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Functional properties, phenolic constituents and antioxidant potential of industrial apple pomace for utilization as active food ingredient

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Abstract

Apple pomace is a waste biomass generated after apple fruit processing. In present investigation, efforts were made to comprehend influence of differently dried pomace on cell wall properties and phenolic profile. Different drying techniques were employed to remove moisture content from fresh apple pomace. Total dietary fiber yield (74%) and array of functional properties such as density, water and oil holding capacity, swelling capacity and glucose dialysis retardation index (36.91%) was found better in freeze dried fraction. The higher total phenolics (5.78 ± 0.08 mg GAE/g dry weight) content was also recorded in freeze dried fraction followed by oven and sun drying. The 50% aqueous acetone was found as more efficient solvent for extraction of phenolic constituents. RP-HPLC analysis has revealed presence of quercetin, phloridzin and phloretin as major phenolics. Thus, it is evident from the results that pomace generated at industrial scale can be utilized as a source of dietary food ingredient.

Keywords: Dietary fiber; Drying; Apple pomace; Polyphenols; Antioxidant

1. Introduction

Dietary fibers demonstrated to have imperative role in improvement and management of human health, especially gastrointestinal system. However, type and source of dietary fiber greatly influence their functional properties. At present, the primary sources employed in food industries are of cereal origin with minimal contribution from fruits and vegetables. However, later has additional benefits owing to the presence of array of bioactive components particularly antioxidant molecules [1]. 'Apple pomace' is one of such source advocated to have enormous potential as dietary food component [2]. It is the waste residue left after extraction of juice from apple (*Malus domestica*) fruits. The major part (approx. 95%) of the generated biomass is skin/pulp tissues, which consists of cell wall polysaccharides (e.g. pectin, cellulose, hemicellulose, lignin and gums) and skin bound phenolic compounds i.e. dihydrochalcones, flavonols, flavanols and phenolic acids [3]. Apple pomace possess strong antioxidant properties due to the presence of phenolics like epicatechin, its dimer, quercetin glycosides, chlorogenic acid, phloridzin and 3-hydroxy-phloridzin [4]. The phenolics rich extract of pomace were found to exhibit anticarcinogenic activity by preventing colon cancer [5]. The non-starch polysaccharides are known as dietary fiber [2] and diet generally enriched with fiber is associated with good digestive health, with reduction in gastrointestinal problems, helps in weight management, lower risk of coronary heart disease, better glycemic control and lower possibility of certain type of cancer [6]. However, these physiological effects are exerted by specific dietary fiber, which may vary depending upon the fiber source and processing method [7]. Fruit fibers reported to have an edge over cereal in terms of better soluble: insoluble ratio, lower phytic acid content, and presence of associated bioactive molecules such as antioxidant [8]. In processing of high moisture biomass like apple pomace, method of moisture removal could

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be an important factor affecting actual properties of dietary fiber and release of skin-bound phenolic. Hence, the present study pursued to assess the functional propeties, phenolic content and antioxidant potential of differently dried fiber fractions.

2. Materials and methods

2.1. Industrial apple pomace collection

Pomace was collected from fruit processing unit of Himachal Pradesh Horticultural Produce Marketing and Processing Corporation Ltd (HPMC), Parwanoo, Himachal Pradesh, during September 2011. Potassium meta-bisulfite (at 600 ppm) was added as preservative to avoid spoilage of the pomace during transportation. Preserved pomace brought to CSIR-IHBT and stored at $10 \pm 2\,^{\circ}C$ until drying was done.

2.2. Chemicals and reagents

2,2′-Diphenyl-1-picrylhydrazyl, Folin-Ciocalteu's phenol reagent, gallic acid, trolox, phloridzin, phloretin, quercetin was purchased from Sigma–Aldrich (Germany). All other solvents and chemicals were of analytical grade and obtained from Merck (Mumbai, India). The dialysis membranes procured from Thermo Scientific.

