickpeas and lentils, are primarily grown in the Middle East, common or dry beans (*Phaseolus vulgaris L*.) are considered a crop of the "new world," with large-seeded varieties (like kidney, cranberry, and yellow Mayacoba) originating in the Andes and small-seeded varieties (like pinto, black, and navy) coming from Mesoamerica (Miklas *et al.,* 2022). Pulses are better suited for semiarid regions, while legume crops do particularly well in tropical and humid conditions. These crops stand out as nutrient- and energy-dense foods due to their nutritional profile, sustainable yield, and storage stability (Uebersax *et al.,* 2022).

Sprouting is a low-cost and bioprocessing method that the food industry uses to boost the nutrients in seeds and grains, including cereals, oilseeds, legumes, and vegetable seeds. The breakdown of macronutrients into smaller molecules, such as amino acids, simple sugars, and other nutritional components, results in the greatest nutrient utilization (Ohanenye *et al.,* 2020). In addition to being an excellent source of phenolic compounds, vitamins, and minerals, sprouts also distinguish themselves by reducing the anti-nutritional elements found in grains and seeds, which improves the foods sensory qualities and digestion. By lowering anti-nutritional components, sprouting improves organoleptic properties, increases free limiting amino acids, accessible vitamins, and protein digestion and utilization (Hassan *et al.,* 2020). Sprouts can be consumed in both forms as a raw form and cooked. After sprouting procedure completed the obtained sprouts preserved for protection of microbial attack (Sadaf *et al.,* 2023).

The mung bean also called the green gram (*Vigna radiata L*.), is a plant species in the legume family that is thought to be a native crop of India. It is a little green bean with a circular form that is mostly grown in East, Southeast, and South Asia. Many fresh, fermented and dried meals have been made from mung bean seeds. They are referred to as "green pearls" and are incredibly popular meals in China. It can be found in both sweet and savory recipes (Wang *et al.,* 2021).

In the food processing business, it has potential use in flour goods and dairy products. Mung beans are a great addition to a balanced diet since they are a higher-quality source of protein (20-24%) with a higher digestion. Mung bean cultivars like NIFA Mung-19 In terms of nutrition, mung beans are an excellent provider of important elements including zinc up to 6.2 mg/100g, iron >8.7 mg/100g, and protein up to 31%. Mung bean sprouting also boosts the nutritional content by encouraging the production of enzymes that eliminate or lessen the antinutritional and indigestible problems in legumes. When it comes to their nutritional value and antioxidant activity, mung beans, lentils, and chickpeas outperform other legumes. Numerous chronic disorders, such as cancer, obesity, and cardiovascular disease, may be inhibited by them (Nayab *et al.,* 2022).

Additionally rich in dietary fiber and the important amino acid lysine, red and white kidney beans supplement diets based on cereals that frequently have low lysine levels. They also include precursors to vitamin A, such as lutein, zeaxanthin and ß-carotene (Margier *et al.,* 2018). Worldwide, there is a significant consumption of red kidney beans. Red kidney beans have long been used in traditional medicine in Asian nations, particularly China (Hou *et al.,* 2019). The moisture, protein, fiber, and ash contents of red kidney beans are 8.85-10.2%, 22.9-26.3%, 3.80-7.00% and 3.1-4%, respectively (Enyiukwu *et al.,* 2020). A variety of bioactive substances, vitamins, and minerals found in red kidney beans have been shown to have nephroprotective, hepatoprotective, anti-inflammatory and anticancer properties (Sudhakaran and Bukkan, 2021).

The raw white kidney beans have a total carbohydrate content of 57.7%, 3.5% minerals, 1% fat, and 5.1% crude fiber. They also contain 20%-25% complex carbs and 50%-60%. White kidney beans are high in unsaturated fatty acids and low in sodium and saturated fats (linoleic acid). It also includes a significant amount of phytochemical substances, including as flavonoids and isoflavonoids (Suvan *et al.,* 2020). Because of aerobic respiration and biochemical metabolism, germination can alter phytochemical substances and their functional characteristics. Sprouts include a variety of antioxidants and compounds linked to antioxidants. The biggest concentrations found in sprouts are in minerals, phenolic compounds, vitamin E, and phytosterols. One of the major pulse crops that is cultivated all over the world is black grams. A vitreous covering of gums and mucilage firmly attaches the husk to the cotyledon, making it difficult to process black grams into dehusked seed. Despite numerous attempts to speed up the dehusking process and increase the yield of milling by using pre-

treatments such water, oil, and enzymes, there is still a significant amount of milling loss, amounting to 20-30% of the total seeds. Black gram sprouts are an important source of protein, comprising 20.8-30.5% and carbs, which range from 56.5-63.7% (Saeed *et al.*, 2020).

