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Nutritional and functional properties of adzuki bean: A potential crop

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Abstract
The majority of the population relies on cereals like wheat, rice, and corn for their diet, which provide ample carbohydrates, energy, and vitamin B-complex, but lack essential amino acids, micronutrients, and functional compounds. However, these nutrients can be found in underutilized grains and legumes, which can help create a more balanced diet and combat silent hunger. Beans, such as the Adzuki bean (*Vigna angularis*), are an important source of protein, carbohydrates, vitamins, and minerals, especially for poor populations worldwide. Adzuki beans, which have nutraceutical and nutritional properties, have been consumed for centuries in various parts of the world and are native to China. They require a similar climate and soil as soybeans and are an excellent source of starch, minerals, vitamins, and well-balanced amino acids. Adzuki beans also have nutraceutical value for diabetes patients due to their high resistant starch and phenolic components, making them ideal for developing processed and healthy food products. The present work has investigated the physicochemical, functional and nutritional properties of Adzuki bean that commonly occurred in markets. Physicochemical, functional and nutritional properties of Adzuki bean were investigated. Protein content were 29.76±10.93, 27.43±5.05, 34.43±2.20, 32.10±2.02, 27.14±0.87 for adzuki bean. Proteins found in legume flours are considered to be of high quality because they contain all essential amino acids required by the human body. The maximum WAC in % was found in legume sample LOCAL TOTRU (1.60±2.72) and minimum was observed in HPU 51 (1.03±0.05). Next the OAC in % highest OAC was observed in IC 341951 and LOCAL TOTRU (0.93±0.11 in both cases) and minimum OAC was found in IC 341960 and IC 341944 (0.67±0.28 in both cases). The sample code IC 341944 having bigger size seeds as compared with other variety. Similarly the small size seeds were found of LOCAL TOTRU. Other hand the sample code IC 341960, IC 341951 and HPU 51 shown the similar types of seed morphology. The data was shown in studied of 1000 seeds per species.

Keywords: Azuki bean, nutrients, physical and chemical nutraceutical

1. Introduction

In this day and age, millions of people still do not have enough food to eat, despite the fact that farming methods and yield improved dramatically over the last century. Majority of the population relies on a diet based on cereals such as wheat, rice and corn and they are not aware of food grains which are store house of macro and micro nutrients and underestimate. One such seeds are of Beans. Beans are members of the Fabaceae family, which include legumes and are important food crops both economically and nutritionally (Punia *et al*. 2020) [44].

Dried beans may supply to some of the health enhancing nutrients associated with plant based diets. Beans are important source of protein and are rich in number of micronutrients, including potassium, magnesium, folate, iron and zinc. Beans make an excellent source of protein for vegetarians and vegans. Vegetarians have important role of dried beans in their diets because it contributes to some of the health benefits.

Despite of their high nutritional quality people are not including beans in their diet because of unawareness Adzuki beans are one such bean that have many nutritious and medical properties but underestimated. Adzuki bean (*Vigna angularis*) is one such under-explored bean which needs to be explored for its possible food use. Adzuki bean is a traditional edible underutilized legume.

The crop of adzuki bean (*Vigna angularis* (Willd.) Ohwi & H. Ohashi) is widely cultivated in East Asian countries, mainly in China, Japan and Korea, where it has been cultivated for thousands of years. Adzuki bean is one of the high-value and popular food legumes like soybean and mung bean (Liu and Xu. 2016) [24].

"Adzuki" is Japanese word which means small due to its small shape it got Nameadzuki beans (Small beans). There are at least 60 varieties of adzuki beans, and they're grown in more than 30 countries of the world (Kramer *et al*. 2012) [19].

It is widely grown in the northeast and northern parts of China. In India its cultivation is confined to North- east and Northern hill zones. In Himachal Pradesh Azuki beens are grown in Sirmour, Chamba, Mandi and Kangra district (Shweta, 2013) [53]. You may know adzuki beans as azuki beans, aduki bean, red beans, or red mung beans. Like other types of beans and peas, they are part of the legume family (Gohara *et al*. 2016) [3]. Adzuki beans are available in many varieties around the world depending on grain size and color, harvest time, climate and region where it is cultivated. In Asiatic countries, variety of foods can be prepared by millions of people using adzuki beans (e.g., paste in pastries, desserts, cake, porridge, adzuki rice, jelly, adzuki milk, ice cream) (Lestari, 2014) [20].

