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Effect of canning on color, protein and phenolic profile of grains from kidney bean, field pea and chickpea

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ABSTRACT

The aim of the present study was to evaluate the effect of canning on color, protein and phenolic profile of grains of kidney bean, field pea and chickpea varieties/accession. Color of grains of different pulses was enhanced after canning. Grains L^* (lightness) decreased while a^* (redness to yellowness) and b^* (greenness to blueness) increased after canning in all the pulses. Protein profiling of grains of different pulses after canning revealed that kidney bean and chickpea, respectively, had the least and the most thermally susceptible polypeptides. Kidney bean and chickpea showed higher Percentage washed drained weight (PWDW) than field pea. Pulse with more grain hardness and PWDW showed higher degree of grain splitting during canning. Grain splitting was also higher in dark colored accessions/varieties as compared to the light colored. Ferulic acid was the most predominant compound present in raw grains of different pulses. Raw kidney bean grains showed higher accumulation of catechin, chlorogenic, protocatechuic acid, p-coumaric acid and ferulic acid than those of chickpea and field pea. Canning caused reduction in all the phenolic compounds except gallic acid and most prominent effect of canning on protocatechuic acid, chlorogenic and ferulic acid was observed.

1. Introduction

Canned beans have distinctive color, convenient to use and provide high consumer value (Uebersax, 2006). Bean varieties having ease of preparation, processing efficiency and high yield of raw product were preferred by the processors (Wassimi, Hosfield, & Uebersax, 1990; Hosfield, Uebersax, & Occena, 2000). The common bean (*Phaseolus vulgaris*) is the important legume consumed in most of the countries including South America, Central America, East Africa and Central Africa where animal protein is less available (Shellie-Dessert & Bliss, 1991). Chickpea being the 3rd most important legume in the world represents 14% of the total world production (Kelley, Parthasarathy Rao, & Grisko-Kelley, 2000). Kabuli chickpea are commonly used for canning, boiling and roasting while desi varieties are used in dhal or ground to flour.

Water uptake is the important attribute used in canning. Beans were soaked to hydrate them and blanched using hot water. Soaking reduces anti-nutrient content as well as the time necessary for proper cooking (Gathu, Karuri, & Njage, 2012). Bean varieties with uniform and rapid grain expansion during soaking, high water holding capacity during processing and less splitting are desirable with the processors (Hosfield, 1991). Hosfield et al. (2000) reported that uncooked grains were increased to 80% in weight during soaking and moisture content was increased to 53–57%. Various genetic and environmental factors and their possible interactions affect the cooking time of the grains (Hosfield & Varner, 1984; Ghaderi, Hosfield, Adams, & Uebersax, 1984).

Acceptability of the canned beans may vary from person to person and it is the most desirable characteristic in relation to canning. Consumers are mostly concerned about the texture, firmness and visual appearance including color development in canned beans (Wassimi et al., 1990). Canned bean are of high interest as they are ready to use and the demand is expected to increase they are having high shelf life (Warsame & Kimani, 2014). High cost of losses experienced in industrial canning procedure is the major challenge for the producers which can be reduced by evaluating the canning quality of bean cultivars at a micro level so as to restrict the release of cultivar having poor canning properties (Balasubramanian, Slinkard, Tyler, & Vandenberg, 2000; Van Der Merwe, Osthoff, & Pretorius, 2006). The aim of the study was to evaluate the effect of canning on color, protein and phenolic profile of grains from kidney bean, field pea and chickpea varieties/accession.

2. Materials and methods

2.1. Materials

Kidney bean varieties and Field pea accession were procured from Regional Centre, National Bureau of Plant Genetic Resources, Phagli, Shimla, and Chickpea varieties were obtained from PAU, Ludhiana for the current study. The grains were cleaned for removing the foreign materials and debris. They were then stored in airtight boxes until use.

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2.2. Grain characteristics

Grains form different legume accessions/varieties were randomly selected and seed weight seed volume and bulk density were determined according to the method explained by Kaur, Singh, Sodhi, and Rana (2009).

2.3. Color characteristics

Color measurements (L^*, a^* & b^*) of the cleaned grains from different pulse accession/varieties were carried out using a Ultra Scan VIS Hunter Lab (Hunter Associates Laboratory Inc., Reston, VA, U.S.A.). The L^* is for lightness, the a^* is for redness-greenness, and the b^* is for yellowish-bluish. The color values were measured for both raw and canned grains. The total color differences (ΔE) was also calculated on the basis of color change in canned grains (ΔL^*, Δa^* and Δb^*) as explained by Good, 2002:

$$\Delta E = \sqrt{(\Delta L*)^2 + (\Delta a*)^2 + (\Delta b*)^2}$$

2.4. Hydration and swelling characteristics

Hydration and swelling characteristics of grains were evaluated by the method described by Williams, Nakul, and Singh (1983).

