EFFECT OF PROCESSING CONDITIONS ON PHYSICOCHEMICAL PROPERTIES OF SPRAY-DRIED Spondias tuberosa Arr. Cam. Fruit Powder

M.I.S. Maciel¹, M.M.B. Souza², M.E. Silva Júnior³, A.M.P. Santos⁴

¹- Department of Home Science - Federal Rural University of Pernambuco, Graduate Program in Food Science and Technology - CEP: 52171-900 - Recife - PE - Brazil, Phone: 55 (81) 3320-6536 - Fax 55 (81) 3320-6540 - e-mail (m.inesdcd@gmail.com)

²- Technology Center - Federal University of Paraíba, Graduate Program in Food Science and Technology - CEP: 58051-900 - Paraíba - PB - Brazil, Phone: 55 (81) 8716-0364 - e-mail (michelle-mmbs@hotmail.com)

³- Department of Home Science - Federal Rural University of Pernambuco, Graduate Program in Food Science and Technology - CEP: 52171-900 - Recife - PE - Brazil, Phone: 55 (81) 8557-8554 - e-mail (marcony172009@hotmail.com)

⁴- Technology and Geoscience Center - Federal University of Pernambuco, Course of Food Engineering - CEP: 50711-970 - Recife - PE - Brazil, Phone: 55 (81) 2126-8214 - e-mail (lia_pinheiro@yahoo.com.br)

ABSTRACT – This study was aimed to select the best umbu drying condition powder using the response surface methodology (RSM). The independent variables were inlet air temperature (90 to 190 °C), feed flow rate (0.2 to 1.0 L/h⁻¹) and maltodextrin 10 DE concentration (10 to 30%). The responses evaluated to select the best drying condition were water activity, moisture, hygroscopicity and retention of total phenolics. Statistical analysis showed that the best condition of the spray drying umbu powder was obtained at a temperature of 110 °C, the feed flow rate of 0.84 L/h⁻¹ and 10% of maltodextrin 10 DE.

PALAVRAS-CHAVE: Spondias tuberosa Arr. Cam.; spray drying; maltodextrin 10 DE.

INTRODUÇÃO

Spondias tuberosa Arruda, Cam. "Umbuzeiro" is a plant species endemic to the Caatinga biome (a semi-arid region of Brazil) and this plant is a source of sustenance for small-plot farmers during the dry season. One of the most important from the Anacardiaceae family, the genus Spondias comprises approximately 8 to 12 species. It can be found in regions of the Agreste (Piauí), Cariris (Paraíba), Caatinga (Pernambuco and Bahia) and the North and Northeast of Minas Gerais. The importance of
their roots was called "sacred tree of the Wild" by the famous writer Euclides da Cunha. The fruit of umbuzeiro is an ellipsoidal drupe, glabrous or slightly hairy, with thick epicarp, yellow - green in color and flesh ranging from thin to thick, white - green in color, soft and juicy. The endocarp is a very resistant seed with varying size. The weight of the fruit varies from 8 to 23 g, consisting of 22% bark, 68% pulp and 10% seed. The pulp is white-green, soft, juicy and generally have aroma and sharp acidity, is Rich in ascorbic acid, mineral salts (calcium, potassium and magnesium) and source of tannins and phenolic compounds (Neto et al., 2012; Silva et al., 2014). Due to its pleasant acidic taste and rich aroma, it is used as food resource for producing candy, gelly, ice cream and juices or cooked with milk and sugar to make the traditional "umbuzada" or even consumed as fresh fruit. However, its high perishability requires the use of technologies aimed at increasing its shelf life.

Among the several drying technologies spray drying is one method that is widely used to produce fruit juice and pulp powders. The final characteristics of the powder product obtained in a spray drying process depend on some process variables, such as characteristics of the atomized liquid type and operating mechanism of the atomizer, drying air characteristics, solids concentration and also the type of carrier agent (Silva et al., 2014; Tonon et al., 2010).

