Food Chemistry 117 (2009) 282–289

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Diversity in properties of seed and flour of kidney bean germplasm

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ARTICLE INFO

Article history:
Received 25 September 2008
Received in revised form 31 March 2009
Accepted 1 April 2009

Keywords:
Kidney bean
Flour
Physicochemical
Pasting
Texture

ABSTRACT

The genetic diversity in seeds (physicochemical, hydration, textural and cooking properties) and flours (pasting and gel texture) among kidney bean lines was studied. A wide range of variation was observed for yield and yield-related traits. Seed weight, volume, density, hydration capacity, hydration index, swelling capacity, cooking time and amylose content ranged from 10.2 to 51.7 g/100 seeds, 14 to 46 ml/100 seeds, 0.51 to 2.15 g/ml, 0.03 to 0.62 g/seed, 0.16 to 0.97, 1.24 to 1.93 ml/seed, 50 to 120 min, and 0.09% to 5.02%, respectively. Hardness, cohesiveness, gumminess, springiness and chewiness of hydrated seeds ranged from 0.81 to 2.03 g, 0.18 to 0.48, 0.20 to 0.97 g, 0.31 to 0.51 and 0.08 to 0.43 g, respectively. Pasting temperature, peak viscosity, breakdown, final viscosity and setback ranged from 79 to 95 °C, 402 to 3235 cP, 9 to 393 cP, 862 to 5311 cP, and 363 to 2488 cP, respectively. Hardness, cohesiveness, gumminess, springiness, chewiness and adhesiveness of flour gels ranged from 3.9 to 5.3 g, 0.52 to 0.76, 1.47 to 23.52 g, 0.91 to 0.99, 3.21 to 23.91 and 13.2 to 178.5 g s, respectively.

1. Introduction

Legumes are the edible fruits or seeds of pod-bearing plants belonging to the order *Leguminosae* and are widely grown throughout the world. Legumes have been considered as the most significant food source for people of low incomes (Bressani & Elias, 1979). Legumes have a high food value and store well, play an important role in the diet of most of the people of the world, being second only to cereals as a source of human and animal food (Singh, Kaur, Sandhu, & Sodhi, 2004). Legumes not only add variety to the human diet, but also serve as an economical source of supplementary proteins for the large human populations in developing countries, such as India, where the majority of the population is vegetarian (Kaur & Singh, 2007b). In general, legumes are sources of complex carbohydrate, protein and dietary fibre, having significant amounts of vitamins and minerals, and high energetic value (Tharanathan & Mahadevamma, 2003). Legumes are generally soaked before cooking to ensure uniform expansion of the seed coat and cotyledon and to ensure their tenderness (Hoff & Nelson, 1965). Kidney bean (*Phaseolus vulgaris* L.) is the most widely produced and consumed food legume in Africa, India, Latin America and Mexico (FAO, 2002). This bean usually contains 20–30% protein on a dry basis, and the protein has a good amino acid composition but is low in sulphur-containing amino acids (notably methionine) and tryptophan (Gueguen & Cerletti, 1994; Sathe, 2002). Dry beans have recovered prestige in the diets of developed countries. This is due, in part, to health problems related to meat consumption, as well as the discovery of the benefits of legumes in the diet and the protection they afford against colon disease (Champ, 2001; Hangen & Bennink, 2003; Lee, Prosky, & DeVries, 1992; Mathres, 2002). Kidney beans have numerous health benefits, e.g., they reduce heart and renal disease risks, lower glycaemic index for persons with diabetes, increase satiation, and prevent cancer. Furthermore, kidney beans are regarded as an important source of protein and minerals for livestock feed production, as well as potential raw materials for processing into human food (Shimelis & Rakshit, 2007). A wide variation in chemical, thermal, pasting and textural properties of seeds, flour and starches of black gram and chickpea lines has been reported previously (Singh et al., 2004; Kaur & Singh 2005).

The objectives of the present investigation were to evaluate (i) physicochemical, hydration and textural properties of seeds from different kidney bean germplasm lines, (ii) composition, pasting and textural properties of flours and (iii) relationship between different properties of seeds and flours.

2. Materials and methods

2.1. Materials

The seed material for the present experiment comprised 50 diverse germplasm accessions (36 exotic and 14 indigenous) of kidney bean, namely EC18639, EC28758, EC45816, EC57004, EC116177, EC398501, EC398523, EC398548, EC405199, EC405179, EC405203, EC405213, EC405230, EC493713, EC498445, EC506078, EC530944,

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doi:10.1016/j.foodchem.2009.04.002

EC530952, EC530955, EC530966, EC530968, EC530969, EC530974, EC530977, EC530978, EC530991, EC530993, EC530996, EC540796, IC11660, IC199223, IC202271, IC262749, IC278582, IC313249, IC313257, IC341755, NC2162, NC58584, PI163833, PI197967, PI204719, PI240554, PI301808, PI312296, PI339501, PLB10-1, Laxmi, Vaspa and Triloki, which were grown at the Regional Station of the National Bureau of Plant Genetic Resources (NBPGR) located in Phagli area of Shimla at latitude of 31°.06′N and longitude of 77°.10′E in the year 2006–2007. The lines for quality analysis of seed and flour were selected on the basis of genetic variability observed for various characteristics but primarily for seed size and colour. The agroclimatic conditions of the area where crop was grown: rainfall (1350 mm), topography (submountainous) and temperature (14 °C), soils are shallow to moderately shallow, having loam to clay loam texture with varying proportions of gravel.