Legumes are naturally produced in an environmentally sustainable way, they are a more affordable source of protein than animal sources. There are numerous established health advantages of regularly consuming legumes (Didinger and Thompson, 2021). Because of these qualities, legumes are a great choice for creating products with additional value. Legumes can be used for purposes other than those associated with traditional diets and uses if they are incorporated into other food products. This means that the food business has a greater chance of utilizing legume ingredients in different food systems (Dhull *et al.,* 2022).

Sprouting is one of the best method use in the food industry to improve the nutritional profiling of cereals, grains, legumes, vegetables and after they have sprouted (Zhang *et al.,* 2020). The epidemiological studies indicates that the intake of legumes based sprouts can lower the risk of chronic illness, neurological diseases and cardiovascular diseases (Mir *et al.,* 2021). Most commonly sprouting seeds are legumes such as mung beans, kidney beans, black gram beans, cereal grains such as rice, and wheat etc.

The sprouts are gained from various types of plants which generally includes roots, shoot and seeds. Sprouts are best source of bioactive compounds such as vitamins, polyphenols and antioxidants. The consumption of sprouts is most common in Asia and Western nations, and these are often consider as a component of good health. Sprouts have also obtained a lot of interest in consumers that are increasingly try to find best nutrition especially among the consumers who are concerned about their health. Compared to cereals, legume-based sprouts have a lower carbohydrate content, a higher protein and fibre content, and an extremely rich nutritional profile (Siddiq *et al.,* 2022).

Ingredients derived from legumes are ideal for creating a wide range of food products, such as doughs and composite combinations, meat substitutes and extenders, baked goods, snack foods, dairy products, and local or ethnic goods (Hill, 2022). Consumers now have significant alternatives to the energy-intensive manufacturing and processing of animal-based meals thanks to the development, promotion, and use of protein-rich legume-based meat substitutes (Ahmad *et al.,* 2022).

Aims and Objectives

Keeping in view the unique role of raw and sprouted legume beans study is designed to achieve the following objectives:

- Preparation of raw legume beans flour (black grams, red kidney beans, white kidney beans and mung beans)
- Sprouting of legumes (black grams, red kidney beans, white kidney beans and mung beans)
- Investigation of antioxidants, physicochemical and nutritional profile differences between the raw and sprouted beans

2. Material and Methods

Present study was intend to analyze the nutritional comparison between raw and sprouted legumes (mung bean, black gram beans, white kidney beans and red kidney beans). The research work was performed in the Food Technology Lab, Food Processing and Preservation Lab and Food Analytical Lab Department of Food Science and Technology, Govt College Women University, Faisalabad.

2.1. Procurement of raw materials

The procurement of raw material such as mung beans, black gram beans, white kidney beans and red kidney beans was purchased from Ayub Agriculture Research Institute, Faisalabad and NIAB, Faisalabad.

2.2. Preparation of raw beans flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

Raw beans (mung beans, black gram beans, white kidney beans and red kidney beans) was properly cleaned to remove stones, dirt, and other extraneous matters before being used for further processing. Cleaned mung beans was washed, dried and ground into flour, packed and stored for further study.

2.3. Development of sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The development of sprouted beans flour prepared by method as described by (Swieca *et al.,* 2020).

2.4. Analysis of Raw and Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

2.4.1. Physiochemical Properties of Raw and Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The physiochemical properties water and oil absorption capacity and bulk density of raw and sprouted legumes was determine the method of (Wabie *et al.,* 2023).

2.4.2. Determination of bioactive compounds of Raw and Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The total phenolic compounds (TPC), DPPH and total flavonoid content (TFC) was determined by the method as described by Wabie *et al.* (2023).

2.4.3. Mineral Analysis of Raw and Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The mineral analysis (calcium, potassium and sodium) of raw material was determined by the method as described in AACC (2019).

2.4.4. Proximate Analysis of Raw and Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The proximate analysis of raw material (crude protein, crude ash, crude fat, crude fiber, crude moisture and NFE) was determined by the method as described AACC (2019).

2.4.5. Statistical Analysis

All the data was statistically analyzed.