Several carrier agents have been used in spray drying, with maltodextrin and gum arabic major encapsulants used in drying fruit juices (Phisut, 2012). Researchers have mentioned to the good potential of maltodextrin 10, 15, and 20 DE, to be applied as encapsulating wall materials in spray drying of fruit pulp. Our research group had experimented spray drying umbu pulp using the carrier agent maltodextrin 15 DE (Silva et al., 2014), however the aroma decreased. So, we thought it was worthwhile to study the potential of maltodextrin 10 DE, as a carrier agent in the process of spray drying umbu pulp in order to obtain the powder with a better aroma.

2. MATERIAL AND METHODS

2.1 Materials

Ripe umbus were acquired from the Supply and Logistics Center of Pernambuco (Pernambuco, Brazil). They were selected, washed in running water, sanitized and pulped. Pulp was frozen stored (-22 °C) in polyethylene bags, being thawed according to the quantity required for each test. The carrier agent used was maltodextrin 10 DE MOR-REX 1910 (Corn Products, Mogi Guacu, Brazil).

2.2 Sample Preparation and Spray Drying

The pulp was sifted to eliminate particles whose diameter was greater than the diameter of the nozzle atomizer to facilitate passage. Maltodextrin 10 DE, at concentrations calculated on the basis of the weight of the sieved pulp was added to the pulp stirred until complete dissolution. Water (approximately 50% v/v) was added before the solution entered the atomizer. Spray drying process was performed in a laboratory scale spray dryer Labmaq model MSD 1.0 (Ribeirao Preto/SP, Brazil), with a 1.2 mm diameter nozzle. The mixture was fed into the chamber by the peristaltic pump, drying flow rate was 30 m³/h air flows and air compressor pressure was 0.6 bar.

2.3 Experimental Design

Response surface methodology was applied in this study with goal to optimize the simultaneous process variables (independent variables) to reached the best response (dependent variables). The study was carried out with the central composite rotatable design (CCRD) with 17 experimental combinations including six central point (Table 01). Select independent variables were: inlet air temperature (90 to 190 °C), feed flow rate (0.2 to 1.0 L h⁻¹) and carrier-agent concentration (10 to 30%
Responses factors (dependent variables) were: moisture content, water activity, hygroscopicity, phenolic compounds content.

Table 1 - Experimental design for spray drying runs with their corresponding response values

