Contents lists available at ScienceDirect

Food and Bioproducts Processing

journal homepage: www.elsevier.com/locate/fbp

Characterization of antioxidant and antimicrobial properties of spray-dried extracts from peanut skins

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ARTICLE INFO

Article history:
Received 7 December 2016
Received in revised form 25 July 2017
Accepted 1 August 2017
Available online 8 August 2017

Keywords:
DPPH
On-line HPLC-ABTS
ORAC
Phenolics
Staphylococcus aureus
Spray-drying

ABSTRACT

This study aimed to produce dried extracts from peanut skin using spray-drying technology for application as a natural antioxidant and antimicrobial in foods. The extracts were spray-dried with 10, 20, or 30% of maltodextrin (carrier) at different temperatures (130, 150, and 170 °C), to establish the best conditions to produce the powders. The powders were characterized with regards to moisture, hygroscopicity, particle size, and solubility, and the stability of phenolic compounds was evaluated throughout 120 days at 25 °C. The antimicrobial and antioxidant activities of powders were also evaluated. Powders produced at higher temperatures and 30% of maltodextrin presented the best results for hygroscopicity, solubility, and particle size, and the powder produced at 150 °C with 30% of maltodextrin showed the high stability of phenolic compounds during storage. All powders presented remarkable antioxidant activity and showed bacteriostatic activity against *Listeria monocytogenes*, and bactericidal activity against *Staphylococcus aureus*. Taken together, these results indicate that the best conditions (of those tested) for spray drying peanut skin extracts were at 150 °C and with 30% of maltodextrin. The resultant powders have technological potential due to the high stability, good physical properties, and remarkable antioxidant/antimicrobial activities, which could be applied as natural additives to improve food quality.

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1. Introduction

Peanuts belong to the Leguminosae family and are rich in oils, proteins, and vitamins, which make this product an important source of energy and amino acids. Currently, the peanut is consumed all over the world due to its unique flavor and versatility in processing. According to the United States Department of Agriculture (USDA), the production of peanuts has increased. The current global production is 42.29 million metric tons, and China is the main producer, followed by India, Nigeria, and the United States of America (USDA, 2017). At the same time, the increase in peanut production has also increased the production of

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http://dx.doi.org/10.1016/j.fbp.2017.08.001
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peanuts byproducts from the processors, encouraging further studies for the use of these residues that are rich in bioactive compounds.

The increased demand for healthier foods with lower levels of chemical additives has stimulated research on new food additives. Peanuts byproducts may play an important role due to their remarkable antioxidant and antimicrobial activities. However, these properties may vary according to the cultivar tested, as well as the extraction and drying processes, encouraging further studies with this approach (Chukwumah et al., 2009). During the processing of peanuts, high amounts of byproducts are produced, which mainly come from the skin of the peanuts. Data from the literature show that the alcoholic extracts of peanut skins are rich in phenolic compounds, which are responsible for the intense reddish color of the extract, as well as for the antimicrobial and antioxidant activities (Yu et al., 2006, 2010; Constanza et al., 2012; Nepote et al., 2002). In addition, a recent study showed that peanut skin polyphenols are able to reduce plasma fatty acid levels in rats (Bansode et al., 2014). In another approach, Dean et al. (2016) reported the successful application of dried peanut skin extracts to improve the antioxidant content in milk chocolate. These data reinforce the potential of this byproduct in production of natural food additives and application in new functional foods. However, there are few studies in the literature evaluating the antimicrobial and antioxidant activities in dried extracts, and these are the materials with the highest potential for food application. Thus, this study aimed to produce a dried extract from the peanut skin using the spray-drying technology and to evaluate the processing conditions: powder characteristics, antimicrobial and antioxidant activities, and the stability of the phenolic compounds.

2. Material and methods

2.1. Materials

The peanut skins used in this study were obtained from the cultivar runner IAC866 by the blanching process and kindly donated by Coplana (Jaboticabal, Brazil). The material was vacuum packaged in polyethylene films and stored at −20 °C. Maltodextrin DE10 was used as carrier and kindly donated by Ingredion (Mogi-Guaçu, Brazil).