3. Results and Discussion

3.1. Physiochemical Properties of Raw and Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

3.1.1. Physiochemical Properties of Raw Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The mean values for physiochemical properties of raw legume beans has been showed in Table 1. The water absorption capacity, oil absorption capacity and bulk density of raw red kidney beans are 4.05±0.08 mL/g, 4.24±0.02 mL/g and 0.68±0.03g/cm^3 respectively. Pangastuti *et al.* (2013) reported the bulk density of red kidney beans flour as 0.41g/$cm^{3.}$ The water absorption capacity and oil holding capacity of red kidney bean flour was 4.97mL/g and 4.50mL/g, respectively, which is similar to the study by Mukta *et al.* (2020). The water absorption capacity, oil absorption capacity and bulk density of raw white kidney beans are 2.26±0.02mL/g, 2.04±0.03mL/g and 1.28±0.02g/cm^3 respectively. The water absorption capacity, oil absorption capacity and bulk density of raw mung beans are 2.25±0.02mL/g, 1.43±0.02mL/g and 0.73±0.03g/cm^3 respectively. The water absorption capacity, oil absorption capacity and bulk density of raw black gram beans are 1.36±0.03 mL/g, 2.03±0.03mL/g and 0.46±0.03g/cm^3 respectively.

3.1.2. Physiochemical Properties of Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The mean values regarding the physiochemical properties of sprouted legume beans has been showed in Table 1. The water absorption capacity, oil absorption capacity and bulk density of sprouted red kidney beans are 4.26±0.02 mL/g, 4.83±0.02mL/g and 1.04±0.02 g/cm^3 respectively. The water absorption capacity, oil absorption capacity and bulk density of sprouted white kidney beans are 4.44±0.02mL/g, 2.59±0.03mL/g and 1.43±0.03g/cm^3 respectively. The water absorption capacity, oil absorption capacity and bulk density of sprouted mung beans are 2.33±0.02mL/g, 2.10±0.02mL/g and 0.83±0.03g/cm^3 respectively. The water absorption capacity, oil absorption capacity and bulk density of sprouted black gram beans are 2.00±0.02 mL/g, 2.26±0.02mL/g and 0.50±0.02g/cm^3 respectively.

Table 1: Mean values for physiochemical properties of raw and sprouted Legume Beans Flour

Physiochemical properties						
Legume Beans	**Raw**			**Sprouted**		
	Water absorption capacity mL/g	**Oil absorption capacity mL/g**	**Bulk Density g/cm^3**	**Water absorption capacity mL/g**	**Oil absorption capacity mL/g**	**Bulk Density g/cm^3**
Red Kidney Beans	4.05±0.08^E	4.24±0.02^D	0.68±0.03^D	4.26±0.02^G	4.83±0.02^D	1.04±0.02^D
White Kidney Beans	2.26±0.02^E	2.04±0.03^E	1.28± 0.02^I	2.44±0.02^F	2.59±0.03^B	1.43±0.03^A
Mung Beans	2.25±0.02^D	1.43±0.02^J	0.73±0.03^C	2.33±0.02^A	2.10±0.02^A	0.83±0.02^A
Black Gram Beans	1.36±0.03^I	2.03±0.03^H	0.46±0.03^B	2.00±0.02^J	2.26±0.02^C	0.50±0.02^E

3.2. Anti-oxidants of Raw and Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

3.2.1. Anti-oxidants of Raw Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The mean values antioxidants compounds of raw legume beans has been showed in Table 2. The DPPH, TFC and TPC of raw legume beans based composite flour are 4.03±0.04mg/mL, 3.00±0.01 mgRE/g and 2.28±0.04mgGAE/g respectively. The DPPH, TFC and TPC of raw red kidney beans are 0.24±0.08mg/mL, 0.34±0.08mgRE/g and 0.58±0.03mg GAE/g respectively. The DPPH, TFC and TPC of raw white kidney beans are 0.35±0.02mg/mL, 0.44±0.03mgRE/g and 0.32±0.03mg GAE/g respectively. The findings of white kidney beans agreed with the findings of Hardeep *et al*. (2013). The DPPH, TFC and TPC of raw mung beans are 0.29±0.02mg/mL, 0.50±0.02 mgRE/g and 0.42±0.03 respectively. The DPPH, TFC and TPC of raw black gram beans are 0.30±0.03mg/mL, 0.55±0.03 and 0.46±0.03mg GAE/g respectively.

