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Some physicochemical and rheological properties of starch isolated from avocado seeds

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ABSTRACT

Seeds from avocado (*Persea americana* Miller) fruit are a waste byproduct of fruit processing. Starch from avocado seed is a potential alternative starch source. Two different extraction solvents were used to isolate starch from avocado seeds, functional and rheological characteristics measured for these starches, and comparisons made to maize starch. Avocado seed powder was suspended in a solution containing 2 mM Tris, 7.5 mM NaCl and 80 mM $NaHSO_3$ (solvent A) or sodium bisulphite solution (1500 ppm SO_2, solvent B). Solvent type had no influence ($p > 0.05$) on starch properties. Amylose content was 15–16%. Gelatinization temperature range was 56–74 °C, peak temperature was 65.7 °C, and transition enthalpy was 11.4–11.6 J/g. At 90 °C, solubility was 19–20%, swelling power 28–30 g water/g starch, and water absorption capacity was 22–24 g water/g starch. Pasting properties were initial temperature 72 °C; maximum viscosity 380–390 BU; breakdown −2 BU; consistency 200 BU; and setback 198 BU. Avocado seed starch dispersions (5% w/v) were characterized as viscoelastic systems, with $G' > G''$. Avocado seed starch has potential applications as a thickening and gelling agent in food systems, as a vehicle in pharmaceutical systems and an ingredient in biodegradable polymers for food packaging.

1. Introduction

Native to Mexico and Central America, the avocado tree (*Persea americana* Mill) belongs to the Lauraceae family. Its commercially valuable fruit has high monounsaturated oil-content. Easily adaptable to many tropical regions, it is currently distributed throughout the tropics and some areas in the subtropics. Commercial production centers mainly in Mexico, California, Chile, Israel, Australia and South Africa. Mexico is the largest worldwide avocado producer, with 3.4 million tons annual production; in 2009 it accounted for 32% of global avocado production [1]. Avocado fruit have a dark olive-green peel and thick pale yellow-green pulp rich in oils and prized for its sensory attributes [2].

Avocado production has grown rapidly in recent years and the avocado fruit processing industry has followed suit. The fruit is used in the food, cosmetics, and pharmaceutical industries in applications as diverse as ice cream, mayonnaise, and sandwich spreads. Research has also been done on dehydrating, freezing and canning avocado fruit [3]. Processing avocado fruit results in substantial waste, particularly from discarded seeds, which represent about 16% of fruit dry weight [4]. These by-products can cause environmental problems, particularly propagation of pests such as insects and rodents. They also generate financial losses due to the high cost of transport to disposal areas [5]. Efforts are ongoing to develop integrated use strategies for avocado fruit.

Avocado seed proximate composition (wet base) is water (51–58%); starch (29%); sugars (2.21–3.50%)—mainly arabinose (2.04–2.15%); protein (2.38–2.45%); and ash (1.24–1.34%) [6]. It contains high levels of potassium and antioxidants, and is an excellent dietary fiber source. Indeed, the seed's tannins and polyphenolic compounds contents provide it a higher antioxidant activity than its edible portion, and even higher than common synthetic antioxidants such as Trolox [4,6].

Starch is widely used as a functional ingredient in food systems. Its thickening, gelling and stabilizing properties are essential to

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imparting viscosity, texture and consistency, properties that make it useful in the manufacture of paper, adhesives and biodegradable packaging, among other products [7]. Rising demand for starch in food products and the manufacture of biodegradable materials is notably impacting the supply of natural starch sources normally used in human diets. Much current starch research focuses on identifying non-conventional starch sources that pose no competition to starches used in human diets and that can function as raw materials in industrial processes. Avocado seeds are a waste byproduct and have high starch content, making them a promising natural, alternative starch source.

Starch from avocado seeds has received limited research attention, and starch isolation techniques are still being developed. Khan [8] isolated starch from avocado seeds by soaking seed slices in a sodium hypochloride solution, grinding the slices, and allowing the starch to settle out. The resulting avocado starch granules were oval-shaped with a relatively smooth surface, an average diameter of 5–35 μm, a B-type x-ray diffraction pattern, and were non-ionic and not waxy. Builders et al. [9] isolated starch from avocado seeds by first finely chopping the seeds, soaking this meal in a 0.075% w/v sodium metabisulphite solution for 24 h, washing and then filtering the mash. This suspension was allowed to stand for 12 h for starch granule sedimentation, the supernatant decanted, and the resulting starch cake washed and air-dried. In another technique, Lacerda et al. [10] isolated starch from avocado seeds using a sodium metabisulphite solution and then oxidized the starch in sodium hypochlorite solutions at 0.5, 1.0 and 2.0%. Multiple analyses showed the treated starch samples to exhibit decreases in gelatinization enthalpy, average roughness, degree of relative crystallinity and pasting properties.

