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ANTIOXIDANT CAPACITY OF PULP OF *MANGIFERA INDICA* L. (VARIETY "TYPE CLASS") DEHYDRATED EMPLOYING SPRAY DRYING

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Abstract

Tropical and subtropical countries are producers of a wide variety of fruits, including mango, which is a source of bioactive compounds. The main goal of this work was evaluate the antioxidant capacity of mango pulp (*Mangifera indica* L) variety "type class" dehydrated using the spray drying technique. Mango fruits were collected from Turbana – Colombia. Then, dehydration process of mango pulp was made through spray drying method and the antioxidant activity was evaluated by different techniques such as total phenols, DPPH, and ABTS. The IC_{50} values for DPPH and ABTS assay were found to be 112.36±1.00 and 66.22±1.10 µg/mL respectively. This finding suggest that the spray drying technique could be employed as an alternative to microencapsulate compounds with antioxidant activity.

Keywords: *Microencapsulation, bioactive, Spraydrying, Phenols*

Introduction

The tropical and subtropical countries are producers of a great variety of fruits that by their exotic characteristics of aromas, flavors, and nutritional contents are highly appreciated by the food industry, for the development of new techniques through which healthy products of excellent quality can be obtained with varied sensorial characteristics and easy use. However, most of these fruits depend on the seasonality in the crops and high perishability, because their water contents are susceptible to the deterioration by enzymatic reactions, chemical, and microbial action [1-3]

Within this large group are found the class mangoes, these have bioactive compounds such as polyphenolic compounds, carotenoids, vitamins E and C [2]. Antioxidants compounds are key considering that they prevent harmful effects caused by oxidative stress and act as free-radical scavengers or metal-chelating agents [4,5]. However, mangoes are fruits susceptible to injuries; therefore, they need special care during storage and commercialization [1]. It must be mentioned that the most of mangoes fruits availability is determined by the seasonality in the crops and high perishability caused by chemical and enzymatic reactions, microbial growth, which produce fuits economic losses [3].

The drying of fruits is a technique used to reduce water inside food product, the production of fruit powder can be an interesting approach to reduce costs of packaging, storage and transportation and extent the fruit shelf-life [6]. Although there are high variety of drying techniques available for industrial applications, spray drying is the most economic drying technique due to its low operational costs; moreover, this technique maintains the fruit quality by rapid dehydration [7-12].

Different studies have been carried out about the mango drying. For example, Zotarelli et al., [13] studied the mango powder production by spray drying and cast-tape drying. Caparino et al., [14] assess the effect of drying on some physical and microstructural properties of mango. Nevertheless, the antioxidant capacity of mango pulp has not been determined yet. Therefore, the aim of this study was determinate the antioxidant capacity of mango pulp microencapsulated by means of spray drying.

Methods

Obtaining the pulp of the mango type class

The class variety mangoes were collected in the town of Turbana, located in the north of the department of Bolívar (10°16'22" north latitude and 75°26'38" west longitude). 5.6 kilograms were purchased on a particular plot. The mangoes were selected taking into account that they were free of external damages and had commercial maturity; they were washed and blanched at 90°C for 5 min. The pulps were obtained [2, 15, 16].

Microencapsulation of the pulp

Microencapsulation was performed by taking 300 g of maltodextrin which were added to 700 g of mango pulp with constant agitation. The preparation was homogenized with ultra-turrax ultraturrax IKA T-10 basic at 14000 rpm for 15 minutes and it was stored at 4°C until being fed to the spray dryer [7].

Spray drying of the pulp

The mixture was fed to a buchi mini spray dryer model B-290 (BÜCHI Labortechnik, Germany). The inlet and outlet temperature was maintained between 170°C ± 5°C and 70°C ± 5°C, respectively. The obtained microcapsules were collected in a self-sealing polyethylene package and stored in a room with humidity and temperature controlled at 45% and 20±5°C [2]. Subsequently, the samples were homogenized and tested for vitamin C content (ascorbic acid) by the iodometric titration method [2]. The contents of crude fiber, ash, fat, carbohydrates, and protein were determined

according to the methodology described by Morillas and Delgado [17].

Determination of minerals

The dry and calcined samples (ash) were treated with HCl according to the method recommended by the AOAC. The phosphorus, calcium, and iron minerals were determined by the atomic absorption spectrophotometry [17].

Particle Size

For the measurement of the particles a NIKON ECLIPSE E-100 microscope (40X lens) was used. Very small samples of microcapsules were placed on boxes for objects that later were placed in the grid of the equipment. The morphology, size, and edges of the particles were observed [4].

Measurement of antioxidant activity

To determine the antioxidant activity of the microcapsules, three methodologies were used: total phenols, 1,1-diphenyl-2-picrylhydrazyl radical ($DPPH^{\bullet}$), and 2,2'-azino-bis- (3-ethylbenzothiazoline)-6 ($ABTS^{+}$).

Determination of the total phenols

The total phenol content was determined by the Folin-Ciocalteu colorimetric method. A mixture of phosphowolfroic and phosphomolybdic acids in basic media was used as reagents, which were reduced by oxidizing the phenolic compounds, resulting in blue oxides of tungsten (W_8O_{23}) and molybdenum (Mo_8O_{23}). A standard curve was constructed using as standard gallic acid between 50-500 µg/mL. The corresponding extract was diluted to a concentration at which the phenol content would be within the range of the standard curve. The results were expressed as mg gallic acid/250 mL sample. The absorbance readings were performed at 760 nm on a Thermo Scientific ™ visible UV spectrophotometer GENESYS 10S [18-20].

