

Original Article

MICROENCAPSULATION OF PULP OF *MANGIFERA INDICA* L. BY SPRAY DRYING AND ANTIOXIDANT ACTIVITY

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ABSTRACT

Objective: The objective of this study was to microencapsulate mango pulp (*Mangifera indica* L) flounder variety by the spray drying method and to evaluate its potential antioxidant activity.

Methods: The fruits were collected in the municipality of Turbana-Bolívar (10 ° 16 '22 "N 75 ° 26' 38" W), Colombia. The pulps obtained from the healthy fruits were microencapsulated by the spray drying method. The obtained microcapsules were measured the particle size and the mineral content was determined. The antioxidant activity was determined by three methodologies: total phenols, DPPH•, and ABTS••.

Results: The results obtained demonstrate that the microcapsules of the mango pulp (*M. indica* L) have a mineral content in the following order of importance calcium>phosphorus>iron. The IC₅₀ values for the DPPH• and ABTS•• assay were found to be 110.54±1.50 µg/ml and 65.33±1.00 µg/ml respectively. The total phenol content was 73.11±1.54 mg AG/100 mg of microcapsules, which may be related to the antioxidant activity.

Conclusion: The spray drying method was a suitable technique to microencapsulate the mango pulp (*M. indica* L), which was shown to possess antioxidant activity.

Keywords: Microencapsulation, *Mangifera indica*, Spray drying, Phenols

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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 [1-5].

Within this large group are found the chancleta mangoes, which national production reaches considerable volumes in periods of harvests, however, these are lost due to lack of technical assistance, due to transportation difficulties, and inadequate postharvest handling, generating large economic losses [6-7].

The drying of fruits is an increasingly used technique, which seeks to reduce the water content of products with humidity higher than 80%, and thus achieve to prolong its shelf life. However, the dehydration techniques are very varied, and the quality of the dehydrated products depends fundamentally on the drying method applied. The powders obtained by spraying represent a viable alternative to obtain products of high commercial value due to the reduction of weight, ease of preservation, product quality in general, and by the diversity in its use [8-10]. The powder formulation facilitates the transport and preserves the product from the bacterial degradation by

drastically reducing the water activity increasing the shelf life of the product. This process is presented as an option since it is desirable to retain most of the organoleptic and nutritional properties of the concentrate [11-13].

Currently, the powdered foods made from fruits and vegetables with good nutritional and hydration properties are of interest at industrial and commercial level. Accordingly, the objective of this research was to microencapsulate the mango pulp (*M. indica* L) chancleta variety by the spray drying method and to evaluate its potential antioxidant activity.

MATERIALS AND METHODS

Chemicals and reagents

Maltodextrin, ascorbic acid, HCl, phosphowolfric acid, phosphomolybdic acid, gallic acid, potassium persulfate, ethanol, were donated by the faculty of pharmaceutical sciences of the University of Cartagena.

Obtaining the pulp of the mango variety chancleta (*M. indica* L)

The chancleta 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 through a mesh refiner of 1.5 mm of the aperture; they were packed in airtight bags and then cooled to a temperature of 4 °C [14].

Microencapsulation of the pulp

Microencapsulation was performed by taking 300 g of maltodextrin which was 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 min and it was stored at 4 °C until being fed to the spray dryer [4].

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 were 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 [15-19]. 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 [2].

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 [15-18].

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 [2].

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[•]), and 2,2'-azino-bis-(3-ethyl-benzothiazoline)-6 (ABTS^{•+}).

Determination of the total phenols

The total phenol content was determined by the Folin-Ciocalteu colourimetric method. A mixture of phosphomolybdic and phosphomolybdic acids in basic media was used as reagents, which were reduced by oxidizing the phenolic compounds, resulting in blue oxides of tungsten (W₈O₂₃) and molybdenum (Mo₈O₂₃). 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 [20-21].

DPPH[•] radical method

The scavenging activity of DPPH free radicals was determined using the method described by Silva *et al.* [22], with some modifications. 75 µl of sample was added to 150 µL of a methanolic solution of DPPH[•] (100 µg/ml) and incubated at room temperature for 30 min, after which the disappearance of the DPPH radical was spectrophotometrically determined at 550 nm in the reader of microplates multiskan ex (Thermoscientific) [23-26]. Ascorbic acid was used as a positive control for the uptake of DPPH[•] radicals (25 µg/ml). The IC₅₀ was determined by evaluating several serial concentrations of the sample by linear regression analysis. The results were expressed as the mean±SD of the percentage of uptake of the DPPH[•] radical relative to the control group.