The present study objective was to identify, describe and compare some functional and rheological properties of avocado seed starch isolated using two different extraction methods.

2. Materials and methods

2.1. Seed powder preparation

Chopped avocado seeds (*P. americana* Mill cv. Hass) were spread onto a tray and placed in an oven at 60 °C until dry. The chopped seeds were turned periodically to ensure uniform drying. Once dry, the seeds were finely ground (20-mesh screen) using a Retsch® Ball Mill grinder (Retsch GmbH, Germany) for 10–20 s, depending on initial seed size. The resulting seed powder was stored at 4 °C until use.

2.2. Starch isolation

Starch was extracted from the avocado seed powder with two different wet fractionation techniques. The first technique was based on Khan [8] method. Using a Kitchen-Aid® blender (Benton Harbor, MI, USA), the seed powder was wet-milled in a solution containing 2 mM Tris (pH 7.0), 7.5 mM NaCl and 80 mM $NaHSO_3$ (solvent A). The resulting slurry was passed through 80-mesh screens followed by two washings with solvent A to separate the fiber solids from the starch. The avocado starch residue was oven-dried at 40 °C for 12 h, and then milled in a Mykros impact mill (Infraestructura Inteligente, Mexico) until passing through a 0-mesh screen.

In the second technique, starch was isolated following de la Torre et al. [11]. modified as follows. Seed powder was suspended in a sodium bisulphite solution (solvent B, 1500 ppm SO_2) at 1:5 (w/v), and the suspension left to soak under constant agitation for 1 h. It was then passed through an 80-mesh screen, producing a solid fraction containing fiber and a liquid fraction containing starch. The liquid fraction was left to precipitate for 4 h, and the supernatant removed with a siphon. The settled starch fraction was washed three times by re-suspension in distilled water, and then centrifuged at 1100 × *g* for 12 min (Mistral 3000i, Sanyo MSE, UK) in the final wash to recover the starch. This was dried at 40 °C for 12 h in a convection oven, weighed and milled in a Cyclotec mill (Tecator, Sweden) until passing through a 20-mesh screen. The resulting avocado seed starch powder was stored at room temperature in a sealed container. Physicochemical and rheological characterization was done of the isolated starches. All the properties were analyzed in triplicate and compared to commercial maize (*Zea mays*) starch (28% amylpose content; Maizena®, Unilever Food Solutions, Mexico).

2.3. Amylose content

Apparent amylose content was estimated after iodine complexation following Morrison and Laignelet [12].

2.4. Differential scanning calorimetry (DSC)

Starch gelatinization was determined with a DSC-7 (PerkinElmer Corp., Norwalk, CT), using the technique described by Ruales and Nair [13]. The DSC device was calibrated with indium and the data analysed using the Pyris software program. Two milligrams (d.b.) of starch were weighed into an aluminum pan and the moisture level adjusted to 70% by adding de-ionized water. The pan was then hermetically sealed and left to equilibrate for 1 h at room temperature. Samples were scanned at temperatures between 30 and 120 °C at a heating rate of 10 °C/min. Gelatinization temperature was determined by automatically calculating onset temperature (*To*), maximum peak temperature (*Tp*), final temperature (*Tf*), and gelatinization enthalpy (ΔH) from the resulting thermogram.

2.5. Solubility, swelling power (SP) and water absorption capacity (WAC)

Solubility, water absorption and swelling power patterns were measured at 60, 70, 80 and 90 °C following de la Torre et al. [11]. Briefly, 40 ml of a 1% starch suspension (w/v) was prepared in a previously tared, 50 ml centrifuge tube. A magnetic agitator was placed in the tube, and it was kept at a constant temperature (60, 70, 80 or 90 °C) in a water bath for 30 min. The suspension was then centrifuged at 2120 g for 15 min, the supernatant decanted and the swollen granules weighed. From the supernatant, 10 ml were dried in an air convection oven (Imperial V) at 120 °C for 4 h in a crucible to constant weight. Percentage solubility and swelling power were calculated using the following formulas:

$$\%\text{Solubility} = \frac{\text{dry weight at } 120^{\circ}\text{C(g)}}{\text{Weight of sample(g)}} \times 400$$

$$\text{Swelling power} = \frac{\text{weight of swollen granules(g)}}{(\text{sample weights(g)} \times (100 - \%\,\text{solubility})}$$

water absorption capacity was measured using the same conditions as above, but was expressed as weight of the gel formed per sample, divided by treated sample weight.

2.6. Pasting properties

Pasting properties were evaluated following the method of Wiesenborn et al. [14]. using a viscoamylograph (Brabender PT-100, Germany). Briefly, 400 ml of 6% (d.b.) starch suspension were heated to 95 °C at a rate of 1.5 °C/min, held at this temperature for 15 min, cooled to 50 °C at the same rate, held at this second