DPPH• radical method

The scavenging activity of DPPH free radicals was determined using the method described by Leon et al., [21]. 75 µl of sample were added to 150 µL of a methanolic solution of DPPH• (100 µg/mL) and incubated at room temperature for 30 minutes, after which the disappearance of the DPPH radical was spectrophotometrically determined at 550 nm in reader of microplates multiskan ex (Thermoscientific). Ascorbic acid was used as a positive control for the uptake of DPPH• radicals (25 µg / mL). The IC_{50} was determined by evaluating several serial concentrations of the sample by linear regression analysis. The results were expressed as the mean ± S.M. of the percentage of uptake of the DPPH• radical relative to the control group [22].

$ABTS^{\cdot+}$ radical method

The free radical scavenging activity ABTS was determined using the method described by Leon et al., [21]. The ABTS radical was formed following the reaction of ABTS 3.5 mM with 1.25 mM of potassium persulfate (final concentration). The samples will be incubated between 2-8°C and in the dark for 16-24h. Once the ABTS radical was formed, it was diluted with ethanol until an absorbance of 0.7 ± 0.05 at 734 nm was obtained. At a volume of 190 µL of the ABTS• radical dilution 10 µL of the sample under study was added and incubated at room temperature for 5 minutes, after passing this time the disappearance of the ABTS radical at 734 nm was spectrophotometrically determined in the multiskan ex microplate reader (Thermoscientific) [22].

Statistical analysis

All the trials were performed by sextupled. The results were expressed as the mean ± SD (standard deviation). The significant differences were determined by ANOVA analysis followed by Dunnett's or Tukey's test, or as appropriate.

Results

The mango pulp could be microencapsulated by the spray drying method, retaining its antioxidant properties and with an efficiency of 97.5% ± 0.20% The particle size of the microcapsules was 5.0 ±

1.58 µm, this being a suitable size to maintain stability and preserve the effectiveness of the product. The chemical characterization is presented in Table 1.

The phenolic compounds quantified in fruit extracts are of great importance because they constitute a group of secondary metabolites that are considered natural antioxidants with multiple biological benefits for humans, such as the prevention of cardiovascular and degenerative diseases. The antioxidant activity of the mango is shown in Table 2.

Discussion

The spray drying is dehydration process usually employed to protect labile compounds from deleterious environmental conditions. The particles powder obtained showed a spherical structure with regular surfaces which can be desirable for the stability of trapped substances as well as to control the release of some ingredients [19]. Powder chemical characterization of mango pulp (*M. indica* L. "type class") was carried out considering parameters such as moisture, protein, ash, vitamin C, calcium, fiber, carbohydrates and iron. When both air temperatures (inlet and outlet) increased, the moisture decreased too (2.22 %) as a result of the dehydration process and mass transfer [2]. Similar reported were published by Patil et al., [23], found that the increase in the inlet temperature and the maltodextrin concentration significantly decreased the moisture of the product obtained. Krishnaiah et al., [24], also found that for the powder of the extract of *Morinda citrifolia* obtained by spray drying, the humidity decreased with the increase in the inlet and outlet temperatures of the process, attributing this also to higher heat transfer rates, providing a greater driving force for moisture evaporation.

It is important determinate the amounts of minerals inside fruits due to they play an interesting role in human diet. It is well known that fruits composition depends on geographical origin [17]. The order of importance of the minerals found in the mango pulp was as follows: calcium> phosphorus> iron.

The IC_{50} values for the DPPH and ABTS assay were 112.36 µg/mL and 66.22 µg/mL respectively. This antioxidant activity could be related to the total phenols contents. It should be mentioned that internal and external factors such as: genetic diversity (variety and origin of the sample) and environmental variables (light intensity, climate, and temperature among others) can affect the amounts of phenolic compounds into the plants [22]. Although, it is important mention the thermal degradation effect on labile compounds due to some of them can undergo structural changes such as: loss of one or more atoms of the fundamental structure which result in the loss of essential properties [19, 20]. In this work it was noted that the dehydration process does not affect the antioxidant activity of the Mango pulp, furthermore, antioxidant results are higher than those obtained for the positive control (Ascorbic acid)

The technique employed (spray drying) was suitable in order to improve the antioxidant activity of Mango pulp due to higher values were obtained. These results could likely contribute to the industrial applications of Mango pulp in the development of new alimentary products with content of antioxidants.

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Table 1. Chemical characterization of the microcapsules of pulp of *M. indica* L variety type class, cultivated in the north of the department of Bolívar - Colombia.

Parameters evaluated	*M. indica* variety type class (mean ± SD)*
	Quantity 100 g
Ash (g)	0.5±0.25
Moisture (g)	2.22±0.10
Protein (g)	0.7±0.20
Fat (g)	0.01±0.01
Crude fiber (g)	1.70±0.22
Carbohydrate (g)	94.87±0.10
Vitamin C (g)	16.22±0.25
Calcium (mg)	13.22±0.22
Phosphorus (mg)	10.35±0.31
Calcium (mg)	13.89±0.33
Iron (mg)	0.35±0.12
Particle Size (µm)	5.0±1.58

*n = 3

Source: By the authors

Table 2. Antioxidant activity of the microcapsules and pulp of M. indica L variety type class, cultivated in the north of the department of Bolívar – Colombia

Parameters evaluated	Pulp of *M. indica* L mean ± SD*	Microcapsules of pulp of *M. indica* L Mean ± SD*	Positive control (Ascorbic acid) Mean ± SD*
$DPPH^{\bullet}$ IC_{50} (µg/mL)	96.09±1 .10	112.36±1.00	15.02±0.50
$ABTS^{\bullet+}$ IC_{50} (µg/mL)	49.82±1.10	66.22±1.10	3.10±0.60
Total phenols (mg AG / 100mg microcapsules)	86.20±1.20	74.12±1.12	--

*n=3

Source: By the authors