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Research Article

Comparison of Physico-Chemical Qualities of the Small and Large Red Kidney Beans (*Phaseolus Vulgaris* L) Flour

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Abstract

Phaseolus vulgaris is an herbaceous annual plant, known for its edible beans, used both as dry seed and as unripe fruit, are referred to as beans. In many developing countries *Phaseolus vulgaris L.* are used as source of protein, the *Phaseolus* family is also a very good source of vitamins, minerals (calcium, potassium, magnesium, copper, phosphor, and iron), complex carbohydrates and unsaturated fatty acids, which are beneficial to human health. The present study was undertaken to determine the physico-chemical properties viz. color, hundred seed weight, hundred seed volume, density, hydration cofficient, hydration capacity and hydration index; proximate composition and mineral content of small and large red kidney beans before and after soaking. The results revealed that both the kidney beans are good source of nutrients. Significant difference existed between seed weight, volume, hydration capacity, hydration cofficient, hydration index of both the kidney beans. comparatively higher content of moisture (12.49 %), crude protein (26.95%), crude fat (1.91%), crude fiber (8.16%), calcium (133.5 mg/100 g), iron (5.64 mg/ 100 g) before soaking were observed in large red kidney beans whereas, higher values for total ash (3.84 %), carbohydrate (50.94 %), physiological energy (311.75 Kcal/100g) before soaking were observed in small red kidney beans.

Keywords: beans, physico-chemical properties, soaking, hydration

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Introduction

Legumes play an important role in agriculture sector and contribute a lot for diet and also a major source of important nutrients for many people both in developed and developing countries. Kidney beans are good source of important nutrients with good amount of protein, mineral matter, crude fiber, and carbohydrates [1]. However, the biological utilization of the nutrients is interfered by various anti-nutritional factors present in legumes [2]. Beans (*Phaseolus vulgaris* L.) are excellent source of proteins (20-30%) and carbohydrates (50-60%) and fairly good sources of minerals and vitamins [3]. Dry beans are widely known for their fiber, mineral and protein contents [4]. The flour and protein concentrate of red kidney been exhibited good functional properties [5]. When beans are prepared for consumption they are usually soaked before cooking this is done to facilitate quicker cooking [6]. Soaking is a process carried out before cooking bean to facilitate physical and chemical changes as the denaturation of proteins, gelatinization of starch and destruction of toxic factors [7]. During soaking, the various soaking properties differ because the distribution of seed reserves among the variety of seeds differs. Thus seeds exhibit different hydration rates and other hydration properties depending upon the size of pore, hygroscopic properties of seed reserve material, concentration gradient, elasticity of seed coat and its permeability. Thus soaking studies are of practical importance as it affects the further processing of [8]. Simple processing methods like soaking, cooking, etc. have been reported to reduce the level of some of the anti-nutritional factors [9, 10]. Soaking prior to cooking causes negligible losses of nutrients but has the advantages of removing the bitter principal in the seeds. Pulses are generally soaked before cooking. Soaking assists in uniform expansion of seed coat and cotyledon and is also essential for uniform cooking and tenderness. The ability of grains to hydrate is related to cooking quality. Higher hydration capacity of pulse grains is associated with shorter cooking time [11]. Color is an important parameter by which a consumer judges pulse quality before purchase. The color of pulse grains is a genetic characteristic and is affected by storage and environmental conditions [11]. Seed size, varietal differences in external and internal composition, length and temperature of storage, affects the water absorption and cooking characteristics of dry beans [12]. The rate of hydration of beans determines their cookability and that the hydration and swelling capacities of the soaked beans would be related to required cooking time. The faster the legume hydration, faster the mass transfer of the bean

constituents such as vitamins from the seed to the soaking medium. Small-seed varieties show also better water-holding capacity, confirmed by changes in the mechanical resistance of seeds. These varieties require shorter soaking than large-seed ones, and hot soaking may be an alternative for them, as it allows reducing the time of this process to two hours [13].