2.2. Production of a peanut skin extract

Bioactive compounds were extracted from peanut skins as follows. 1 g of peanut skins was weighed, dispersed in 10 ml of 80% ethanol aqueous solution, and heated at 60 °C for 50 min in the dark. Next, the mixture was submitted to ultrasound for 15 min, filtered, and centrifuged at 6000 rpm for 15 min (Eppendorf, Hamburg, Germany) to remove the remaining solids. The supernatant was filtered once again on Whatman N° 3 paper and then concentrated in a rotatory evaporator (TE-211 Tecnal Piracicaba, Brazil) at 60 °C to be reduced to 20% of the initial volume. The extract was stored in amber vials at −20 °C until subsequent analyses. For comparison purposes, part of the extract was freeze-dried (LC 1500 Terroni, São Carlos, Brazil) for 24 h and designated as powder 1 (F1). The physical–chemical composition of the concentrated extract is shown in Table 1.

2.2.1. Spray-drying

The peanut skin extracts obtained in Section 2.2 were atomized in a spray-dryer equipment (Model MSD 5.0, Labmaq, Ribeirão Preto, Brazil) with a 2.0 mm nozzle, air flow at 40 l/min, and 44 ml/min of feed flow (controlled by peristaltic pump). Three feeds were prepared by mixing the extract with 10, 20, and 30% of maltodextrin (w/w), and each feed was atomized at 130, 150, and 170 °C, resulting in nine powders (Table 2), which were produced as independent duplicates.

Table 1 – Protein, reducing sugars, lipids, ash and moisture contents (g/kg, on a wet basis) and pH of the concentrated extract.

Parameter evaluated	Mean value ± standard deviation	Method of analysis
Protein content (%)	0.24 ± 0.01	A.O.A.C. (2005)
Reducing sugars content (%)	2.31 ± 0.07	Miller (1959)
Ash content (%)	0.09 ± 0.03	A.O.A.C. (2005)
Lipids (%)	1.41 ± 0.09	Bligh and Dyer (1959)
Moisture (%)	90.93 ± 0.04	A.O.A.C. (2005)
pH	5.30 ± 0.11	Potentiometer

Table 2 – Drying temperatures and percentage of maltodextrin of formulations used for dehydration processes. Formulation F1 was freeze dried and formulations F2–F10 were obtained by spray-drying technology.

Formulation	Drying temperature (°C)	Ratio maltodextrin:extract (m/m)
F1	Freeze-dried (control)	0:100
F2	130	10:90
F3	130	20:80
F4	130	30:70
F5	150	10:90
F6	150	20:80
F7	150	30:70
F8	170	10:90
F9	170	20:80
F10	170	30:70

2.3. Powder characterization

2.3.1. Moisture content and hygroscopicity

A moisture analyzer (MB35 Ohaus, Nanikon, Switzerland) with infrared radiation was used to determine the moisture content of powders obtained in Section 2.2.1. The powders were also analyzed with regard to the hygroscopicity, as proposed by Cai and Corke (2000) with modifications. For this, 0.5 g of the powders were dispersed on Petri dishes and incubated for 7 days under controlled conditions (relative humidity of 75.3%) in a desiccator at 25 ± 1 °C. Thus, the hygroscopicity was determined by measuring the water absorbed by the samples after 7 days and expressed as g of absorbed water per 100 g of powder, considering the dry matter of each powder.

2.3.2. Solubility

The solubility of the powders was evaluated according to the method proposed by Eastman and Moore (1984), and modified by Cano-Chauca et al. (2005). For this, 0.5 g of the powders were added to 50 ml of distilled water and stirred at 100 rpm for 30 min, followed by centrifugation at 3000 rpm for 5 min. Subsequently, an aliquot of 25 ml of the supernatant was removed and heated at 105 °C until a constant weight was reached. The solubility was calculated based on the initial sample mass that was solubilized in 25 ml of supernatant, and the results were expressed as percentage.

2.3.3. Particle sizing of spray-dried powders

Volume mean diameters (D4,3) of spray dried powders produced in Section 2.2.1 were evaluated by laser diffraction (Sald-201V, Shimadzu, Tokyo, Japan), using isopropanol as the dispersion medium.

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