ABTS^{•+} radical method

The free radical scavenging activity ABTS was determined using the method described by Re *et al.* [27], with some modifications. The ABTS radical was formed following the reaction of ABTS 3.5 mmol with 1.25 mmol 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 min, after passing this time the disappearance of the ABTS radical at 734 nm was spectrophotometrically determined in the multiskan ex-microplate reader (Thermo scientific) [28-30].

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 spray drying technique is based on the entrapment of the essential oil compounds on a solid matrix of starches to reduce their mobility. Fig. 1 shows the microencapsulation process of the mango pulp.



Fig. 1: Microencapsulation process by a spray dryer

Microcapsules obtained by spray-drying showed a spherical and smooth shape (fig. 2). The presence of rounded and smooth spheres, as shown, is desirable for the stability of the ingredients, and to control their release and to facilitate their solubility, properties that improve the effectiveness of the active ones when being incorporated in different complex matrices.

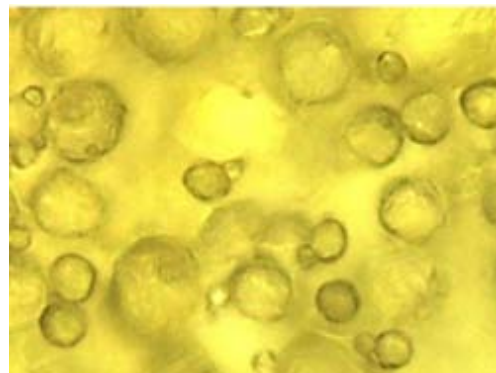


Fig. 2: Photograph of microcapsules of mango pulp, taken from NIKON ECLIPSE E-100 microscope (40X lens)

The chemical characterization of the microcapsules of the pulp *M. indica* L chancleta variety cultivated in the north of the department of Bolívar-Colombia was carried out taking into account parameters such as ash content, moisture, protein, fats, fiber, carbohydrates, vitamin C, calcium, phosphorus, iron, and particle size, the results

are shown in table 1. The increase in the inlet (170 °C) and outlet (70 °C) temperatures of the air decrease the moisture of the product

by 1.86% which shows that as these temperatures increase, the rates of mass transfer and heat increase [4].

Table 1: Chemical characterization of the microcapsules of pulp of *M. Indica* L variety chancleta, cultivated in the north of the department of Bolivar - Colombia

Parameters evaluated	Chancleta (mean±SD)* Quantity 100 g
Ash (g)	0.39±0.06
Humidity (g)	1.86±0.06
Protein (g)	0.55±0.05
Fat (g)	0.01±0.01
Crudefiber (g)	1.07±0.12
Carbohydrate (g)	97.21±0.05
Vitamin C (g)	14.93±0.06
Calcium (mg)	11.63±0.55
Phosphorus (mg)	10.35±0.31
Iron (mg)	0.31±0.02
ParticleSize (µm)	5.92±2.18

*n = 3

Although the fruits are not rich in minerals, they play a very important role in the balance of the human diet, especially because the composition of fruits differs from other foods of animal or vegetable origin [2, 3, 14].

The order of importance of the minerals found in the mango pulp was as follows: calcium>phosphorus>iron.

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.

Table 2: Antioxidant activity of the microcapsules and pulp of *M. indica* L variety chancleta, cultivated in the north of the department of bolívar-colombia

Parameters evaluated	Pulp of <i>M. indica</i> L mean±SD*	Microcapsules of pulp of <i>M. indica</i> L mean±SD*	Positive control (Ascorbic acid) mean±SD*
DPPH• IC ₅₀ (µg/ml)	95.11±1.00	110.54±1.50	14.98±0.33
ABTS•+ IC ₅₀ (µg/ml)	48.75±0.90	65.33±1.00	3.00±0.50
Total phenols (mg AG/100 mg microcapsules)	85.00±1.00	73.11±1.54	---

*n=3

In fruits, it has been found that the main compounds present are mostly phenolic acids, flavonoids and tannins; however, phytochemicals such as vitamin C (ascorbic acid), folic acid (vitamin B), and β-carotene (provitamin A) are also been found, which makes it possible to establish that fruit consumption increases the intake of bioactive compounds with multiple properties for human health.

