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Nutrients, phytochemicals and antioxidant activities of 26 kidney bean cultivars

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ABSTRACT

Detailed characterization in nutrients and phytochemicals with antioxidant activities of 26 kidney beans was performed. The kidney beans contained high levels of dietary fiber (29.32–46.77%), resistant starch (9.16–18.09%) and protein (22.06–32.63%) but low levels of lipid (1.05–2.83%) and sugars (1.55–9.07%). The monosaccharide composition of soluble fiber was dominated by arabinose, galactose, mannose and galacturonic acid. The ratio of essential amino acid to the total amino acid was ranged from 0.29 to 0.36. The predominant fatty acid was polyunsaturated fatty acids, accounting for 47.54–67.26% of total fatty acids. The total tocopherol content was in the range of 12.83–68.35 μg/g, predominantly γ-tocopherol, followed by δ-tocopherol. In addition, certain levels of total phenolics and flavonoids with respective values of 0.25–3.79 mg gallic acid equivalent/g dry weight and 0.19–7.05 mg rutin equivalent/g dry weight resulted in significant antioxidant activities. And a good correlation was observed between TPC and FRAP values ($R2 = 0.8030$). The results indicated that kidney beans are excellent sources of health-promoting compounds.

1. Introduction

The kidney beans (*Phaseolus vulgaris* L.) are consumed for their pods and seeds (Choung et al., 2003), and are widely used in traditional foods especially in Asian countries. Kidney beans are versatile dietary ingredients which are utilized in variety of foods, such as bakery products, salads and canned food (Nciri et al., 2015). Epidemiologic studies showed that there was a positive association between the consumption of kidney beans and the reduction of the risk of cardiovascular diseases, obesity, diabetes type IIand certain types of cancer (Dueñas et al., 2015). Health benefits of kidney beans have been attributed to their unique nutrients and phytochemicals.

Nutritionally, kidney beans are excellent sources of dietary fiber, protein, carbohydrates, minerals and phytochemicals, including phenolic compounds. Dietary fiber and resistant starch, as indigestible carbohydrates were beneficial for health, such as promoting weight loss, balancing blood sugar levels, reducing risk of suffering from heart disease and improving the gut health (Trompette et al., 2014). Dietary fibers are also functional ingredients that could be used to modify physiochemical qualities of the end products, including their consistency, texture, rheological behavior and sensory characteristics. Kidney beans are also rich in pulse-based proteins. Pulse-based proteins are gluten-free and not a typical source of allergens (Han et al., 2010). Also, they are sustainable source of dietary protein and have many nutritional advantages, including high content of lysine and representing good digestibility (Boye et al., 2010). Proteins from pulses exhibited health benefits including cholesterol reduction, cancer prevention and diabetes (type II) control (Duranti, 2006; Toews and Wang, 2013). Phenolic compounds in kidney beans have been shown to have antioxidant, anti-inflammatory, anti-hypertensive, anti-atherosclerotic, antitumor and antiaging activities (García-

Abbreviations used: HPLC/RI, High performance liquid chromatography coupled to a refraction index detector; GC, gas-liquid chromatography; HPAEC-PAD, High performance anion exchange chromatography coupled with pulsed amperometric detection; UPLC-FLD, Ultra-high performance liquid chromatography coupled with fluorescence detector; FRAP, Ferric reducing antioxidant power; TPC, The total phenolic content; GAE, Gallic acid equivalent; DW, Dry weight; TE, Trolox equivalent; SD, Standard deviation.

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Lafuente et al., 2014).

Differences in chemical constitute and bioactivities have been observed among the different cultivars of other legumes (Zhang et al., 2014). There is a large diversity in species and cultivars for which result in variability of their nutritional and phytochemical composition, hence their bioactivities. In the present study, the nutrients, phytochemicals and antioxidant properties of 26 different kidney beans cultivars were investigated. The samples were analyzed for proximate composition (moisture, ash, protein, lipid, dietary fiber, resistant starch and sugars), monosaccharide composition of soluble fiber, fatty acid and amino acid composition, tocopherol, total phenolics, total flavonoids and antioxidant activities. The results from current study will provide a good base for further utilization of kidney beans.

2. Materials and methods

2.1. Samples

26 varieties of kidney beans (Fig. 1) cultivated in China were purchased from local supermarket in Shandong Province and Jiangxi Province, China in September 2015. The whole kidney beans were ground into fine powder size, which stored at 4 °C in sealed plastic bags prior to analysis.

2.2. Chemical reagents

4-Morpholinoethanesulfonic acid (MES) and hydroxymethyl aminomethane (Tris) were purchased from Aladdin Bio-Chem Technology Co., LTD (Shanghai China). Protease (350 tyrosine Units/mL), amyloglucosidase (3300 U/mL), thermo-stabilized α-amylase (10,000 U/mL) and α-pancreatic amylase (3 Ceralpha U/mg) were purchased from Megazyme (Megazyme International Ireland Ltd.). Standards of α-tocopherol, β-tocopherol, γ-tocopherol and δ-tocopherol (HPLC grade, percent purity was ≥95%) were purchased from Stanford Analytical Chemicals Inc. (Eugene, Oregon, USA). The Folin-Ciocalteu reagent, gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (6-hydroxy-2,5,7,8-tetramethylchroman- 2-carboxylic acid) Trolox and monosaccharide standards including arabinose, rhamnose, galactose, fucose, glucose, xylose, mannose, galacturonic acid and glucuronic acid were obtained from Sigma Chemical Co. (St. Louis, MO, USA). All the other chemicals and reagents used in this study were analytical grade.

