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Functional properties of select seed flours

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ABSTRACT

Proximate composition of select commercially sold cereal, oilseed, dry bean, and tree nut seeds was determined. Full fat and defatted seed flours were evaluated for their color, bulk density, Water Holding Capacity (WHC), Oil Holding Capacity (OHC), and Least Gelation Concentration (LGC). On a dry weight basis (dwb), rice, wheat, pearl millet, black gram, chickpea, and soybean flours registered higher moisture content among the tested seeds. Seed protein content (dwb) ranged from 7.79 ± 0.72 g/100 g (rice) to 31.48 ± 0.76 g/100 g (soybean). On a dwb, rice (1.23 ± 0.07 g/100 g) and macadamia (67.63 ± 0.04 g/100 g) registered the lowest and the highest amount of lipid. Defatting typically improved flour lightness as indicated by an increase in the L^* value as compared to the corresponding full fat flour. Upon defatting, bulk density of the tested flours decreased. Under the experimental conditions, WHC of full fat flours (range 0.66 ± 0.11–2.97 ± 0.02 g/g improved upon defatting (range 1.48 ± 0.00–3.53 ± 0.02 g/g). OHC of full fat flours (range 0.64 ± 0.14–1.44 ± 0.07 g/g) increased upon defatting (range 1.00 ± 0.12 –3.40 ± 0.46 g/g). LGC of the tested flours ranged from 8 g/100 mL–18 g/100 mL.

1. Introduction

The global food production over the past five decades (1961–1963 to 2007–2009) has increased by 170 per cent thereby increasing the daily per capita food availability from 2220 kcal in early 1960s to >2800 kcal in 2009 (FAO, 2013c). Globally, of the 50,000 edible plant species, only a few hundred contribute to food supplies and 15 crop plants provide 90% of world's food energy intake. Rice, maize, and wheat make up two-thirds of this total as they serve as the staples for over 4000 million people (FAO, 2013a). With continued recognition of importance of contribution of plant foods to human diet and health (Borneo & Leon, 2012; Deshpande, Sathe, & Salunkhe, 1984; Fraser, 2009; Li, 2011; Reddy, Pierson, Sathe, & Salunkhe, 1984a, 1984b) utilization of plants and plant-based foods is likely to increase.

With increased global population and the decline in agro-biodiversity (FAO, 2013b), economic crop production and development of plant based-foods (De Boer & Aiking, 2011; FAO, 2013c; Parry & Hawkesford, 2010) is needed. Compared to animal proteins plant proteins are less expensive and are therefore an important food proteins source in many developing countries (Bhat & Karim, 2009; Chel-Guerrero, Perez-Flores, Betancur-Ancona, & Davila-Ortiz, 2002). Typically, proteins are mainly stored in edible plant seeds. Globally, seed flours have been used in production and processing of myriads of foods in numerous ways. Seed flours may be used singly (e.g., wheat bread, frying batters) or in combination (e.g., certain ready to eat breakfast cereals, snack foods, frying batters, certain breads and others). Understanding how seed flours may function in a specific food is therefore important.

Seed flour(s), either singly or mixed, can be used (Sanz, Salvador, Vélez, Muñoz, & Fiszman, 2005) in myriad of foods prepared in numerous ways and therefore investigating seed flour functional properties is challenging. Part of the difficulty is due to the several variables that need to be accounted for during functional assessment(s). Therefore, many investigations often focus on the selected seed flour or its targeted component to assess their functional potential in a specific food or food product group. In certain food preparations selected seed flour may be used (e.g., white leavened bread) while in others two or more seed flours may be blended (e.g. a fermented and steamed product known as idli prepared using rice-black gram flour blend) to achieve desirable product quality (Reddy, Sathe, & Salunkhe, 1982). Several articles discussing functional properties of seed flours (Bhat & Karim, 2009; Borneo & Leon, 2012; Chau & Cheung, 1998; Deshpande, Sathe, Cornforth, & Salunkhe, 1982; Kohajdová, Karovičová, & Schmidt, 2011; Sathe, Ponte, Rangnekar, & Salunkhe, 1981; Sathe & Salunkhe, 1981),

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food proteins (Boye, Zare, & Pletch, 2010; Gonzalez-Perez & Vereijken, 2007; Kinsella, 1979; Sathe, 2002; Sharma, Su, Joshi, Roux, & Sathe, 2010; Shewry & Halford, 2002; Tandang-Silvas, Tecson-Mendoza, Mikami, Utsumi, & Maruyama, 2011), lipids (McClements, 2013), and fiber (Tosh & Yada, 2010; Xu, 2012) may provide useful reading.

Earlier, we reported our findings on chemical composition (Venkatachalam & Sathe, 2006) and protein properties of major edible nut seeds (Sathe et al., 2009). Although several publications have reported assessment of functional properties of seed flours and proteins, comparative evaluation of functional properties of cereal, legume (dry beans and oilseeds), tree nut, and oilseed seed flours, full fat and defatted, under the same experimental conditions are lacking. In this report, we summarize the findings of an assessment of select functional properties of seed flours, full-fat and defatted, prepared from seeds procured in the retail local markets that included cereals, legumes (dry beans and oilseeds), tree nuts, and oilseeds.