It is important to note that there are several internal and external factors that affect the quality and/or quantity of phenolic compounds in the plants, such as: the genetic diversity (variety and origin of the sample), stage of maturity, environmental variables (light intensity, climate, temperature, fertilizer use, wounds), method of extraction, processing, and storage [21].

The microcapsules studied showed a good antioxidant activity. The IC₅₀ values for the DPPH and ABTS assay found were 110.54±1.50 µg/ml and 65.33±1.00 µg/ml respectively. The antioxidant activity of these horticultural products can be related to the total phenols contents.

DISCUSSION

The mango pulp could be microencapsulated by the spray drying method, retaining its antioxidant properties and with an efficiency of 98%±0.50%. The particle size of the microcapsules was 5.92±2.18 µm, this being a suitable size to maintain stability and preserve the effectiveness of the product.

At present, several studies have focused on the drying of different types of fruits, in fact, during the process of obtaining guava powder

by spray drying, Patil *et al.* [31] found that the increase in the inlet temperature and the maltodextrin concentration significantly decreased the moisture of the product obtained.

Caliskan and Nur [32] reported consistent results, where the increase in inlet and outlet temperatures decreased the moisture content of the product due to high operating temperatures leading to high heat transfer values.

Krishnaiah *et al.* [33] 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.

Due to in the spray drying the heat is directly involved, the thermal degradation is the most important deleterious phenomenon, the loss or thermal degradation of antioxidant metabolites (ascorbic acid), which are thermolabile compounds [4, 34-35]. In the thermal degradation, the chemical compounds undergo significant changes in their structure (loss of one or more atoms of the fundamental structure) due to the action of high temperatures, resulting in a loss of the properties of compound [4]. However, ascorbic acid content ranging from 9.79 to 186 mg/100 g of mango pulp [7]. Moreira *et al.* (2001) [36] reported the content of ascorbic acid of 37 mg/100 g, values that are below the value reported in the present investigation. In this work it was observed that the microencapsulation process does not affect the antioxidant activity of the pulp of *M. indica* L, in addition, our results are higher than those obtained for the positive control (table 2).

The availability of maltodextrin in the product increases the structure of the granule giving rise to larger particles. Pang *et al.* [37] similarly discloses the increase in the size of the particles of the orthosiphon extract during spray drying as the concentration of maltodextrin increases.

On the other hand, Tonon *et al.* [38] reported that the increase in maltodextrin concentration from 10% to 30% produced larger particles in the acai powder (13,27 μm to 21,35 μm) obtained by spray drying, which attributed to the exponential increase in the viscosity of the feed liquid, which in turn causes larger droplets during the drying process.

The phenol content is related to the antioxidant activity; in fact, other studies indicate that the phenols act by the elimination of free radicals [39]. The content of phenol in the microcapsules was 73.11 ± 1.54 mg AG/100 mg microcapsules, this value is higher than reported in other studies for freeze-dried powder from *Syzygium cumini*, which was 13.99 mg GA equivalents/10 mg and is reported with a high antioxidant power [40].

CONCLUSION

Spray drying was a suitable technique for the dehydration of the mango pulp because it increased the chemical stability, improved the manipulation and conserved to a great extent the nutraceutical metabolites of the fruit. The results revealed that the percentage of preservation of ascorbic acid (vitamin C) of the mango after spray drying was higher than 65.