2.2. Seed weight

Seed weight was determined in triplicate. Kidney bean grains were randomly selected and 50 kernels of kidney bean grains were counted. The counted grains were then weighed and expressed in grams.

2.3. Seed volume

Seed volume was determined in triplicate (Williams et al., 1983). Fifty seeds were transferred to a 50-ml measuring cylinder and 25 ml distiled water were added. The difference in the volume was noted down and divided by 50 to calculate the volume per seed.

2.4. Bulk density

Kidney bean grains were gently added to a 100-ml graduated cylinder, previously tared. The bottom of the cylinder was gently tapped on a laboratory bench, several times, until there was no further diminution of the sample level after filling to the 100 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/ml). All the measurements were in triplicate.

2.5. Hydration capacity

Fifty seeds were transferred to a 125-ml Erlenmeyer flask and water was added to 100 ml. The flask was lightly stoppered and left overnight at room temperature. Next day the grains were drained, superfluous water was removed with absorbent paper and the swollen seeds were reweighed. Hydration capacity per seed was recorded as:

$$(\text{weight after soaking} - \text{weight before soaking})/50.$$

2.6. Hydration index

Hydration index was calculated as:

$$\text{hydration capacity per seed}/\text{weight of one seed}(g)$$

2.7. Swelling capacity

Swelling capacity was calculated by reweighing the soaked seeds. Seeds were transferred to a 100-ml measuring cylinder and 50 ml water were added. Swelling capacity per seed was recorded as:

$$\frac{\text{volume after soaking} - \text{volume before soaking}}{50}$$

2.8. Swelling index

Swelling index was calculated as swelling capacity per seed/volume of one seed (ml).

2.9. Textural properties of soaked seeds

Texture profile analysis (TPA) of soaked kidney bean lines was performed on a single soaked grain from each variety, using a TA/XT texture analyser (Stable Microsystems, Crawley, UK). The grain was subjected to 75% compression with a probe (P/75) at a speed of 1 mm/s. The textural parameters of hardness (maximum height of the force peak on the first compression cycle), springiness (ratio of the time elapsing between the end of first bite and the start of second bite), cohesiveness (ratio of the positive force areas under the first and second compressions), gumminess (product of hardness and cohesiveness) and chewiness (product of gumminess and springiness) were determined. Twenty repeated measurements were performed on each sample.

2.10. Cooking time

For the determination of cooking time, about 250 ml distiled water were brought to boiling point in a 500-ml beaker fitted with condenser to avoid evaporation losses during boiling and then 25 g seed was added. Boiling was continued, and boiled seeds at intervals of 2 min were drawn and tested for their softness by pressing between the forefinger and thumb. The time taken to achieve the desirable softness was recorded as the cooking time of the sample.

2.11. Preparation of kidney bean flour

About 30 g of seeds from different legume lines were ground to pass through sieve No. 72 (BIS) to obtain flour, which was packed in airtight containers.

2.12. Proximate composition

Flour samples were evaluated for their moisture, ash, fat and protein (% $N \times 6.25$) contents by employing standard methods of analysis (AOAC, 1990). Studies were conducted in triplicate.

2.13. Amylose (%)

Amylose content of the isolated starch was determined by using the method of William, Kuzina, and Hlynka (1970). A starch sample (20 mg) was taken and 10 ml of 0.5 N KOH were added to it. The suspension was thoroughly mixed. The dispersed sample was transferred to a 100 ml volumetric flask and diluted to the mark with distiled water. An aliquot of test starch solution (10 ml) was pipetted into a 50-ml volumetric flask and 5 ml of 0.1 N HCl were added, followed by 0.5 ml of iodine reagent. The volume was diluted to 50 ml and the absorbance was measured at 625 nm. The measurement of the amylose was determined from a standard curve developed using amylose and amylopectin blends.

2.14. Pasting properties of kidney bean flours

Pasting properties of legume flour gels were evaluated using Rapid Visco Analyzer (RVA4, Newport Scientific Pvt. Ltd., Warriewood, Australia) from different legume lines. Viscosity profiles of flours were recorded using flour suspensions (29 g total weight). The temperature–time conditions included a heating step from 50 to 95 °C at 6 °C/min (after an equilibration time of 1 min at 50 °C), a holding phase at 95 °C for 5 min, a cooling step from 95 to 50 °C at 6 °C/min and a holding phase at 50 °C for 2 min. A typical RVA curve for