Adzuki bean are small red beans that have an inherently sweet, nutty taste. Apart from their taste, Adzuki bean seed is an important source of protein, starch, mineral elements, and vitamins. Adzuki bean is referred to as the “weight loss bean” because of its low calorie and fat content, digestible protein and ample bioactive compounds (Kitano-Okada, 2012) [56]. Azuki bean have potential to fulfill human requirements by possess both nutraceutical and nutritional properties. However, adzuki’s global use for human consumption has been restrained partly due to limited knowledge about its nutrient composition and the processing challenges faced in making adzuki-based food products (Agarwal and Chauhan, 2019) [2] So, there is great scope for utilization of this grain for the development of processed and health food products. In this research paper physical characteristics, nutrient composition and finally, the potential health benefits that could be associated with higher consumption of adzuki are highlighted. To simplify and enhance the design of the machinery for harvesting, processing, and storing crops, knowledge of physical attributes is crucial. On the basis of physical qualities, several cleaning, grading, and separation operations are created. The size, shape, and density properties of the material have a significant impact on how many different types of machines operate. The potential of these materials in product development is efficiently utilised through the design of new processing equipment and the adaption of existing ones. According to Yalcin and Orzarslan (2004), the physical characteristics of food products are crucial in the modelling and computation of heat and mass transfer during basic food processing and freezing. Therefore, the physical characteristics of legumes must be taken into consideration when building machinery and facilities for tasks like harvesting, handling, conveying, separating, drying, aerating, storing, and mechanically extracting oil, among others. Functional qualities provide insight into how foods interact with other components of a system, either as a processing aid or as a direct contributor to product attributes.

During the preparation, processing, and storage of food, the majority of functional features have an impact on the sensory qualities of the food or food ingredients (Oyebode *et al*., 2007) [79]. Considering all of their useful qualities, legumes are frequently used in the food industry. In the creation of new industrial food products, functional qualities are crucial. According to Yalcin and Orzarslan (2004) and Oyebode *et al*. (2007) [79], they may be affected by factors including pH, proteinsource, lipid, drying processes, concentration, etc. Engineers, food scientists, and processors will benefit from several physical characteristics of these legumes, such as form, size, and specific gravity, in order to develop effective processes and machinery for clearing, sorting, and grading.

2. Materials and Methods

2.1 Samples and Sample Preparation

The Flour legumes seeds samples were: IC 341960, IC 341944, IC 341951, HPU 51, Local Totru. The legumes seeds were dry cleaned by removing particles such as stone, broken seeds, immature seeds and other unwanted materials.

2.2 Physical properties of Raw legume Seeds

2.2.1 Determination of seed weight

About 100 seeds of equivalent sizes were selected. One hundred seeds of comparable sizes were chosen. A chemical balance was used to carefully weigh and count the seeds. Ohaus Adventurer AR3130 (Idowu, 2005) [25].

2.2.2 Determination of seed size

One hundred seeds from the majority of each sample were chosen at random to ascertain the size of the seeds. Each of the 100 seeds was measured with a vernier calliper to 0.01 mm to determine the seed sizes in terms of the three linear dimensions: length, L, in millimetres; width, W, in millimetres; and thickness, T, in millimetres. (Mohsenin, 2007; Idowu, 2005) [26, 25].

2.2.3 Determination of Geometric Mean Diameter and Degree of Sphericity

Using the following mathematical relationships, the geometric mean diameter and degree of Sphericity of the seeds were calculated:

$$D_e = (LWT)^{1/3}$$

$$\varnothing = \frac{(LWT)^{1/3}}{L}$$

Where,
L =length, mm
W =width, mm
T = thichness, mm
(Mohsenin, 2007; Conskuner and Karababa, 2007) [26, 80].