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AUTHOR CONTRIBUTION

All authors contributed equally

CONFLICTS OF INTERESTS

All authors have none to declare

REFERENCES

- Castro A, Cardozo J, Isaza L, López A, Rodríguez S. Propuesta para el desarrollo de un clúster frutícola en el departamento de Cundinamarca. [Tesis de Pregrado]. Bogotá. Universidad del Rosario; 2011. Disponible en: <http://repository.urosario.edu.co/bitstream/handle/10336/2279/1020734967-2011.pdf>. [Last accessed on 10 Jun 2017].
- Morillas-Ruiz JM, Delgado-Alarcon JM. Nutritional analysis of vegetable food with different origins: evaluation of antioxidant capacity and phenolic total compounds. *Nutr Clin Diet Hosp* 2012;32:8-20.
- Kuskoski M, Asuero A, Troncoso A, Mancini-Filho J, Fett R. Aplicación de diversos métodos químicos para determinar actividad antioxidante en pulpa de frutos. *Food Sci Technol* 2005;25:726-32.
- Zapata K, Cortes FB, Rojano BA. Polyphenols and Antioxidant Activity of Sour Guava Fruit (*Psidium araca*). *Inf Tecnol* 2013;24:103-12.
- Pennington J, Fisher R. Food component profiles for fruit and vegetable subgroups. *J Food Comp Anal* 2010;23:411-8.
- Quintero V, Giraldo G, Lucas J, Vasco J. Physicochemical characterization of the common mango (*Mangifera indica* L.) during the ripening process. *Biotechnol Sect Agropecu Agroind* 2013;11:10-8.
- Ribeiro SMR, Schieber A. Bioactive compounds in mango (*Mangifera indica* L.) bioactive foods in promoting health: fruits and vegetables. Chapter 34. Elsevier Inc; 2010. p. 507-23.
- Aguiar G, Favaro-Trindade C, Ferreira C. Microencapsulation of lycopene by spray drying: Characterization, stability and application of microcapsules. *Food Bioprod Process* 2012; 90:37-42.
- Ahmed M, Akter MS, Lee JCh, Eun JB. Encapsulation by spray drying of bioactive components, physicochemical and morphological properties from purple sweet potato. *LWT Food Sci Technol* 2010;43:1307-12.
- Esquivel-Gonzalez BE, Ochoa-Martinez LA, Rutiaga-Quinones OM. Microencapsulation of bio active compounds by spraydrying. *Rev Iber Tecnología Postcosecha* 2015;16:180-92.
- Ersus S, Yurdagel U. Microencapsulation of anthocyanin pigments of black carrot (*Daucus carota* L.) by a spray drier. *J Food Eng* 2007;80:805-12.
- Parra-Huertas RA. Revisión: microencapsulación de alimentos. *Revista Facultad Nacional Agronomía. Medellín* 2010;63:5669-84.
- Lopez O. Microencapsulation of oily substances by aspersion drying. *Rev Cubana Farm* 2010;44:381-9.
- Ramirez R, Arenas L, Acosta K, Yamarte M, Sandoval L. Effect of scalded on the nutritional quality pulp sour sop (*Annona muricata* L.). *Rev Iber Tecnología Postcosecha* 2012;13:48-57.
- Gil-Garzon M, Alzate-Tamayo L, Sanchez-Camargo A, Millan-Cardona L. Spray drying: an alternative to conserve bioactive and aromatic compounds from garlic extract (*Allium sativum* L.). *Re Lasallista Investig* 2011;8:40-52.
- Soottitawat A, Bigeard F, Yoshii H, Furuta T, Ohkawara M, Linko P. Influence of emulsion and powder size on the stability of encapsulated D-limonene by spray drying. *Innov Food Sci Emerg Technol* 2005;6:107-14.
- Bule MV, Singhal RS, Kennedy JF. Microencapsulation of ubiquinone-10 in carbohydrate matrices for improved stability. *Carbohydr Polym* 2010;82:1290-96.
- Pajaro-Castro NP, Leon-Mendez G, Osorio-Fortich MR, Torrenegra-Alarcon ME, Roperio J. Microencapsulation of *Cinnamomum verum* L. essential oil by spray drying and its potential antioxidant activity. *Rev Cubana Farm* 2017. [Article in Press].
- Matiz GE, Leon G, Fuentes K. Microencapsulation of essential oil of thyme (*Thymus vulgaris*) in polymer matrices of modified yam starch (*Dioscorea rotundata*). *Rev Colomb Cienc Quim Farm* 2015;44:189-207.
- Granados-Conde C, Torrenegra-Alarcon ME. Antioxidant activity and phenolic content of *Rheum rhabarbarum* petiole. *Rev Cubana Farm* 2016;50:1.
- Rojano BA, Vahos ICZ, Arbelaez AFA, Martinez AJM, Correa FBC, Carvajal LG. Polyphenols and antioxidant activity of the freeze-dried palm naidi (acai colombiano) (*Euterpe oleracea* Mart). *Ver Fac Nal Agr Medellín* 2011;64:6213-20.
- Silva BM, Andrade PB, Valentão P, Ferreres F, Seabra RM, Ferreira MA. Quince (*Cydonia oblonga* Miller) fruit (Pulp, Peel, and Seed) and Jam: antioxidant activity. *J Agric Food Chem* 2004;52:4705-12.
- Granados-Conde C, Torrenegra-Alarcón ME, Yanez-Rueda X. Evaluation of the antioxidant activity of essential oil of *Myrcianthes leucoxyla* obtained by two extraction methods. *Rev Cubana Farm* 2017;51:1.
- Granados-Conde C, Torrenegra-Alarcón ME, Yañez-Rueda X. Extraction, characterization and antioxidant activity of essential oil from *Eucalyptus globulus* Labill. *Rev Cubana Farm* 2017;51:356-66.
- Granados-Conde C, Torrenegra-Alarcon ME, Pajaro-Castro NP, Leon-Mendez G, Tejada C. Antioxidant activity of essential oil from *Matricaria chamomilla* L. *Rev Cubana Farm*. 2017;51:4-10.
- Granados-Conde C, Yáñez-Rueda X, Santafé-Patino GG. Evaluation of antioxidant activity of the essential oil of *Calycolpus moritzianus* y *Minthostachys mollis* of the North of santander (Colombia). *Bistua* 2012;10:12-23.
- Re R, Pellegrini N, Proteggente A, Pannala A, Yang M, Rice-Evans C. Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biol Med* 1999;26:1231-7.
- Leon G, Torrenegra M, Osorio MR, Gil J. Extraction, characterization and antioxidant activity of essential oil from *Plectranthus amboinicus* L. *Rev Cubana Farm* 2015;49:708-18.
- Granados C, Santafe GG, Acevedo D. Chemical composition and evaluation of antioxidant activity of leaf essential oil *Eucalyptus*