3.1.2. Anti-oxidants of Sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

During sprouting of legumes have higher amounts of phenolics, which are linked to more active endogenous enzymes including hydrolase and polyphenol oxidase (Gharachorloo *et al.*, 2012). The mean values for bioactive compounds of sprouted legume beans has been presented in Table 2. The DPPH, TFC and TPC of sprouted red kidney beans are 0.28±0.02mg/mL, 0.40±0.02mgRE/g and 0.62±0.02mgGAE/g respectively. The DPPH, TFC and TPC of sprouted white kidney beans are 0.39±0.02mg/mL, 0.40±0.03mgRE/g and 0.44±0.03mg GAE/g respectively. The DPPH, TFC and TPC of sprouted mung beans are 0.32±0.02mg/mL, 0.52±0.02mgRE/g and 0.56±0.02 respectively. The DPPH, TFC and TPC of sprouted black gram beans are 0.36±0.03mg/mL, 0.57±0.02mgRE/g and 1.92±0.02mg GAE/g respectively. The results were in accordance Kim *et al.* (2012) sprouting of mung beans increases its antioxidant activity due to increase in vitamin C content.

Table 2: Mean values for anti-oxidants of raw and sprouted legume beans flour

Legume Beans	Antioxidants					
	Raw			Sprouted		
	DPPH mg/mL	TFC mgRE/g	TPC mgGAE/g	DPPH mg/mL	TFC mgRE/g	TPC mgGAE/g
Red Kidney Beans	0.24 ± 0.08^{E}	0.34 ± 0.02^{D}	0.58 ± 0.03^{D}	0.28 ± 0.02^{G}	0.40 ± 0.02^{D}	0.62 ± 0.02^{B}
White Kidney Beans	0.35 ± 0.02^{E}	0.44 ± 0.03^{E}	0.32 ± 0.03^{I}	0.39 ± 0.02^{F}	0.49 ± 0.03^{B}	0.44 ± 0.03^{A}
Mung Beans	0.29 ± 0.02^{D}	0.50 ± 0.02^{J}	0.42 ± 0.03^{C}	0.32 ± 0.02^{A}	0.52 ± 0.02^{A}	0.56 ± 0.02^{A}
Black Gram Beans	0.30 ± 0.03^{I}	0.55 ± 0.03^{H}	0.46 ± 0.03^{B}	0.36 ± 0.02^{J}	0.57 ± 0.02^{C}	1.92 ± 0.02^{D}

3.3. Proximate Composition of raw Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

3.3.1. Proximate composition of Raw Legume beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The proximate composition of raw legume beans has been showed in Table 3. The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of raw red kidney beans 7.99±0.08, 1.33±0.02, 17.15±0.03, 5.51±0.02, 2.75±0.03 and 65.63±0.02% respectively. The current result regarding raw red kidney beans compare able with the study of Ahmad *et al.* (2014) determined the crude moisture 8.12 and crude fat 1.92% in red kidney beans. The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of raw white kidney beans 6.13±0.02, 1.97±0.02, 10.42±0.02, 3.23±0.03, 1.97±0.03 and 65.28±0.04% respectively. The current findings regarding raw white kidney beans compare able with the study of Neveen *et al.* (2023) determined the crude moisture 6.95%, crude protein 9.54% and crude fat 2.00%. The NFE value observed in this study is in conformity with the value of 65.44% for red kidney bean (Scholnick *et al.*, 2020). The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of raw mung bean 7.06±0.02, 5.02±0.03, 24.78±0.03, 3.67±0.02, 5.59±0.02 and 53.88±0.02% respectively. The results regarding raw mung bean compare able with the study of Islam *et al.* (2017) determined the crude protein 24.25%, crude ash 3.00% and crude fiber 6.00%. The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of raw black gram bean 7.36±0.02, 3.58±0.02, 20.94±0.02, 3.72±0.03, 4.55±0.03 and 59.85±0.02% respectively. The current result regarding raw mung bean compare able with the study of Wabi *et al.* (2023) determined the crude moisture 7.13% and crude ash 6.00%.