Materials and Methods

Sample Collection and Preparation

Sample of small red kidney beans was purchased from local market of Haldwani (Nainital), India while large red kidney beans (large red kidney beans) were purchased from local market of Pantnagar (U.S.Nagar) India. All kidney beans were thoroughly cleaned and hand sorting is done in order to remove stones, dust materials, glumes, stalks, and broken, undersized and immature grains. The grains was then divided in to two as control and soaked in one day in distilled water and drained. Following these, the control was subjected to grinding and soaked kidney beans were dried in oven at 50C for 6 hrs. And the fully dried grains were subjected to grinding. Each kidney bean flours packed using high density polyethylene bag (HDPP) respectively and stored in air tight container for analysis.

Experimental Design

Completely randomized design was used in this experiment and the effect of soaking on physical properties (seed weight, density, volume, hydration cofficient, and hydration capacity and hydration index), proximate composition and minerals (Fe and Ca) of kidney beans flours were studied.

Physical Properties, Proximate Composition and mineral analysis

The color was determined by using Munsell soil color chart [14]. The Figures of hues, values and chroma were recorded. Analysis of physical properties like Seed weight, density, volume, hydration coefficient, hydration capacity and hydration index of Unprocessed and soaked seeds of kidney beans were also analysed [12, 15, 16]. The proximate composition (moisture content, crude protein, crude fat and total ash) and minerals (Fe and Ca) were analysed using American association of analytical chemists (AOAC) standard methods [17]. The total carbohydrate contents were obtained by subtracting protein, ash, fat and moisture contents from 100.

Statistical Analysis

Data on the nutrient composition and physico-chemical characteristics was calculated for their mean value and independent sample *t*-test and paired *t*-test was used for comparison of means and significance was accepted at 0.05 level of probability ($p < 0.05$) [18].

Results

Physical properties of kidney bean seeds

The small red kidney beans was found to have darkest color (dark red) while the light color was recorded for large kidney beans.

Small red kidney beans

Large red kidney beans (Local cultivar)

Small red kidney beans after soaking

Large red kidney beans after soaking (Local cultivar)

Kidney bean	Hue	Value	Chroma	Color
Small	7.5 R	3	6	Dark red
Large	5R	6	6	Red

The hundred seed mass of kidney beans were in the range of 22.47 41.76g. Hundred seed volume for small red kidney bean was found to be 20 ml where as that of large red kidney beans was found to be 40 ml. Density of small red kidney bean was found to be 1.12 g/ml where as that of locally cultivar was found to be 1.04 g/ml. Hydration coefficient of small red kidney bean was found to be 1.95 where as that of large red kidney beans was 1.90. Hydration capacity of small red kidney bean was found to 0.21 g/seed where as that of large red kidney beans was found to be 0.38 g/seed. Hydration index of small red kidney bean was found to be higher (0.97) than the hydration index of large red kidney beans (0.92) (**Table 1**).

Table 1 Physical properties of small red and large red kidney bean seeds

Kidney bean	Hundred seed mass (g)	Hundred seed volume (ml)	Density (g/ml)	Hydration coefficient	Hydration capacity (g/seed)	Hydration index
Small red	22.47±1.08	20±0.57	1.12±0.05	1.95±0.018	0.21±0.007	0.97±0.017
Large	41.76±0.05	40±1.52	1.04±0.00	1.90±0.005	0.38±0.001	0.92±0.004
*t*cal	30.67*	21.21*	2.63	3.16*	38.17*	4.44*

All values are the mean of triplicate observations ±SD
t stat at 4*df* and 0.05 significance level – 2.77
*Significant at 0.05 level ($p<0.05$)

Proximate Composition of kidney bean flour

The moisture contents of both kidney bean flours were in the range of 11.84 and 12.49% respectively which is significantly different ($p<0.05$). The crude fat content of small red kidney bean flour was found to be 1.19%, whereas that of large kidney bean flour was found to be 1.91% on dry weight basis. There was significant difference between the fat content of both the samples. The protein content of large kidney bean flour had higher value (26.95) than small kidney bean flour (24.32) significantly ($p<0.05$). There was significance difference ($p<0.05$) between both ash and fiber contents of small and large kidney bean flour. Higher content of ash was found in small kidney bean flour and higher fiber content was shown in the large kidney bean flour. The carbohydrate and energy contents of the small and large kidney bean flour were 50.94, 47.47% and 311.75, 308.39kcal (**Table 2**).

