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# Physicochemical and functional properties of whole legume flour

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ABSTRACT

The physicochemical, functional and pasting properties of whole flours from pinto bean, lima bean, red kidney bean, black bean, navy bean, small red bean, black eye bean, mung bean, lentil and chickpea were investigated. Significant differences in physicochemical characteristics and functional properties were observed ($P < 0.05$). Bulk densities, water absorption indices, water solubility indices, oil absorption capacities, emulsion activities, and emulsion stabilities ranged from 0.543 g/mL to 0.816 g/mL, 4.09 g/g to 6.13 g/g, 19.44 g/100 g to 29.14 g/100 g, 0.93 g/g to 1.38 g/g, 61.14%–92.20%, and 84.15%–96.90%, respectively. *Phaseolus* legume flour exhibited higher water absorption capacity, oil absorption capacity, emulsion activity, and emulsion stability compared with other kinds of legume flour. Pasting properties were significantly different ($P < 0.05$). Pasting temperatures and the peak, final, and setback viscosities of the flours ranged from 73.2 °C to 83.0 °C, 96.2 RVU to 216.8 RVU, 118.5 RVU to 243.8 RVU, and 28.3 RVU to 103.2 RVU, respectively.



## 1. Introduction

Legumes are dicotyledonous seeds of plants with approximately 17,600 species in about 690 genera that belong to the family of *Leguminosae*. Edible legumes include soybean, faba bean, pea, mung bean, small red bean, cowpea, kidney bean, hyacinth bean, and pigeon bean, among others. The annual production of legumes ranks the fifth in the world after wheat, rice, maize, and barley (Hoover, Li, Hynes, & Senanayake, 1997). China is very rich in leguminous plants and statistical data indicates the cultivation of more than 20 types of legumes. These leguminous plants are well known in the planting history of China. More of them have a wide range of adaptabilities and thus, are planted nearly all over the country. Currently, faba bean, pea, mung bean, small red bean, and black eye pea are the main leguminous plants grown in China. Mung bean is one of the main leguminous crops planted for food in Asia (Srinives &Yang, 1993, chap. 2).

Legumes are food resources that offer various health benefits. They are sources of complex carbohydrates, proteins, and dietary fiber, as well as significant amounts of vitamins and minerals (Morrow, 1991; Tharanathan & Mahadevamma, 2003). The protein content of legume grains range from 17 g/100 g to 40 g/100 g, much higher than that in cereals (7–3 g/100 g) and approximately equal to the protein content of meat (18–25 g/100 g)(De Almeida Costa, Da Silva Queiroz-Monici, Pissini Machado Reis, & De Oliveira, 2006). In developing countries, legumes are the second largest sources of human food after cereal, particularly for those low-income ones. They are used to enrich the diversity in human foods and provide a cheap source of protein in developing countries (Kaur, Singh, Sodhi, & Rana, 2009).

Health problems such as hypertension, gall-stone which are related to meat consumption have raised great social attention recently. Thus, leguminous has been found to play an important role in several favorable physiological responses, such as reducing heart and kidney diseases, lowering the sugar indices of diabetic patients, increasing in satiety, and reducing the occurrence of cancer (Mathres, 2002). In recent years, dried beans have regained their previous roles as food sources in developed countries (Kaur et al., 2009). Whole flour or the partial use of different legumes has attracted increasing research interest. Studying their functional properties is important to efficiently utilize the flours produced from legumes and helps consumers easily accept them. Previous studies have mainly focused on the functional properties of flour from legumes that are commonly planted in developed countries, and studies on legumes as food products have continued (Chau, Cheung, & Wong, 1997). The crude proteins and starch content of 1696 germplasm accessions of nine Chinese legumes (i.e., faba bean, pea, mung bean, adzuki bean, cowpea, kidney bean, rice bean, pigeon bean, and chickpea) average 25.93 g/100 g and 45.11 g/

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100 g, respectively; their starch contents are far lower than that of soybean and significantly higher than those of wheat, corn, barley, and millet (Zhu et al., 2005). Functional properties significantly affect the processing of legumes. Currently, legume flour has been used as a food ingredient due to its functional properties for its high protein content (Kaur, Sandhu, & Singh, 2007; Kaur et al., 2009). Damodaran (1990) suggested that the functionality of proteins is closely related to their physical and chemical properties, such as molecular weight, amino acid composition and sequence, structure, surface electrostatic charge, and effective hydrophobicity, and affected by some food ingredients, including water, salts, proteins, sugars, and fats, as well as processing methods. Kaur and Singh (2005) investigated the functionality of chickpea and revealed that in addition to proteins, the complex carbohydrates of legumes, such as starch, fibers, and other components (e.g., pectins and mucilages), contribute to their functionality.