3.3.2. Proximate composition of sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The proximate composition of sprouted legume beans has been showed in Table 4. The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of sprouted red kidney beans 11.62±0.02, 1.47±0.02, 20.12±0.02, 2.04±0.03, 3.64±0.02 and 61.11±0.08% respectively. The current result regarding sprouted red kidney beans compare able with the study of Winarsi *et al.* (2020) determined the crude fiber 3.87% in sprouted red kidney beans. The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of sprouted white kidney beans 9.04±0.02, 2.04±0.03, 18.04±0.03, 4.53±0.02, 2.83±0.02 and 63.52±0.02% respectively. The findings regarding sprouted white kidney beans compare able with the study of Dekka *et al.* (2023) crude moisture 10.80% and crude fat 1.85%. The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of sprouted mung bean 15.04±0.02, 1.59±0.02, 26.79±0.02, 3.83±0.02, 7.79±0.03 and 44.96±0.02% respectively. The current result of sprouted mung bean compare able with the study of Masood *et al.* (2014) determined the crude fat 1.56%, crude protein 26.77%. The crude moisture, crude fat, crude protein, crude ash, crude fiber and NFE of sprouted black gram bean 7.82±0.02, 2.08±0.02,

24.83±0.02, 6.08±0.03, 5.63±0.04 and 53.56±0.03% respectively. The current result regarding sprouted black gram bean compare able with the study of Nagessa *et al.* (2023) crude moisture content 7.85% and crude ash 6.09%. Additionally, Megat *et al.* (2016) shown that during sprouting, the fibre content of red kidney beans, mung beans and soybeans was greatly enhanced.

Table 3: Mean values for proximate composition of raw and sprouted legume beans flour

Legume Beans	proximate composition%					
	Raw			Sprouted		
	Crude Moisture	Crude Fat	Crude Protein	Crude Moisture	Crude Fat	Crude Protein
Red Kidney Beans	7.99±0.08^{F}	1.33±0.02^{B}	17.15±0.03^{D}	11.62±0.02^{G}	1.47± 0.02^{D}	20.12±0.02^{D}
White Kidney Beans	6.13±0.02^{E}	1.97±0.03^{A}	10.42± 0.02^{I}	9.04±0.02^{D}	2.04±0.03^{B}	18.04±0.03^{A}
Mung Beans	7.36±0.02^{D}	3.58±0.02^{A}	20.94±0.03^{C}	15.04±0.02^{A}	1.59±0.02^{A}	26.79±0.02^{A}
Black Gram Beans	7.06±0.03^{I}	5.02±0.03^{C}	24.78±0.03^{B}	7.82±0.02^{J}	2.08±0.02^{C}	24.83±0.02^{B}

Table 4: Mean values for proximate composition of raw and sprouted legume beans flour

Legume Beans	Proximate composition%					
	Raw			Sprouted		
	Crude Ash	Crude Fiber	NFE	Crude Ash	Crude Fiber	NFE
Red Kidney Beans	1.51±0.02^{C}	2.75±0.03^{B}	65.63±0.02^{B}	2.04±0.03^{C}	3.64±0.02^{A}	61.11±0.08^{G}
White Kidney Beans	3.23±0.03^{H}	1.97±0.03^{C}	64.28±0.04^{C}	4.53±0.02^{E}	2.83±0.02^{G}	63.52±0.02^{A}
Mung Beans	3.72±0.03^{B}	4.55±0.03^{A}	59.85±0.02^{D}	3.83±0.02^{F}	7.79±0.03^{B}	44.96±0.02^{B}
Black Gram Beans	3.67±0.02^{A}	5.59± 0.02^{D}	53.88±0.02^{E}	3.80±0.02^{A}	5.63±0.04^{D}	53.56±0.03^{C}

3.4. Minerals Analysis of Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

3.4.1. Minerals Content in Raw Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The minerals content of raw legumes beans has been presented in Table 4. The results in the line with Haileslassie *et al*. (2019) who reported that phytates level reduced after soaking and clarify that might due to leaching of the anti-nutrients during sprouting of legumes. The calcium, magnesium and potassium content of raw red kidney beans is 0.26±0.08, 0.23±0.02 and 0.47±0.03mg/100g respectively. The results of raw red kidney beans calcium content is comparable with the study of Serkalem *et al.* (2023) the calcium content of raw red kidney bean is 0.45mg/100g. The calcium, magnesium and potassium content of raw white kidney beans is 0.29±0.02, 0.28±0.02 and 0.33± 0.03mg/100g respectively. The calcium, magnesium and potassium content of raw mung beans is 0.48±0.03, 0.18±0.02 and 0.29± 0.03mg/100g respectively. The current values regarding the

potassium content of raw mung bean is agreed with the findings of Tiwari *et al.* (2017) 0.33mg/100g. The calcium, magnesium and potassium content of raw black beans is 0.59±0.03, 2.22±0.03 and 0.37± 0.03 mg/100g respectively.