2.2.4 Determination of Surface Area

Each of the legume seeds' surface area, SA, in cm^2, was calculated using the relationship provided by Conskuner and Karababa (2007) [80].

$$S_a = \tau D_{e2}$$

Where
SA= surface area
π = 3.142
De = geometric mean diameter

2.2.5 Bulk density

The technique was used to calculate the bulk density, as described by Eabekun and Ehieze (1997) [29]. A 50 g milled sample was placed in a graduated cylinder with a capacity of 100 ml. The bulk density was estimated as the weight per unit volume of the sample after the cylinder.

2.2.6 Determination of angle of repose

Common beans' flow-ability was evaluated using the angle of

repose, which is crucial for material handling machinery. Known precautions: an experiment was conducted using two cylindrical containers, one of which was hollow and was placed on top of the closed container. Samples of common beans were placed in each container. The hollow container was gradually taken away in an upward motion. instructions about how to get beans to spill out of the covered container of the conical shape's creation Koocheki *et al*. (2007) [30] and Bart-Plange *et al*. (2012) [31]. The apex elevation was measured, and the calculation of the repose angle ϕ trigonometry rule Bart-Plange *et al*. (2005) [32] was used. Previously used for category B cocoa beans and "Obatanpa" in Bart-Plange and Baryeh (2003) [33] and Bart-Plange *et al*. (2005) [32]. Respectively, a kind of maize depict the experimental setup for measuring the repose angle.
The angle of repose

$$\frac{\phi = \tan^{-1} te}{Adjacent} = \tan^{-1} hr$$

2.3. Functional properties of legume flour
2.3.1 Water Absorption Capacity (WAC)
The water absorbing capacity was calculated using the techniques used by Sosulski *et al*. in 2002 [34] and Onimawo *et al*. (2003) [35]. Twenty milliliters of water were combined with a 2 g sample of each bean, let to remain at room temperature for a while, distilled water, followed by 30 minutes of 2,000 xg centrifugation. The capacity to absorb water was then stated as a percentage of water taken up per gram of sample.

$$\%WAC = \frac{V2 - V1}{V2} \times 100$$

Where,
V1 = volume of water absorbed, $cm^3$and V2 = volume of water used, cm^3.

2.3.2 Oil Absorption Capacity (OAC)
Additionally, the oil absorption capability was calculated using the approach outlined by Onimawo and Sosulski in 2002 *et al*. (2003) [35]. The sample, weighing two grams, was combined with 20 milliliters of refined, known-specific gravity soybean oil. Following that, it was allowed to stand at room temperature for 30 minutes and then 2000 xg centrifuged for 30 minutes. Oil absorption capacity (OAC) was stated as a percentage of oil absorbed per gram of sample.

$$\%OAC = \frac{V2 - V1}{V2} \times 100$$

Where,
V1 = volume of oil absorbed, cm^3
V2 = volume of oil used, cm^3

2.3.3 Foaming Capacity (FC) and Foaming Stability (FS)
The foaming strength (FS) and capacity (FC) of the procedure outlined by was used to determine the samples. Onimawo *et al*. (2003) [35], and YUSUF & CO (2007). The sample was put in two grams. Fill a graduated 100-ml cylinder with 50 ml of distilled water. The suspension was then combined and agitated to create foam for five minutes. Following whipping for 30 seconds, the amount of foam was expressed using the following formula to calculate foaming capacity:

$$FC = \frac{V2 - V1}{V1}$$

Where,
V1 = volume of foam before whipping, cm3
V2 = volume of foam after whipping, cm3
One hour later, the foam was measured in volume, using whipping to calculate the percentage of foaming stability.

2.3.4 Hydration Capacity and Hydration Index
The legume's 100 seeds were counted and weighed. The seeds were then put into a measuring cylinder. A hundred milli litres of distilled water were added. An aluminium foil covering was then placed over the cylinder, and left to remain at room temperature for 12–18 hours. Decanting was used to collect the water, and with the help of a filter paper. Following that, the seeds were measured and the following parameters were calculated to determine hydration capacity:

$$HC = \frac{W2 - W1}{n} \left(\frac{g}{seed}\right)$$

Where,
W1 = weight of seeds before soaking
W2 = weight of seeds after soaking
n = number of seeds
The hydration index (HI) was calculated using the formula below:

$$HI = \frac{HC}{W}$$

Where,
HC = Hydration Capacity per seed
W = Weight of one seed (g)