2.5. Cooking time

Cooking time of different pulse accessions/varieties was determined. For the determination of cooking time, about 250 mL distilled water was 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 grains were drawn at intervals of 2 min for testing 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.

2.6. Canning procedure

Canning was done by using modification to the method given by Nleya, Arganosa, Vandenberg, and Tyler (2002). Beans were soaked at 25 °C for 12 h, blanched at 85 °C for 30 min in brine containing 1.3% NaCl and 1.6% sugar. Blanched grains were canned and processed at 121 °C for 14 min. The processed cans were stored at room temperature for 2 weeks prior to evaluation.

2.7. Canning quality evaluation

2.7.1. Hydration capacity (HC)

HC was measured as the ratio of mass of soaked grains to the mass of dry grains (Van Der Merwe et al., 2006). It is represented as

$$\text{HC} = \text{mass of soaked grains (g)}/\text{mass of dry grains}$$

2.7.2. Percentage washed drained weight (PWDW)

Grains were transferred to 8-mesh screen placed at a 15° angle and rinsed with distilled water. It was then allowed to drain for 5 min (Uebersax & Hosfield, 1985). The PWDW was calculated as described by Nleya et al. (2002).

$$\text{PWDW} = [\text{washed drained weight (g)}/\text{weight of can content (g)}] * 100$$

2.8. Texture profile analysis of canned grains

Texture profile analysis (TPA) of canned grains was done using TA/XT texture analyzer (Stable Microsystems, Crawley, UK) on a single canned grain from each variety/accession. The grains were subjected to 75% compression with a probe (P/75) at a speed of 1 mm/s. The textural parameters such as hardness, springiness, cohesiveness and chewiness were recorded. Ten replicates for each sample were recorded.

2.9. Sensory/visual evaluation of canned grains

Sensory/visual analysis of canned grains was done as described by Lu and Chang (1996) with slight modifications. Texture (on the basis of cohesiveness/clumping), taste, splitting, overall acceptance and color of canned beans were measured by a visual rating procedure and sensory evaluation. A 9-point scale was used for the attributes of canned beans: texture (1 = no clumping, 9 = extremely clumped); taste (1 = bad taste, 9 = great taste); splitting (1 = no splitting, 9 = extremely split); overall accepted (1 = poorly acceptance, 9 = highly accepted); color (1 = poor color development, 9 = high color development).

2.10. SDS-PAGE

SDS-PAGE (Sodium dodecyl sulfate polyacrylamide gel electrophoresis) analysis of canned grain proteins was carried out according to modified method of Laemmli (1970). Resolving gel of pore size 11.25% and stacking gel of pore 5% size were prepared for separation of proteins. 80 μg of total proteins solution was mixed in equal volume of 2× Laemmli buffer [100 mM Tris buffer (pH 6.8); 4% SDS; 2% β-mercaptoethanol; 20% glycerol; 0.04% bromophenol blue] and heat denatured for 5 min at 95 °C followed by incubation for 2 min at 4 °C. After filling the upper and lower tanks with Tris-glycine-SDS running buffer (25 mM Tris buffer; 250 mM glycine; 0.1% SDS), heat denatured protein samples were loaded on to the wells. The electrophoresis was carried out at 35 mA constant current followed by staining of proteins with Coomassie brilliant blue R250 dye (50% methanol; 10% glacial acetic acid; 0.2% w/v CBBR-250). Stained gels were destained by using destaining solution (20% methanol and 12% glacial acetic acid) followed documentation by using HP Scanjet 4010 scanner at 600 dots per inch resolution.

2.11. Extraction of phenolic compounds

Canned grains were freeze dried, ground and passed through 60 mesh sieve to get uniform particle size. Extraction of phenolic acids from ground samples before and after canning was done by using the method of Ross, Beta, and Arntfield (2009) and Luthria and Pastor-Corrales (2006) with slight modifications. The ground samples were treated with methanol containing 10% acetic acid. The mixture was sonicated and the volume of the extract was adjusted to 10 mL. This was used for hydrolysis with base. Ten millilitres of distilled water and 5 mL of 10 M NaOH with 2% ascorbic acid were added to the extract. The mixture was stirred overnight at ambient temperature. The pH of the extract was adjusted to 2. The liberated phenolic acids were extracted with 15 mL of diethyl ether-ethyl acetate. The DE/EA organic layer containing the phenolic acids liberated from base hydrolysis was collected by pipetting off the upper organic (supernatant) layer from the bottom aqueous residue layer. The DE/EA organic layers (supernatants) were combined and the combined DE/EA layer was evaporated to dryness under rotary vacuum.

2.12. HPLC assay

Phenolic content was quantified using high performance liquid chromatogram of Agilent technologies (1260 infinity) at wavelength