3.4.2. Minerals Content in sprouted Legume Beans Flour (Mung Bean, Black Gram, Red Kidney Bean and White Kidney Bean)

The sprouting process had a significant effects on the minerals content. The minerals content of raw legumes beans has been presented in Table 5. The calcium, magnesium and potassium content of sprouted red kidney beans is 1.29±0.02, 0.27±0.02 and 0.51±0.02mg/100g respectively. The findings of calcium content of sprouted red kidney beans agreed with the study of Abera *et al.* (2023) the calcium content is1.95±0.04mg/100g. The calcium, magnesium and potassium content of sprouted white kidney beans is 0.33±0.02, 0.29±0.03 and 0.54±0.03mg/100g respectively. The calcium, magnesium and potassium content of sprouted mung beans is 0.48±0.03, 0.18±0.02 and 0.29± 0.03mg/100g respectively. The current values regarding the potassium content of sprouted mung bean is agreed with the findings of Tiwari *et al.* (2017) 0.7mg/100g. The calcium, magnesium and potassium content of sprouted black beans is 0.61±0.02, 3.22±0.02 and 0.44±0.02 mg/100g respectively. The present findings regarding the sprouted black beans of magnesium content similar with the findings of Kotue *et al*. (2018) is 3.86 mg/100g.

Table 5: Mean values for mineral analysis of raw and sprouted Legume Beans Flour

Legume Beans	Mineral Analysis mg/100g					
	Raw Beans			Sprouted Beans		
	Calcium	Magnesium	Potassium	Calcium	Magnesium	Potassium
Red Kidney Beans	0.26 ± 0.08^{F}	0.23 ± 0.02^{B}	0.47 ± 0.03^{D}	1.29 ± 0.02^{G}	0.27 ± 0.02^{E}	0.51 ± 0.02^{CD}
White Kidney Beans	0.29 ± 0.02^{E}	0.28 ± 0.03^{A}	0.33 ± 0.02^{I}	0.33 ± 0.02^{F}	0.29 ± 0.03^{E}	0.54 ± 0.03^{A}
Mung Beans	0.48 ± 0.02^{D}	0.18 ± 0.02^{A}	0.29 ± 0.03^{C}	0.52 ± 0.0^{D}	0.23 ± 0.02^{E}	0.33 ± 0.02^{A}
Black Gram Beans	0.59±0.03	2.22 ± 0.03^{C}	0.37 ± 0.03^{F}	0.61 ± 0.02^{C}	3.22 ± 0.02^{A}	0.44±0.02F

Conclusion

It has been concluded that the sprouting of legumes improves the bioavailability of nutritional substances. The sprouted legume beans indicates the high score in physiochemical properties, antioxidants, minerals content and proximate composition as compared to raw legume beans. In the comparison between the raw beans and sprouted beans, sprouted beans have superior digestibility, higher enzyme activity, better nutrient bioavailability, and improved protein quality. Because of these advantages, sprouted beans flour are a great complement to a balanced diet, especially for consumers who want to increase their nutritional intake and enhance their digestive health.

References

1. AACC. 2019. Approved methods of American association of cereal chemists (11th ed.). St Paul, MN: AACC International. Methods 44-15.02, 46-12.01, 30-25.01 and 08-01.01.
2. Abera, S., Y. Weldegebriel and S. Bhagwan. 2023. Effect of Processing Methods on Antinutritional Factors (Oxalate, Phytate, and Tannin) and Their Interaction with Minerals (Calcium, Iron, and Zinc) in Red, White, and Black Kidney Beans. International Journal of Analytical Chemistry.