2.4 Nutritional analyses
The Association of Official Analytical Chemists (AOAC, 2005) guidelines were followed while analysing the various flours for moisture, ash, crude proteincrude fat, crude fibre, and carbohydrate contents in triplicate. The flours were dried in an oven for three hours at 105 °C. The nitrogen content was calculated using factor 6.25, while the protein content was calculated using the Kjeldahl technique. The Soxhlet extraction technique was used to determine the fat content. The muffle furnace was used to measure the ash at 550°C for two hours. The flour sample was first digested with acid to determine the amount of crude fibre, and then it was rinsed with distilled water. The material was also alkali digested before being cleaned once more with distilled water. In a hot air oven, the residue was dried, and the amount of fibre was determined. According to Ranganna (1986), the formula for calculating the amount of carbohydrates is: [100 - (moisture + ash + protein + fat + fibre)]. The findings were given in weighted averages. The energy content was calculated using the Atwater factor, with each gramme of fat being multiplied by 9 kcal/g and each gramme of carbohydrate and protein being multiplied by 4 kcal/g.

3. Result and Discussion

3.1 Legume seed sample description

Each of the legume seed samples utilized for this investigation is depicted in a photograph on Plates 1 to 5 shown in figure 1. Table 1 listed the details information regarding these five different types of legumes. The weight of the each type of legumes is shown in the table for different types of legumes. As we can see that the sample code IC 341944 shown the heaviest seed per 1000 seeds and the lightest seed was found in LOCAL TOTRU.

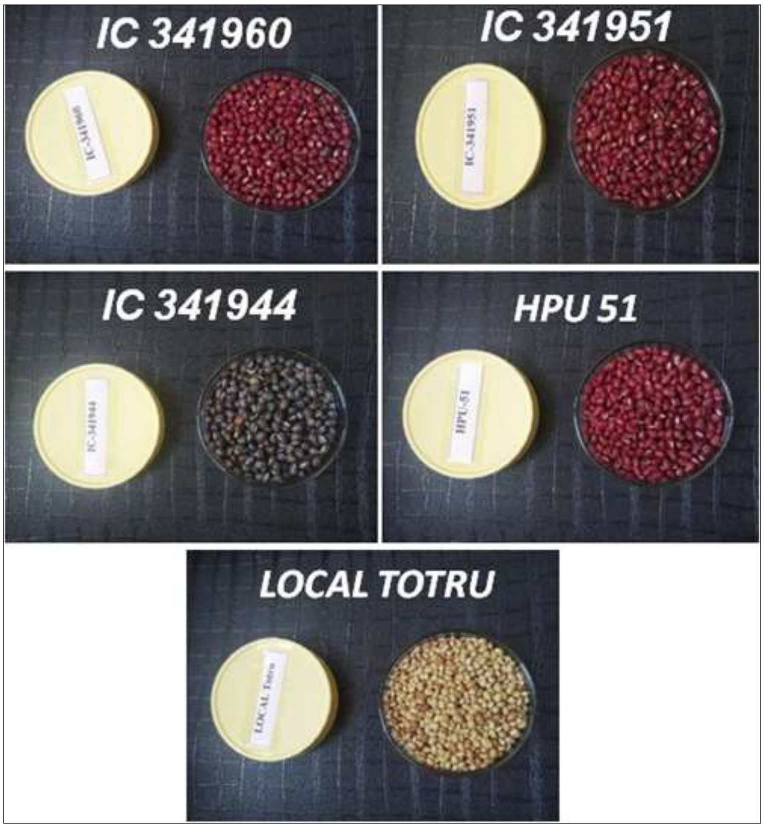

Table 1: Legume seed samples, sources of collection

S/N	Sample code	Local name	Source of collection	Mean weight (gm) per 1000 seeds
1	IC 341960	Adzuki beans	Kangra (HP)	81.67±1.527525232
2	IC 341944	Adzuki beans	Chamba (HP)	130.90±2.00748599
3	IC 341951	Adzuki beans	Chamba (HP)	73.27±0.642910051
4	HPU 51	Adzuki beans	Kangra (HP)	84.10±0.854400375
5	LOCAL TOTRU	Adzuki beans	Kangra (HP)	44.13±0.321455025

3.2.1. Seed Weights and Sizes

The seed weights and sizes are listed in Table 2 according to the three linear parameters of length, breadth, and thickness. From the results shown in table 2 we observed that the seed sizes are varied from different variety of Adzuki seeds. The sample code IC 341944 having bigger size seeds as compared with other variety. Similarly the small size seeds were found of LOCAL TOTRU. Other hand the sample code IC 341960, IC 341951 and HPU 51 shown the similar types of seed morphology. The data was shown in studied of 1000 seeds per species.

