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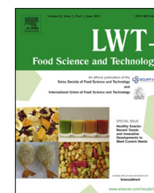

Research note

Total phenolics, carotenoids and antioxidant properties of Tommy Atkin mango cubes as affected by drying techniques

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ABSTRACT

Mango (*Mangifera indica* L) cubes were dehydrated using different techniques; lyophilization or freeze-drying, cabinet (hot-air), vacuum and Infra-red (FD, CD, VD, IRD, respectively). Total phenolics, carotenoids, ascorbic acid contents and antioxidant properties (ABTS, DPPH, FRAP, ORAC) of mango powder were determined. Mango powder contained high quantity of phenolics (936.2–1725.2 mg GAE/100 g db, with highest in FD and lowest in CD samples), ascorbic acid (97–225 mg/100 g db, highest in FD and lowest in IRD samples) and total carotenoids (3.3–5.2 mg/100 g db). Freeze–dried powder had the highest antioxidant properties than those from other drying techniques. ORAC values varied from 408 to 651 μ mol TE/100 g db. Solubility of cabinet-dried powder was the highest. Water and oil Absorption Index ranged between 2.54–2.87 and 1.69–2.75, respectively. Freeze dried powders had the lower bulk density than samples from other drying techniques. Physicochemical characteristics of the freeze- and cabinet-dried mango powders offer potential application in food products.

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1. Introduction

Mango (*Mangifera indica* L.) is a widely consumed tropical fruit in fresh or processed form throughout the world. This fruit has limited storage life since it cannot be stored at low temperatures because of its susceptibility to chilling injury. Moreover, mangoes need to be treated with hot water as quarantine requirement which accelerates the ripening process (Kim, Lounds-Singleton, & Talcott, 2009). These limitations lead to substantial postharvest losses creating massive quantity of culled fruit as bio-waste, which offers a potential to be developed into value-added products.

Polyphenols, carotenoids, and vitamins impart health-promoting properties to mango due to their antioxidant activities (Dorta, Lobo, & González, 2012a; Siddiq, Sogi, & Dolan, 2013; Sogi, Siddiq, Roidoung, & Dolan, 2012) and the fiber content of mango offers potential for its use in bakery products (Vergara-Valencia et al., 2007). Since mangoes are susceptible to decomposition because of their high water content and nutrients, drying can effectively preserve this fruit while offering expanded usage in different food products. The method of drying can have a negative impact on quality; for example, hot air drying was shown to have negative effect on the antioxidant properties of mango (Dorta, Lobo, & Gonzalez, 2012b). Currently, mango slices are dried by dipping in sugar for marketing as a snack product; however, presently, dried mangoes for use in various food applications are not available commercially. The objective of this study was to evaluate different methods for drying mango and evaluate the antioxidant and functional properties of dried mangoes powders.

2. Materials and methods

2.1. Materials

Market-ripe Tommy Atkin mangoes with green-purple peel, firm texture and light yellow flesh were procured from a local source. Fruits were sorted, washed, and sanitized (5-min dip in Fruit & Vegetable Wash at 3.75 g/L water; SC Johnson Professional, Sturtevant, WI, USA). Mangoes were peeled/diced manually using stainless steel knives to get ∼10 mm cubes.

All chemicals used in this study were of analytical grade and were purchased from Sigma–Aldrich (St Louis, MO, USA) and W.W.

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Grianger, Inc. (Lake Forest, IL, USA). Unless noted otherwise, all extractions/dilutions were made using 80:20 methanol–water (methanol-80).

2.2. Drying of mango cubes

Four drying techniques were employed: 1) Freeze drying (FD) – Samples were frozen at −20 °C and dried in a pilot-scale lyophilizer (Vertis Company Inc., Gardiner, NY, USA) with the condenser temperature and chamber vacuum at −55 °C and 4 Pa respectively; 2) Hot-air/Cabinet dying (CD) – samples were dried in a cabinet dryer (Proctor and Schwartz Inc., Philadelphia, PA, USA) operated at 60 ± 2 °C with constant air circulation; 3) Vacuum drying (VD)– Samples were kept in a vacuum oven (Sheldon Manufacturing Inc., Cornelius, OR, USA) set at 60 ± 2 °C and vacuum was maintained at 66.7 kilo-Pascal; 4) Infra-red drying (IRD) – The mango cubes were dried in a custom-made IR heating unit consisting of aluminum housing, with two 40-Watt IR bulbs. The drying was terminated based on the appearance of dehydrated mango cubes. The dried mango cubes were ground using a coffee grinder to pass through US-40 Sieve (0.5 mm), packaged in polyethylene bags and stored at −20 °C until analyzed. The mango powders were used for analyzing antioxidant, physico–chemical and functional properties.

2.3. Total phenolics, ascorbic acid and carotenoids analysis

Total phenolics, as gallic acid equivalent (GAE), were determined according to Singleton and Rossi (1965). Briefly, 1 g samples were mixed with 20 mL of methanol-80, agitated on water-bath shaker for 1 h, followed by centrifugation (10,000 × *g* for 10 min). Supernatants were collected and residues were re-extracted twice using 10 mL of methanol-80 by 1-min vortexing and centrifugation (10,000 × *g* for 5 min).