For efficient utilization and consumer acceptance of legume seed flours, a study of their functional properties is necessary (Adebowale & Lawal, 2004). The successful performance of legume flour as a food ingredient depends on the functional characteristics, such as foaming, emulsification, gelation, water and oil absorption capacities, and viscosity that they contribute to the end product (Adebowale & Lawal, 2004). Several investigators have studied the functional properties of lima bean, mung bean, chickpea, and field pea flours (Chel-Guerrero, Pérez-Flores, Betancur-Ancona, & Dávila-Ortiz, 2002; Kaur & Singh, 2005; Singh, Kaur, Rana, & Sharma, 2010). Adebowale and Lawal (2004) reported a comparative study on the functional properties of bambarra groundnut, jack bean, and mucuna bean flour (Adebowale & Lawal, 2004). Onimawo and Asugo (2004) studied the nutrient content and functional properties of pigeon pea flour. In these reports, the tested legume flour was usually prepared after removing kernel skin and lipids. There were no reports on the properties of whole legume flour up to now. More important, great diversity has been found in the functional properties of legume flours derived from different varieties. Diversity was supposed to be in the properties of different whole legume flours. However, few studies have focused on the comparison of properties among different kinds of whole legume flour.

Therefore, the present study is aimed to investigate and compare the physicochemical, functional, and pasting properties of whole flours derived from ten different legume varieties and thus provides useful information on the effective utilization of these legume varieties in food processing.

## 2. Materials and methods

### 2.1. Materials

Ten commercial legume seeds, pinto bean (*Phaseolus vulgaris* L.), lima bean (*Phaseolus vulgaris* L.), red kidney bean (*Phaseolus vulgaris* L.), black bean (*Phaseolus vulgaris* L.), navy bean (*Phaseolus vulgaris* L.), small red bean (*Vigna umbellata* L.), black eye bean (*Vigna sinensis* S.), mung bean (*Vigna radiate* L.), lentil (*Lens culinaris* M.) and chickpea (*Cicer arietinum* L.), were purchased from a local supermarket. All of the seeds were air dried at 25 °C and ground into small size that can pass through sieve no. 72 (British Sieve Standards).

### 2.2. Proximate composition of legume flour

Flour samples from different legume cultivars were estimated for their moisture, ash, fat, and protein ($N \times 6.25$) contents by employing the standard methods of analysis (AOAC, 2003). Total starch contents were determined using the Total Starch Kit (Megazyme Co., Wicklow, Ireland).

### 2.3. Physicochemical properties

#### 2.3.1. Water absorption index and water solubility index

The water absorption index (WAI) and water solubility index (WSI) of the legume flours were determined by referring to the method reported by Kaur and Singh (2005) with slight modification. A legume flour sample (2.5 g) was dissolved in 30 mL distilled water and cooked in water bath at 70 °C for 30 min. Then the cooked paste was cooled to room temperature, transferred to pre-weighed centrifuge tubes, and centrifuged at 3000 g for 20 min. The supernatant was decanted into a pre-weighed evaporating dish to determine its solid content and the sediment was weighed. The weight of dry solids was recovered by evaporating the supernatant overnight at 105 °C. WAI and WSI were calculated using the following equations:

$$\text{WAI}\ (g/g) = \frac{\text{Weight of sediment}}{\text{Weight of flour sample}}$$

$$\text{WSI}\ (g/100\,g) = \frac{\text{Weight of dissolved solids in supernatant} \times 100}{\text{Weight of flour sample}}$$

#### 2.3.2. Bulk density

Flour samples were gently transferred into 10 mL graduated cylinders that were previously weighed. The bottom of the cylinder was gently tapped on a laboratory bench several times until no further diminution of the sample level was observed after it was filled up to the 10 mL mark. Bulk density is defined as the weight of the sample per unit volume of the sample (g/mL). Measurements were made in triplicate.

### 2.4. Functional properties

#### 2.4.1. Water and oil absorption

Water absorption of legume flours was measured by the centrifugation method reported by Kaur and Singh (2005). For water absorption, samples (3.0 g) were dissolved in 25 mL of distilled water and placed in 50 mL pre-weighed centrifuge tubes. The mixtures were stirred at 5 min intervals and held for 30 min, followed by centrifugation for 30 min at 3000 g. The supernatant was decanted, the excess moisture was removed by draining for 25 min at 50 °C, and the sample was reweighed. For oil absorption, the method of Kaur and Singh (2005) was used. Samples (2.5 g) were mixed with 30 mL peanut oil in pre-weighed centrifuge tubes and stirred for 1 min. After a holding period of 30 min, the tubes were centrifuged at 3000 g for 30 min. The oil was then removed with a pipette when it formed a separate layer; the tubes were inverted for 25 min to drain the oil prior to reweighing. Triplicate determinations were carried out and the water and oil absorption