Table 2: The seed weights and sizes of selected under utilsed legumes

Sample code	Mean weight (gm) per 1000 seeds	Length(cm)	Width (cm)	Thickness (cm)
IC 341960	81.67±1.527525232	6.90±0.3	4.73±0.11547	4.33±0.1154701
IC 341944	130.90±2.00748599	7.53±0.472582	5.73±0.152753	5.30±0.3
IC 341951	73.27±0.642910051	6.57±0.288675	4.60±0.458258	4.23±0.4041452
HPU 51	84.10±0.854400375	6.67±0.416333	5.00±0.264575	4.67±0.4725816
LOCAL TOTRU	44.13±0.321455025	5.00±0.3	3.77±0.152753	3.37±0.1527525

Values are means of three replicates standard deviation; means with different letters in the same column are significantly different (p<0.05).

3.2.2. Other Physical Properties of the Legume Seeds

Table 3 presents the results of a study on the physical properties of legume seeds. These physical properties include the geometric mean, surface area, degree of Sphericity, and bulk density. In this context, each of these properties refers to a specific characteristic of the seeds that can be measured or calculated. The geometric mean is a measure of central tendency that is calculated by taking the nth root of the product of n numbers. In the context of this study, the geometric mean is used to describe the average size of the legume seeds. Specifically, it is calculated as the square root of the product of the length, width, and thickness of each seed. The surface area of a seed is the total area of its outer surface. This property is important because it can affect the rate at which water and nutrients are absorbed by the seed. In this study, the surface area of the legume seeds was measured using a specialized instrument called a surface area analyzer.

The degree of sphericity is a measure of how closely a seed resembles a perfect sphere. This property is important because it can affect the way in which the seed interacts with its environment, including how it rolls or moves through soil. In this study, the degree of sphericity of the legume seeds was calculated by comparing the surface area of the seed to that of a perfect sphere with the same volume. Finally, the bulk density of the seeds is a measure of their mass per unit volume. This property is important because it can affect the storage and transportation of the seeds. In this study, the bulk density of the legume seeds was measured by filling a container of known volume with a known mass of seeds and then calculating the mass per unit volume. Overall, the physical properties of legume seeds are important to understand because they can affect how the seeds grow and develop, as well as how they are stored and transported. By measuring and analyzing these properties, researchers can gain insight into the underlying mechanisms that govern seed growth and development, and develop better methods for producing and managing legume crops. From the data showed in table 3 we observed that the sample code IC 341944 showed the highest geometric mean diameter around 229±27.79 followed by HPU 51 (156.58±29.78) and then IC 341960 (141.40±3.25). The minimum geometric mean diameter was found in LOCAL TOTRU seeds. Similarly the surface area, degree of sphericity and bulky density was also observed maximum in legume sample of IC 341944 and minimum value observed in LOCAL TOTRU seed.

Table 3: Some physical properties of the legume seeds

Legume samples	Geometric mean diameter (mm)	Surface area(mm^2)	Degree of sphericity(mm)	Bulk density (g/cm3)
IC 341960	141.40±3.25	85.28±1.30	0.76±0.03	0.81±0.003
IC 341944	229.46±27.79	117.63±9.56	0.81±0.02	0.83±0.004
IC 341951	129.28±30.23	80.01±12.44	0.77±0.03	0.82±0.005
HPU 51	156.58±29.78	91.03±11.56	0.81±0.03	0.77±0.005
LOCAL TOTRU	63.43±5.98	49.94±3.11	0.80±0.02	0.85±0.005

Values are means standard deviation (n=3); means with different letters in the same column are significantly different (p<0.05).