2.3. Extraction and drying of dietary fiber fraction

Industrial apple pomace was put in 10 L plastic can and mixed with tap water for separation of seed/twigs. After mixing, extraneous material separated from the slurry. Seedless pomace was washed thrice to reduce concentration of soluble solids (5.2–0.2 °Bx). The seedless apple pomace then recovered from slurry by filtration using muslin cloth, as shown in flow diagram (Fig. 1). Hot-air oven, sun drying and freeze or low temperature drying method was used to remove the moisture of extracted fiber fraction from pomace. In case of hot-air oven method, fibrous material was spread over aluminum trays in thin layer (0.5–0.75 cm) for removal of moisture at $60 \pm 2\,^{\circ}C$ in industrial hot-air tray drying oven (MSW-215), until no further decrease in weight was observed. The fraction was converted into fine powder using cutting mill (Retsch) (1 mm) and packed in polybags (HiDispo^{TM} Bag-12, HIMEDIA). This dried fiber fraction was considered as 'FI' and stored at room temperature. In case of sun drying, seedless pomace was spread thinly (0.5–0.75 cm) in aluminum trays and kept under sun in an open area and jumble every 1 h to ensure uniform drying. The average humidity and temperature was 48%–72% and 11.0–26 °C, respectively during the drying period. After drying, pomace fraction (FII) was processed similar to F1. The third fraction (FIII) was obtained by low-temperature drying (−55 °C) using freeze drier (CHRIST Alpha 1–2 L Dplus, Germany). Similar to FI, the dried fraction was powdered, packed and stored till further analysis.

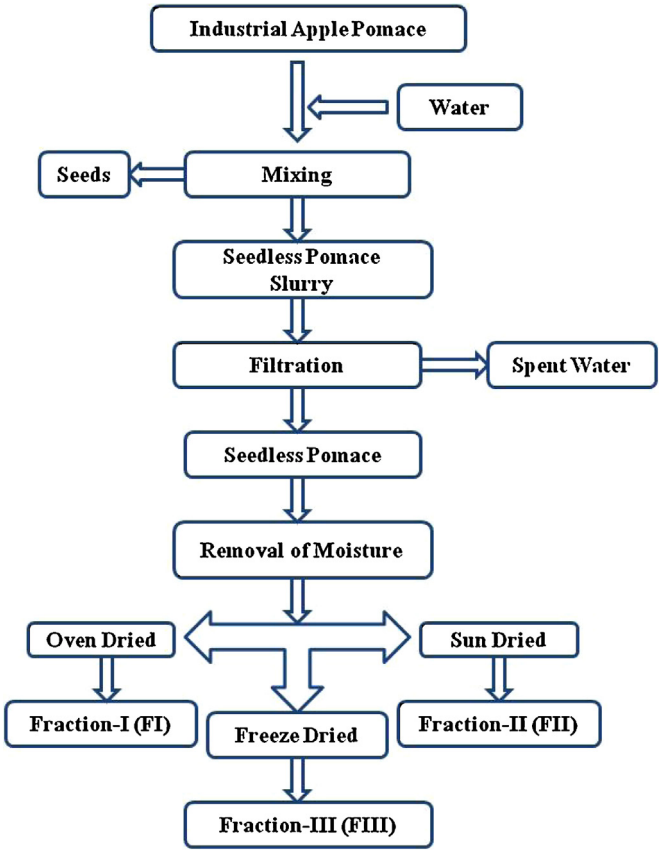

Fig. 1. Flow diagram for preparation of dietary fiber fractions from apple pomace.

2.4. Dietary fiber content

Total dietary fiber (TDF), doluble dietary fiber (SDF) and insoluble dietary fiber (IDF) contents were determined according to phosphate buffer based enzymatic-gravimetric method AOAC (labeled 991.42, 993.19 and 985.29) with slight modifications [9]. In brief, fiber fractions were gelatinized with heat stable α-amylase, digested with protease and amyloglucosidase to make samples protein and starch free. Subsequently, IDF were filtered and washed with warm distilled water, which was pooled and combined with 4 times volume of 95% ethanol, before heating at 60 °C to precipitate SDF. The precipitates were weighed after drying at 105 °C in hot-air oven until reaching constant weight.

2.5. Measurement of functional properties

2.5.1. Density

Bulk density was measured using the method of Elkhalifa et al. [10]. A 50 mL graduated cylinder was filled with 10 g fiber fraction followed by gentle tapping of the cylinder. The volume of fiber powder was read directly and results were expressed as g/mL. In packed density, a calibrated 10 mL graduated syringe filled with fiber fraction and pressure was applied manually until additional pressure would not further reduce the volume.