- camaldulensis* from norte de santander (colombia). Rev U. D. C. A Act Div Cient 2015;18:235-40.
30. Granados C, Yáñez Y, Acevedo D. Evaluation of antioxidant activity of the essential oil of *Myrcianthes leucoxyla* from norte de santander (Colombia). Inf Tecnol 2014;25:11-6.
 31. Patil V, Kumar ChA, Pratap SR. Optimization of the spray-drying process for developing guava powder using response surface methodology. Powder Technol 2014;253:230-6.
 32. Caliskan G, Nur DS. The effects of the different drying conditions and the amounts of maltodextrin addition during spray drying of sumac extract. Food Bioprod Process 2013; 91:539-48.
 33. Krishnaiah D, Sarbatly R, Nithyanandam R. Microencapsulation of *Morinda citrifolia* L. extract by spray-drying. Chem Eng Res Des 2012;90:622-32.
 34. Mendoza FA, Arteaga M, Pérez O. Behavior of vitamin C in a product based on whey and variety Magdalena River mango (*Mangifera Indica*) during spray drying. Rev Chil Nutr 2016;43:159-66.
 35. Ungar Y, Osundahunsi OF, Shimoni E. Thermal stability of genistein and daidzein and its effect on their antioxidant activity. J Agric Food Chem 2003;51:4394-9.
 36. Moreiras O, Carbajal A, Cabrera L, Cuadrado C. Tablas de composición de alimentos. Ediciones Piramide. Madrid. España; 2006.
 37. Pang SF, Yusoff MM, Gimbin J. Assessment of phenolic compounds stability and retention during spray drying of *Orthosiphon stamineus* extracts. Food Hydrocolloids 2014;37:159-65.
 38. Tonon R, Brabet C, Hubinger M. Influence of process conditions on the physicochemical properties of acai (*Euterpe oleraceae* Mart.) powder produced by spray drying. J Food Eng 2008;88:411-8.
 39. Goveas S, Abraham A. Evaluation of antimicrobial and antioxidant activity of stem and leaf extracts of *Coscinium fenestratum*. Asian J Pharm Clin Res 2013;6:218-21.
 40. Jebitta R, Allwin J. Antioxidant activity, total phenol, flavonoid, and anthocyanin contents of Jamun (*Syzygium cumini*) pulp powder. Asian J Pharm Clin Res 2016;9:361-3.