Further we analyze some other physical properties of the legume seeds are listed in table 4. The results shown that some other physical properties such as true density, porosity, angle of repose, aspect ratio and mean diameters of the legume seeds of different variety.

True density: True density refers to the density of a material without any air pockets or voids. In the case of legume seeds, true density can be measured by determining the mass of a known volume of the seeds. The true density of legume seeds can be an important factor in determining their quality and suitability for different applications. We observed that the true density maximum observed in legume sample LOCAL TOTRU (1.23±0.03) and minimum was found in sample IC 341951 (1.05±0.06).

Porosity: Porosity is the measure of the void space in a material. In the case of legume seeds, porosity can be an important factor in determining their ability to absorb water and nutrients, as well as their susceptibility to spoilage. The highest porosity was observed in LOCAL TOTRU (54.09±5.39) and lowest was found in sample IC 341951 (26.96±9.04).

Angle of repose: The angle of repose is the maximum angle at which a material can be piled up without it collapsing. In the case of legume seeds, the angle of repose can be an important factor in determining their flow ability and ease of handling. The maximum angle of repose was found in sample IC 341951 (26.46±1.65) and minimum angle of repose was found in LOCAL TOTRU (21.81±1.35).

Aspect ratio: Aspect ratio refers to the ratio of the length of an object to its width. In the case of legume seeds, aspect ratio can be an important factor in determining their shape and size, which can impact their suitability for different applications. The aspect ratio was found maximum in IC 341944 and LOCAL TOTRU (0.76±0.05 and 0.76±0.02 respectively) and the minimum aspect ratio was observed in legume sample IC 341960 (0.69±0.03).

Mean diameters: The mean diameter of legume seeds can be an important factor in determining their size and shape, which can impact their suitability for different applications. The mean diameter is typically calculated as the average of the largest and smallest diameters of the seeds. From the result shown in table 4 we observed that the highest mean diameter was found in the legume sample IC 341944 (6.19±0.25 mm) and lowest diameter was found in LOCAL TOTRU (4.04±0.14 mm).

Overall, understanding these physical properties of legume seeds can be important for determining their suitability for different applications, such as food production, animal feed, or industrial uses.

Table 4: Some other physical properties of the legume seeds

Legume samples	True density	Porosity	Angle of repose	Aspect ratio	Mean diameters (mm)
IC 341960	1.12±0.02	39.91±2.39	27.72±1.26	0.69±0.03	5.32±0.07
IC 341944	1.13±0.03	38.94±4.90	23.59±0.47	0.76±0.05	6.19±0.25
IC 341951	1.05±0.06	26.96±9.04	26.46±1.65	0.70±0.04	5.13±0.36
HPU 51	1.17±0.07	51.48±10.98	23.25±2.59	0.75±0.04	5.45±0.33
LOCAL TOTRU	1.23±0.03	54.09±5.39	21.81±1.35	0.76±0.02	4.04±0.14

Values are means standard deviation (n=3); means with different letters in the same column are significantly different (p<0.05).

3.3 Functional Properties

3.3.1 Water and Oil Absorption Capacity

Water and oil adsorption capacity refers to the ability of a material to attract and hold water or oil molecules on its surface. This property is important in many applications, such as water treatment, oil spill cleanup, and food processing. Table 5 presents the information regarding the water and oil adsorption capacity of various legumes that were utilized in the current study. We have also listed the other functional properties of these legume seeds. The maximum WAC in % was found in legume sample LOCAL TOTRU (1.60±2.72) and minimum was observed in HPU 51 (1.03±0.05). Next the OAC in % highest OAC was observed in IC 341951 and Local TOTRU (0.93±0.11 in both cases) and minimum OAC was found in IC 341960 and IC 341944 (0.67±0.28 in both cases). The adsorption capacity of a material for water or oil depends on its surface properties, such as surface area, porosity, and chemical composition. Materials with high surface area and porosity have more sites available for water or oil molecules to adsorb onto, resulting in higher adsorption capacity. In addition, the chemical composition of the material can also affect its adsorption capacity. For example, materials with hydrophobic (water-repelling) properties will have a higher adsorption capacity for oil than for water, while materials with hydrophilic (water-attracting) properties will have a higher adsorption capacity for water than for oil. To measure the adsorption capacity of a material, various methods are used, including gravimetric analysis, which involves weighing the material before and after exposure to the water or oil, and spectroscopic techniques, which measure changes in the material's surface properties before and after exposure. The adsorption capacity of a material is an important consideration when selecting a material for a particular application. For example, in oil spill cleanup, materials with high oil adsorption capacity are preferred, while in water treatment, materials with high water adsorption capacity are preferred.