2.3. Proximate analyses

The content of moisture, ash, fat, dietary fiber (including soluble dietary fiber and insoluble dietary fiber) and starch (including resistant starch and non-resistant starch) were determined according to official methods (AOAC, 2005). The protein content was calculated by using 6.25 as the nitrogen conversion factor based on nitrogen content (Wang et al., 2010).

2.4. Sugar analysis

Free sugars were determined by high performance liquid chromatography coupled to a refractive index detector (HPLC/RI) according to a previous report (Barros et al., 2010). Briefly, 1 g of dried kidney beans flour was reflux extracted with 30 mL of 80% aqueous ethanol (*v*/*v*) at 80 °C for 30 min. Extracts were then centrifuged at 4500 *g* for 15 min. The supernatant was combined and dried under reduced pressure at 40 °C. The dried residues were re-dissolved in 2 mL of 70% aqueous acetonitrile (*v*/*v*) prior to be centrifuged at 4500 g for 5 min. The supernatants were collected and topped up to 5 mL. Supernatants were filtered through a 0.22 μm polytetrafluoroethylene (PTFE) filter and used as crude extracts for sugar analysis by HPLC/RI. The Agilent 1260 HPLC (Agilent Zorbax NH_2 column, 5 μm, 250 × 4.6 mm) was equipped with a refractive index detector (HPLC-RI) for data processing. The mobile phase used was acetonitrile/deionized water (7:3, *v*/*v*) at a flow rate of 0.8 mL/min. Column temperature was controlled at 35 °C. The results were expressed as g/100 g of dry weight.

2.5. Fatty acid analysis

Fatty acids were determined by gas chromatography (GC) with a flame ionization detector (FID) according to our recent publication (Chen et al., 2014a). Briefly, 10 mg of crude fat was transferred into a 5 mL centrifuge tube containing 10 μL of C21 (4.5 mg/mL) internal standard solution, 2 mL of n-heptane and 0.1 mL of potassium hydroxide methanol solution (2 mol/L). The well-mixed solution were centrifuged for 5 min at 4500 *g*. For the drying samples, anhydrous sodium sulfate were used as a drying agent. Samples were extracted in triplicates.

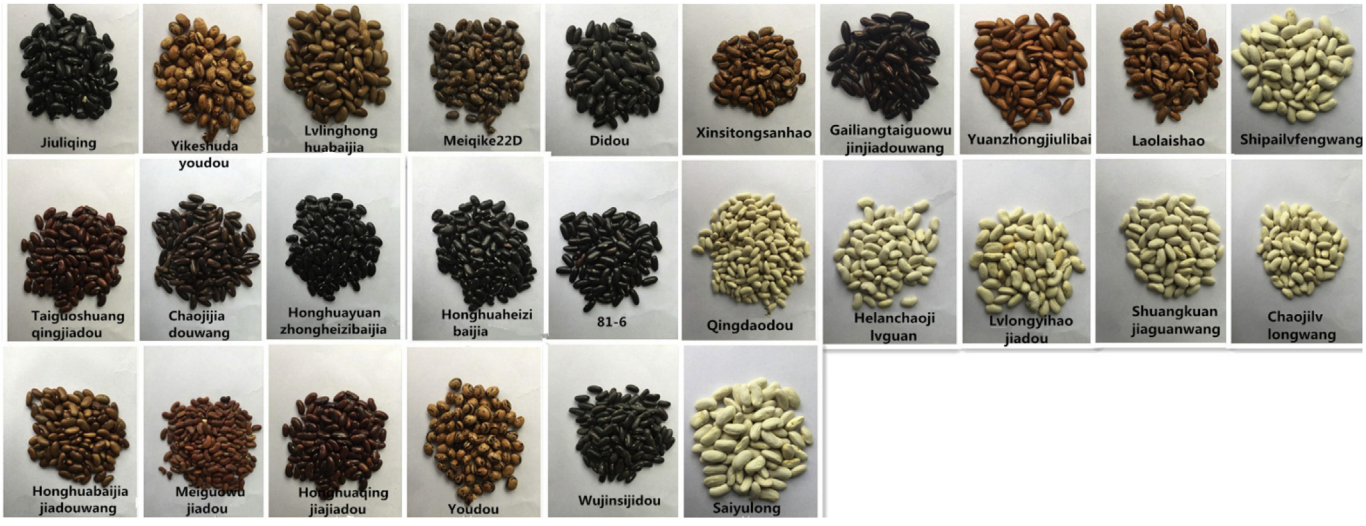

Fig. 1. Representative photographs displaying differences in appearance of twenty-six kidney bean cultivars.