Mineral analysis of kidney bean flour

The calcium content was found be higher in large red kidney beans (133.3 mg/100g) than the small red kidney bean (125.3 mg/100g). Significant differences have been observed in calcium content of both the kidney bean flour. Non-significant difference has been observed between both the kidney beans with regard to iron content. The higher per cent of iron was found in large red kidney beans (5.64 per cent) than the small red kidney bean (5.14 per cent).

Table 2 Proximate composition of small red and large red kidney bean flours

Kidney Bean	Moisture (%)	Total ash (%)	Crude fat (%)	Crude protein (%)	Crude fiber (%)	Total Carbohydrate (%)	Physiological Energy (Kcal/100g)
Small	11.84±0.26	3.84±0.02	1.19±0.12	24.32±0.87	7.87±0.16	50.94±1.32	311.75±8.69
Large	12.49±0.11	3.74±0.06	1.91±0.06	26.95±0.06	8.16±0.87	47.47±0.95	308.39±0.58
***t*cal**	3.93*	2.73	9.16*	2.82*	3.67*	3.22*	1.01*

All values are the mean of triplicate observations ±SD
t stat at 4*df* and 0.05 significance level – 2.77
*Significant at 0.05 level ($p<0.05$)

Discussion

For designing of equipments, for planting, harvesting, dehulling, drying and storage, the information of the physical and mechanical properties of the agricultural products is important. For the two samples of kidney beans under investigation seven physical parameters were gauged. The physical characteristics were color, hundred seed mass, density, hundred seed volume, hydration coefficient, hydration capacity and hydration index which play an important role in cooking dry beans. Legumes having high hydration coefficient require less cooking time. Hardness after cooking increases with a decrease of hydration capacity (g/seed) in the different varieties, but decreases with cooking time [19]. Hue is one of the main properties of a color defined technically as the degree to which a stimulus can be described as similar to or different from stimuli that are described as red, green, blue, yellow. It is the correct word used to refer to just the pure spectrum color. Value is defined as the relative lightness or darkness of a color. Chroma is the colorfulness relative to the brightness of another color that appears white under similar viewing condition

The hundred seed mass provides information about the size and density of the grain. Grain of different density mill differently, and are likely to retain moisture differently and cook differently. One study has reported hundred seed mass of red kidney bean as 23.01 g and of white kidney bean as 46.72 g which are higher than the values obtained in present study [11] whereas another study has reported hundred seed mass of small red kidney bean as 21.91 g which is lower than the values obtained for small red kidney bean in present study where as they reported hundred seed mass of large red kidney bean as 43.94 g which is higher than the values obtained for large red kidney beans in present study[19].

Hundred seed volume of red kidney beans as reported in studies were 28 ml for red and 62 ml for white kidney bean which are higher than the values obtained in present study and hundred seed volume of small red kidney bean as 17ml and of large red kidney bean as 37ml which are lower than the values obtained in present study [11, 19].

Seed density can affect the accurate design of processes and equipment used for handling, storing, and transporting agricultural materials. Density of small red kidney bean was found to be 1.12 g/ml where as that of locally cultivar was found to be 1.04 g/ml. there was no significant difference between the densities of both the samples. Similar study reported lower density values of red kidney bean as 0.82 g/ml and of white kidney bean as 0.75 g/ml [11] while another reported higher density values of small red kidney bean as 1.22 g/ml and of large red kidney bean as 1.17 g/ml than the values obtained in present study [19].

Hydration coefficient shows per cent increase in mass of beans. There was significant difference found between hydration coefficients of both the kidney beans (Table 1). It shows that mass of small red kidney bean and large red kidney beans seed was increased 1.95 times and 1.90 times of its original weight respectively after soaking.

Hydration capacity of small red kidney bean was found to 0.21 g/seed where as that of large red kidney beans was found to be 0.38 g/seed. The results shows that weight gained per seed of large red kidney beans was higher than the weight gained per seed of small red kidney bean seeds after soaking. This may be due to the difference in seed weight before and after soaking. Higher values of hydration capacity of red kidney bean as 0.23 g/seed and of white kidney bean as 0.45 g/seed and lower values of hydration capacity of small red kidney bean as 0.12 g/ml and of large red kidney bean as 0.11 g/ml have been reported by some authors in their studies [11, 19].

Hydration index shows change in the original weight of seeds after soaking. Hydration index of small red kidney bean was found to be higher (0.97) than the hydration index of large red kidney beans (0.92).