Table 5: Functional properties of the selected underutilized legumes

Functional Analysis (%)	WAC (%)	OAC (%)	HC (g/seed)	HI (per Seed)	SC (per seed)	SI
IC 341960	1.23±0.05	0.67±0.28	0.05±0.00	0.54±0.02	0.04±0.00	0.50±0.01
IC 341944	1.13±0.15	0.67±0.28	0.08±0.00	0.79±0.00	0.05±0.00	0.55±0.02
IC 341951	1.07±0.11	0.93±0.11	0.08±0.00	0.80±0.01	0.07±0.00	0.78±0.01
HPU 51	1.03±0.05	0.77±0.05	0.07±0.00	0.67±0.03	0.08±0.00	1.00±0.01
LOCAL TOTRU	1.60±2.72	0.93±0.11	0.08±0.00	0.95±0.00	0.08±0.00	1.33±0.02

Values are means of three replicates and standard deviation; means with different letters in the same column are significantly different (p <0.05).WAC=water absorption capacity; OAC=oil absorption capacity; HC= hydration capacity; HI= hydration index; SC= swelling capacity and SI=. Swelling index.

3.3.2 Nutritional and Functional properties of different types of flours

Legume flours are a good source of protein, dietary fiber, and complex carbohydrates, while containing low levels of fat (Table 6). Proteins found in legume flours are considered to be of high quality because they contain all essential amino acids required by the human body. Legumes also contain a significant amount of dietary fiber, which is beneficial for digestive health and can help lower cholesterol levels. Additionally, legume flours are rich in complex carbohydrates, which are a good source of sustained energy and can help regulate blood sugar levels.

Legume flours have several functional properties that make them useful in various food applications. One of the most significant functional properties of legume flours is their ability to gelatinize, meaning they can form gels when heated in water. This property makes legume flours useful as thickeners and stabilizers in food products such as soups, sauces, and gravies. Legume flours also have emulsification properties, meaning they can help mix and stabilize oil and water-based ingredients. This property makes legume flours useful as emulsifiers in food products such as salad dressings and sauces. In addition, legume flours have water-holding capacity, meaning they can absorb and hold water. This property makes legume flours useful as binding agents in food products such as burgers, meatballs, and sausages. Lastly, legume flours have been found to have antioxidant properties due to their high content of phenolic compounds. These compounds can help protect against oxidative damage caused by free radicals and may have potential health benefits. In conclusion, legume flours are a nutritious and versatile ingredient with several functional properties that make them useful in a variety of food applications. Incorporating legume flours into the diet can provide health benefits and add diversity to the diet.

Table 6: Nutritional and Functional properties of different types of flours

Nutritional Analysis (%)	Moisture	Ash	Protein	Fat	Fibre
IC 341960	5.92±0.08	3.83±0.58	29.76±10.93	2.77±1.44	4.73±0.10
IC 341944	7.31±0.17	3.67±0.32	27.43±5.05	0.89±0.37	3.58±0.15
IC 341951	6.93±0.30	3.70±0.18	34.43±2.20	0.95±0.74	4.19±0.12
HPU 51	6.99±0.13	4.13±0.50	32.10±2.02	0.55±0.22	4.89±0.02
LOCAL TOTRU	7.19±0.03	4.03±0.45	27.14±0.87	1.23±0.82	4.07±0.01

4. Conclusion

This study provided basic information on the composition and physical parameters of five bean varieties. The white variety has the best characteristics (physical and physicochemical) and a reduced cooking time (45 min). Proteins, ash and fibers contents of both varieties present no significant difference (p <0.05). The mineral content differs significantly from one variety to another and the most dominant are potassium, phosphorus and calcium. The research results can be used by investigators and food businesses to develop recipes for processed bean foods, including fortified products.

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