3. Ahmad, H., S. Khalil and M. Gulfraz. 2014. Exploring the potential of red kidney beans (*phaseolus vulgaris*) to develop protein based product for food applications. The Journal of Animal and Plant Sciences. 24(3):860-868.
4. Ahmad, M., S. Qureshi, M.H. Akbar, A. Siddiqui, A. Gani, M. Mushtaq, I. Hassan and S. Dhull. 2022. Plant-based meat alternatives: Compositional analysis, current development and challenges. Applied Food Research. 2:100154.
5. Gharachorloo, M., B.G. Tarzi, M. Baharinia, A.H. Hemaci. 2012. Antioxidant activity and phenolic content of germinated lentil (*Lens culinaris*). Journal of Medical Plants Reserach. 6:4562-4566.
6. Dekka, S., H. Vincent, T. Maria, M.J. Rangarajan, V. Rajagopal. 2023. Unveiling the germination behavior of kidney beans: Insights into their physicochemical, antinutrients, and functional characteristics in whole and dehusked matrices. Food Chemistry Advances 3:100509.
7. Dhull, S. B., J. Kinabo and M.A. Uebersax. 2022. Nutrient profile and effect of processing methods on the composition and functional properties of lentils (*Lens culinaris Medik*): A review. Legume Science. E: 156.
8. Didinger, C. and H.J. Thompson. 2021. Defining nutritional and functional niches of legumes: A call for clarity to distinguish a future role for pulses in the dietary guidelines for Americans. Nutrients. 13:1100.
9. Enyiukwu, D.N., L.A. Chukwu and I.N. Bassey. 2020. Nutrient and anti-nutrient compositions of southern pea (*Vigna Unguiculata*) and mung bean (*Vigna Radiata*) seeds grown in humid Southeast Nigeria: a comparison. Trop Drylands. 3:41-45.
10. Haileslassie, H. A., C.J. Henry and R.T. Tyler. 2019. Impact of pre-treatment (soaking or germination) on nutrient and anti-nutrient contents, cooking time and acceptability of cooked red dry bean (*Phaseolus vulgaris* L.) and chickpea (*Cicer arietinum L.*) grown in Ethiopia. International Journal of Food Science and Technology. 54(8):2540-2552.
11. Hassan, M. 2023. Nutrient and antinutrient compositions of extrudates from fermented and sprouted rice-sesame blends. Diss. 20:4-15.
12. Hardeep, G., P. Gujral, N. Sharma, G. Neha and A. Ali. 2013. Antioxidant Properties of Legumes and Their Morphological Fractions as Affected by Cooking. Food Science and Biotechnology. 22(1):187-194.
13. Hery, W., B. P. Yudhanti, I.M. Nisa Ilmi, A. Isyah. 2020. The effect of long germination on the levels and types of nonenzymatic antioxidants in red kidney bean sprouts. Proceeding ICMA-SURE.3(2):23-26.
14. Hill, H. 2022. "Utilization of dry beans and other pulses as ingredients in diverse food products." Dry beans and pulses: Production, processing, and nutrition. 2:307-329.
15. Hou, D., L. Yousaf, Y. Xue, J. Hu, J. Wu, X. Hu, N. Feng and Q. Shen. 2019. Mung bean (*Vigna radiata L.*): bioactive polyphenols, polysaccharides, peptides, and health benefits. Nutrients. 11:1238-1265.
16. Islam, M.J., M. Hassan, S.R. SR Sarker and A.B. Rahman.2017. (Light and temperature effects on sprout yield and its proximate composition and vitamin C content in Lignosus and Mung beans. Journal of Bangladesh Agril Univversity. 248-254.
17. Kim, D. K., S.C. Jeong, S. Gorinstein, and S.U. Chon. 2012. Plant Foods for Human Nutrition. 67(1): 71.
18. Kotue, T.C., P. Jayamurthy, P. Nisha, A. C. Pieme, G. Kansci and E. Fokou. 2018. Proximate Analysis and Minerals of Black Bean Seeds (*Phaseolus vulgaris L.*) Used to Manage Sickle Cell Disease in West Region. Cameroon. 1(4):1-8.
19. Margier, M., S. Georg´e, N. Hafnaoui, D. Remond, M. Nowicki, L. Chaffaut, M.J. Amiot and E. Reboul. 2018. Nutritional composition and bioactive content of legumes: characterization of pulses frequently consumed in France and effect of the cooking method. Nutrients. 10:e1668.
20. Masood, T., H. U. Shah and A. Zeb.2014. Effect of sprouting time on proximate composition and ascorbic acid level of mung bean (vigna radiate l.) And chickpea (*cicer arietinum l.*) Seeds. The journal of animal and plant sciences. 24(3):250-289.