There was significant difference between the moisture content of both the samples (Table 2). Some Authors have reported moisture content of kidney beans as 11 percent and 12.90 [20, 21].

The total ash which consists of inorganic constituent is the residue that remains after the organic matter has been burnt away. The ash content of small red kidney bean was found to be 3.84 per cent, where as that of large red kidney

beans was found to be 3.74 per cent on dry weight basis (Table 2). There was no significant difference between the ash content of both the samples. Studies have reported the total ash content 3.7 per cent, 3.8 percent which is equal to the values obtained in the present study [22-24].

There was significant difference between the fat content of both the samples (Table 2). Studies have reported the crude fat content of kidney beans as 1.0 per cent which is equal to the crude fat content of small red kidney bean but less than the crude fat content of large red kidney beans in the present study [20, 25]. While others have reported the fat content of kidney beans as 1.70g/100g and 1.90 g/100 g respectively which is more than the fat content of small red kidney beans but less than the fat content of large red kidney beans obtained from the present study [23, 26].

There was significant difference between the fibre content of the samples (Table 2). Authors have reported the crude fibre content of kidney beans as 4.2 per cent and 7.0 per cent respectively [26, 22]. These values are less than the crude fibre content obtained in the present study. Higher crude fibre content (7.87 and 8.16 per cent) has been found in kidney beans as compared to lentil (0.7 per cent), green gram (4.1 per cent), soyabean (3.7 per cent) and cow pea (3.8 per cent) also make them suitable for their use in preventing certain degenerative diseases like diabetes, cancer and heart disease [26].

There was significant difference between the protein content of both the samples (Table 2). one study reported the protein content in kidney beans as 22.10 per cent which is less than the protein content of kidney beans obtained in the present study [26] whereas other reported protein content of kidney beans as 27.5 percent which is higher than the protein content of both the kidney beans obtained in the present study [27].The results show that the kidney beans are rich source of protein as compared to red gram (22.3per cent), Bengal gram (20 per cent) and green gram (24. Per cent) which are commonly consumed in India [26].

The carbohydrate content of small red kidney bean was found to be 50.94 per cent and that of large red kidney beans was 47.47 per cent (Table 2). There was significant difference between the carbohydrate content of both the kidney beans. One study reported the carbohydrate content of kidney beans as 47.00 per cent [20] and other reported the carbohydrate content in kidney bean as 60.60 per cent [26].

Energy is essential for rest, activity and growth. Carbohydrate, protein and fat are three components which provide energy [26].The data presented in Table 2 indicate that the small red kidney bean (311.75 Kcal/ 100 g) exhibited significantly higher value for physiological energy and the lowest physiological energy of 308.39 Kcal/100 g has been observed in the large red kidney beans. Authors have reported the energy value of kidney beans as 346 Kcal/100g and 327 Kcal/100 g [26,28].

Different mineral composition may be due to differences in genes, geographical origin and growing environment in terms of e.g. rainfall pattern, soil fertility and temperature [29]. There was significant difference between the calcium content while non-significant differences between the iron content of both the kidney beans (**Table 3**). Some authors have reported the calcium content of kidney beans as 134 mg/100g and 137mg/100g respectively which is more than the calcium content of kidney beans in the current study [27, 26]. whereas one author reported the calcium content of kidney bean as 129 mg/100g which is more than the value of small red kidney bean and less than the value of large red kidney beans in the present study [21]. In one study iron content of kidney beans was found as 5.8 mg/100g which is more than the iron content of both the kidney beans in the current study [26].

Table 3 Mineral analysis of small red and large red kidney bean flours

Kidney bean	Calcium (mg/100g)	Iron (mg/100g)
Small red	125.30±2.30	5.14±0.30
Local	133.58±2.30	5.64±0.09
***t*cal**	4.24*	2.54

Conclusions

Physico-chemical parameters are important for determining cooking quality therefore important in determining cooking time to save the energy cost for preparation of meals. There was not major difference between both the kidney beans in terms of nutritional quality but small red kidney beans were found to have good hydration properties than large red kidney beans. Hydration properties are positively related with the cookability therefore it can be concluded that small red kidney beans have good cooking quality as compared to the large red kidney beans.

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