Mango powders were extracted and titrated against indophenol dye (2, 6 dichloro indophenol, sodium salt) to determine ascorbic acid content (AOAC, 1991). For total carotenoids, samples were extracted with hexane:acetone (7:3) solution and after phase transfer the absorbance was read at 450 nm using a spectrophotometer (Milton Roy, Pennsylvania, USA) following Davis, Collins, Fish, Tadmor, Webber, & Perkins-Veazie (2007). Total carotenoids were determined as β-carotene equivalent using a standard curve prepared with pure β-carotene (0.5–2.5 μg/mL).

2.4. Antioxidant properties

Sample extraction protocol for antioxidant analysis was the same as for total phenolics. The antioxidant capacities were expressed as μ mol trolox equivalent (TE)/g db.

2.4.1. ABTS assay

The ABTS (2,2′-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt) antioxidant activity was determined using $ABTS^{\bullet+}$ radical cation decolorization assay (Re et al., 1999), with little modification. Briefly, 7 mmol/L ABTS solution and 2.45 mmol/L potassium persulfate were mixed in 1:1 ratio and allowed to stand in the dark for 12–16 h to produce ABTS radical cation ($ABTS^{+}$) stock solution. The $ABTS^{+}$ working solution (3 mL) and 30 μL of blank, standard or sample were mixed and the absorbance was measured at 734 nm after 6 min using a spectrophotometer. The blank was run with methanol-80 and standard curve was prepared using 0.3–1.5 mmol Trolox/L.

2.4.2. DPPH assay

Radical scavenging activity of mango powders was determined following Brand-Williams, Cuvelier, and Berset (1995). Briefly, one part of stock solution of 2,2-Diphenyl-1-picrylhydrazyl or DPPH (0.24 g/100 mL methanol) was diluted with ten parts methanol-80 to get working solution having absorbance of 1.1 ± 0.02 at 515 nm. Blank, standard or samples (0.6 mL) and 3.0 mL of DPPH working solution were mixed, kept in dark for 20 min and absorbance was recorded at 515 nm. Standard curve was prepared to calculate DPPH activity using 50–250 μmol Trolox/L.

2.4.3. Ferrric reducing antioxidant power (FRAP) assay

The ferric reducing ability of dried mango powders was measured following Benzie and Strain (1996). The stock solutions 300 mmol/L acetate buffer, 10 mmol/L 2,4,6-Tris(2-pyridyl)-*s*-triazine (TPTZ) solution in 40 mmol/L HCl, and 20 mmol/L $FeCl_3 \cdot 6H_2O$ solution were prepared. The fresh working solution was prepared by mixing acetate buffer, TPTZ solution, and ferric chloride solution in 10:1:1 ratio respectively. Blank, standard or samples (0.3 mL) were mixed with 3 mL working solution and absorbance was read after 5 min at 595 nm. Methanol-80 and Trolox (50–250 μmol/L) were used for blank and standard curve respectively.

2.4.4. Oxygen radical absorbance capacity (ORAC) assay

The analysis was carried out following Huang, Ou, Hampsch-Woodill, Flanagan, and Prior (2002). Briefly, 150 μL of fluorescein (20 nmol/L) was added to the designated wells of a 96-wells black plate, followed by the addition of 25 μL of blank, standard (Trolox 25–100 μmol/L) or samples to the designated wells. The plate was incubated at 37 °C for 30 min in Microplate Reader (Biotek Instruments, Winooski, VT, USA). Then, 25 μL of freshly prepared 2, 2′ Azobis (2-methylpropionamidine) dihydrochloride (153 mmol/L) was added to all the designated wells. Fluorescence was monitored using 485 nm excitation and 528 nm emissions at 2 min intervals for 180 min.

2.5. Physico–chemical analysis and functional properties

Dehydrated samples (~2.5 g) were analyzed for moisture content using IR moisture meter (Denver Instrument, Bohemia, NY, USA). Titratable acidity of dehydrated mango was determined by taking 0.5 g of sample in 20 mL distilled water, adding two drops of phenolphthalein and titrating against standardized 0.1 mol/L NaOH solution. The pH was measured by taking 0.5 g sample in 50 mL distilled water using Oakton pH meter (Eutech Instruments, Singapore). Loose and packed bulk density of the mango powder was determined by transferring 10 g mango powder to a 250 mL measuring cylinder and measuring its loose and packed volume (CRA, 1998). Solubility of mango powder was determined using the method of (Cano-Chauca, Stringheta, Ramos, & Cal-Vidal, 2005) by dispersing 1 g mango powder in 100 mL water, blending, centrifuging (3000 × *g*, 5 min) and drying supernatant at 105 °C for 5 h). The water/oil absorption indices (WAI/OAI) were determined using methods described by Beuchat (1977) by mixing 1 g of sample with 10 mL of distilled water or oil for 30 s, standing for 30 min, centrifugation at 5000 × *g* for 30 min, draining and measuring gain in weight.

2.6. Statistical analysis

All the experiments were done using three replicates and data reported as mean ± standard deviation. Data were analyzed using JMP 9.0 software (SAS Institute, Inc., Cary, North Carolina, USA). The significant difference comparisons were made by Tukey's HSD test ($p \le 0.05$).

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