21. Miklas, P. N., J.D. Kelly and K.A. Cichy. 2022. Dry bean breeding and production technologies. In M. Siddiq and M. A. Uebersax (Eds.), Dry beans and pulses: Production, processing and nutrition2nd ed. John Wiley. 29:56.
22. Megat, P.M.R., A. Azrina, M.E. Norhaizan. 2016. Effect of germination on total dietary fibre and total sugar in selected legumes. International Food Reserach Journal. 23(1):257-261.
23. Nagessa, W.B. 2023. Effects of processing methods on phytate and tannin content of black small common beans (*Phaseolus vulgaris L*.) cultivated in Mozambique. Cogent Food and Agriculture. 9:2289713
24. Nayab, B.R., A. Samina, K.R. Mohammad, A. Sadia and B. Rosa. 2020. Quantitative Estimation of Protein in Sprouts of *Vigna radiate* (Mung Beans), *Lens culinaris* (Lentils), and *Cicer arietinum* (Chickpeas) by Kjeldahl and Lowry Methods. Research. 27:8-14.
25. Neveen, F. Agamy, M. Nashwa, S. Younes, M.S. Samar and A. Shawir. 2023. Chemical and Anti-Nutritional of Two Kidney Bean after Soaking, Boiling Processing and Sensory Evaluation of Their Produced Burger. Egyptian Journal of Food Science. 51
26. Ohanenye, C. and A. Ikenna C. 2020. "Germination as a bioprocess for enhancing the quality and nutritional prospects of legume proteins." Trends in Food Science and Technology. 101(20):213-222.
27. Pangastuti, H.A., D.R. Affandi and D. Ishartani. 2013. Characterization of the Physical and Chemical Properties of Flour Kidney Beans (*Phaseolus vulgaris L*.) with Some Preliminary Treatments. Journals Food Technology. 21:20-29.
28. Sadaf, W. 2023. "A review on bioactive compounds in sprouts: extraction techniques, food application and health functionality." International Journal of Food Properties. 26(1):647-665.
29. Saeed, A.S., A.A. Syed, A. Rashid and A. Raheel. 2020. Exploring the potential of black gram (*Vigna mungo*) four as a fat replacer in biscuits with improved physicochemical, microstructure, phytochemicals, nutritional and sensory attributes. Applied Sciences. 2:2083.
30. Scholnick, D. A. and A.E. Winslow. 2020. The role of fasting on spine regeneration and bacteremia in the purple sea urchin Strongylocentrotus purpuratus. Plos one. 15(2):e0228711.
31. Serkalem, A., Y. Weldegebriel and S. Bhagwan. 2023. Effect of Processing Methods on Antinutritional Factors (Oxalate, Phytate, and Tannin) and Their Interaction with Minerals (Calcium, Iron, and Zinc) in Red, White, and Black Kidney Beans. Journal of Pharmacognosy and Phytochemistry. 6(1): 336-340
32. Siddiq, M. and M. A. 2022. Global production, trade, processing and nutritional profile of dry beans and other pulses. Dry beans and pulses: Production, processing, and nutrition (Second ed.) John Wiley. 307-329.
33. Sudhakaran, S.M.N. and D.S. Bukkan. 2021. A review on nutritional composition, antinutritional components and health benefits of green gram (*Vigna Radiata L*.) Wilczek. Journal of Food Biochemistry. 45(6):13743.
34. Suvan, P., K.V. Patel and S. Kumar. 2020. Evaluation of SSR-based genetic diversity, protein and mineral content in blackgram genotypes**.** Journal of King Saud University- Sciences. 32:1092-1033.
35. Tiwari, A. and N. Darshika. 2017. Comparative study on antioxidant activity, phytochemical analysis and mineral composition of the Mung Bean (*Vigna Radiata*) and its sprouts. Journal of Pharmacognosy and Phytochemistry. 6(1): 336-340
36. Uebersax, M. A., K.A. Cichy, F.E. Gomez, T.G. Porch, J. Heitholt, J.M. Osorno, K. Kamfwa, S.S. Snapp and S. Bales. 2022. Dry beans (*Phaseolus vulgaris L*.) as a vital component of sustainable agriculture and food security A review. Legume Science. e155.
37. Wabie, A. and M. Maray. 2023. Physicochemical and Functional Properties, Nutritional Value and Bioactive Compounds of Some Composite Flours. Assiut Journal of Agriculture Science. 54 (1):116-131.
38. Wabie, A., M. Mohamed. 2023. Physicochemical and Functional Properties, Nutritional Value and Bioactive Compounds of Some Composite Flours. Assiut Journal of Agriculture Science. 54 (1):116-131.

39. Wang, Y. R., B. Zhang, J. Fan, Q. Yang and H.Q. Chen. 2021. Effects of sodium tripolyphosphate modification on the structural, functional, and rheological properties of rice glutelin. Food Chem. 281:18-27.