2. Materials and methods

2.1. Materials

Seeds and Crisco vegetable oil (The J.M. Smucker Company, Orrville, OH, USA) were purchased in a single batch from the local grocery stores in Tallahassee, FL, USA. The choice of seeds was partly arbitrary and partly based on global use of seeds representing different cereals, oilseeds, legumes (dry beans and oilseeds) and tree nuts. The purchased seeds included three cereals-rice (*Oryza sativa*), wheat (*Triticum aestivum*), and pearl millet (*Pennisetum glaucum*), three oilseeds-peanut (*Arachis hypogaea*), soybean (*Glycine max*), and white sesame (*Sesamum indicum*), two dry beans-black gram (*Phaseolus mungo*) and chickpea (*Cicer arietinum*), and eight tree nuts-almond (*Prunus dulcis*), Brazil nut (*Bertholletia excels*), cashew (*Anacardium occidentale*), hazel nut (*Corylus avellana*), macadamia (*Macadamia integrifolia*), pecan (*Carya illinoinensis*), pistachio (*Pistachia vera*), and walnut (*Juglans regia*). Seeds were manually cleaned to remove any non-seed materials (such as leaf fragments, twigs, and others) prior to their further use. Sources of chemicals and supplies have been reported earlier (Sathe et al., 2009).

2.2. Methods

2.2.1. Preparation of seed flours

Seeds were ground using an Osterizer blender (Galaxie model 869-18R) at speed setting "Grind" to obtain full fat flour (particle size 0.841 mm diameter). Part of the full fat flour was defatted for 8 h using a Soxhlet apparatus (Fisher Scientific Co., Orlando, FL, USA) with petroleum ether (boiling point range of 38.2–54.3 °C) as the solvent (flour-to-solvent ratio of 1:10 w/v). Defatted flours were air-dried in a fume hood at room temperature (RT, ~25 °C) and powdered again using the Osterizer blender to obtain a homogeneous (0.841 mm diameter) sample. Full fat and defatted flours were stored in screw-capped plastic vials at −20 °C until further use.

2.2.2. Proximate composition

Moisture (AOAC Official Method 925.40). An accurately weighed sample (~1 g) was placed in an aluminum pan and dried in a previously heated vacuum oven (Barnstead Lab-Line, Melrose Park, IL, USA; model 3608-5; 95–100 °C, 68–85 kPa) to a constant weight.

Lipid (AOAC Official Method 948.22). A known weight of the sample (~15 g/thimble) was defatted in a Soxhlet apparatus using petroleum ether (boiling point range 38.2–54.3 °C) as the solvent (flour-to-solvent ratio of 1:10 w/v) for 8 h. Defatted samples were dried overnight (~10–12 h) in a fume hood to remove residual traces of petroleum ether and the samples were weighed to calculate lipid content.

$$\text{Lipid (\%)} = \frac{[(\text{Initial wt of full fat flour (g)} - \text{Final wt of defatted flour (g)}]\times 100}{\text{Initial wt (as is) of full fat flour (g)}}$$

Protein (AOAC Official Method 950.48). The micro-Kjeldahl method was used to determine total proteins using 0.1 g of sample. Sample nitrogen content was calculated using the formula:

$$\%N = \frac{(\text{mL of } H_2SO_4 \text{ for sample} - \text{mL of } H_2SO_4 \text{ for blank}) \times \text{normality of } H_2SO_4 \times 1.4007}{\text{Weight of sample (g)}}$$

Protein (%) = total N (%) × appropriate conversion factor for the sample.

The conversion factors used were 5.18 for almond, 5.46 for peanut, and 5.3 for Brazil nut, cashew, hazel nut, macadamia, pecan, pistachio and walnut. Conversion factors for wheat, soybean, and pearl millet were 5.59, 5.69, 5.60; respectively (Tkachuk, 1969). Conversation factor 5.6 was used for the remaining flours.

Ash (AOAC Official Method 923.03). Accurately weighed sample (~0.1 g) was placed in a ceramic crucible (previously heated and cooled until constant weight was obtained) and subjected to ashing in a muffle furnace maintained at 550 °C until a constant final weight for ash was achieved.

Carbohydrate. Total carbohydrate content was determined by the difference.

$$\text{Carbohydrates} = [100 - (\%\text{Proteins} + \%\text{Lipids} + \%\text{Ash})]$$

All proximate composition data are reported on a dry weight basis (dwb).

2.2.3. Bulk density

Bulk density was determined as described by Kaur and Singh (2007). Flour samples were gently filled in 10 mL graduated cylinder (with least count 0.5 mL). The bottom of the cylinder was gently tapped 5 times until there was no further diminution