<table>
<thead>
<tr>
<th>Run</th>
<th>Inlet air temperature (°C)</th>
<th>Feed flow rate (L h⁻¹)</th>
<th>Maltodextrin 10 DE (%)</th>
<th>Water activity</th>
<th>Moisture content (%)</th>
<th>Hygroscopicity (g.100g⁻¹)</th>
<th>Retention of total phenolic (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 (110)</td>
<td>1 (0.36)</td>
<td>1(14)</td>
<td>0.21</td>
<td>3.24</td>
<td>22.92</td>
<td>61.17</td>
</tr>
<tr>
<td>2</td>
<td>1 (170)</td>
<td>1 (0.36)</td>
<td>1(14)</td>
<td>0.12</td>
<td>2.44</td>
<td>22.56</td>
<td>60.97</td>
</tr>
<tr>
<td>3</td>
<td>1 (110)</td>
<td>1 (0.84)</td>
<td>1(14)</td>
<td>0.20</td>
<td>4.32</td>
<td>22.39</td>
<td>67.40</td>
</tr>
<tr>
<td>4</td>
<td>1 (170)</td>
<td>1 (0.84)</td>
<td>1(14)</td>
<td>0.18</td>
<td>2.61</td>
<td>21.43</td>
<td>50.66</td>
</tr>
<tr>
<td>5</td>
<td>1 (110)</td>
<td>1 (0.36)</td>
<td>1(26)</td>
<td>0.20</td>
<td>3.33</td>
<td>13.62</td>
<td>32.39</td>
</tr>
<tr>
<td>6</td>
<td>1 (170)</td>
<td>1 (0.36)</td>
<td>1(26)</td>
<td>0.12</td>
<td>2.57</td>
<td>18.29</td>
<td>56.04</td>
</tr>
<tr>
<td>7</td>
<td>1 (110)</td>
<td>1 (0.84)</td>
<td>1(26)</td>
<td>0.18</td>
<td>4.20</td>
<td>14.13</td>
<td>49.85</td>
</tr>
<tr>
<td>8</td>
<td>1 (170)</td>
<td>1 (0.84)</td>
<td>1(26)</td>
<td>0.17</td>
<td>2.78</td>
<td>18.08</td>
<td>34.06</td>
</tr>
<tr>
<td>9</td>
<td>0 (140)</td>
<td>0 (0.6)</td>
<td>0(20)</td>
<td>0.15</td>
<td>2.43</td>
<td>18.60</td>
<td>42.71</td>
</tr>
<tr>
<td>10</td>
<td>0 (140)</td>
<td>0 (0.6)</td>
<td>0(20)</td>
<td>0.15</td>
<td>2.52</td>
<td>17.89</td>
<td>47.08</td>
</tr>
<tr>
<td>11</td>
<td>0 (140)</td>
<td>0 (0.6)</td>
<td>0(20)</td>
<td>0.15</td>
<td>2.37</td>
<td>17.96</td>
<td>48.80</td>
</tr>
<tr>
<td>12</td>
<td>-1.68 (90)</td>
<td>0 (0.6)</td>
<td>0(20)</td>
<td>0.23</td>
<td>4.26</td>
<td>17.85</td>
<td>52.56</td>
</tr>
<tr>
<td>13</td>
<td>1.68 (190)</td>
<td>0 (0.6)</td>
<td>0(20)</td>
<td>0.15</td>
<td>2.37</td>
<td>17.96</td>
<td>48.80</td>
</tr>
<tr>
<td>14</td>
<td>0 (140)</td>
<td>-1.68 (0.2)</td>
<td>0(20)</td>
<td>0.12</td>
<td>2.45</td>
<td>19.72</td>
<td>18.65</td>
</tr>
<tr>
<td>15</td>
<td>0 (140)</td>
<td>1.68 (1.0)</td>
<td>0(20)</td>
<td>0.17</td>
<td>2.05</td>
<td>17.26</td>
<td>33.62</td>
</tr>
<tr>
<td>16</td>
<td>0 (140)</td>
<td>0 (0.6)</td>
<td>-1.68(10)</td>
<td>0.19</td>
<td>2.33</td>
<td>21.11</td>
<td>57.65</td>
</tr>
<tr>
<td>17</td>
<td>0 (140)</td>
<td>0 (0.6)</td>
<td>1.68(30)</td>
<td>0.14</td>
<td>2.65</td>
<td>18.27</td>
<td>38.00</td>
</tr>
</tbody>
</table>

2.4 Statistical analysis
Experimental design and response surface analysis was performed using the Statistica 7.0 software (Stat Soft, Tulsa, USA) with 95% of confidence level.

2.5 Analysis of pulp
The water activity analyzer (Aqualab model 4TE) was used to determine water activity at 25 °C. The moisture content of powders was determined by using an electronic moisture analyzer (Mars model Idso, Brazil) at 105 °C. Phenolic compounds were extracted with distilled water according to the procedure described by Singleton et al. (1999). Total phenolic content was determined according to the methodology described by Wettasinghe and Shahidi (1999). The results express in mg equivalent of gallic acid by 100 grams of pulp.

2.6 Analysis of powder
Water activity: As described above
Moisture content: The moisture content of powders was determined by using an electronic moisture analyzer (Mars model Idso, Brazil). About 2 g was spread on an aluminum pan and placed in the analyzer. The sample was heated at 105 °C and evaporative moisture losses were reported automatically the percent moisture content.

Hygroscopicity: Was determined according to the method proposed by Cai and Corke (2000).
Total phenolic compounds: Phenolic compounds were extracted with distilled water according to the procedure described by Singleton et al. (1999). Total phenolic compounds content was determined by interpolating sample absorbance against the gallic acid calibration curve, according to the methodology described by Wettasinghe and Shahidi (1999). The results were converted to RPC terms using the dry mass of umbu pulp. Maltodextrin concentration was not used in the calculation.
3. RESULTS AND DISCUSSION

To start the study to assess the best conditions for obtaining the umbu powder, a characterization of the fruit in natura was held meeting the following conditions: moisture content 86.32 ± 0.10%, water activity 0.99 ± 0.01 and content of phenolic compounds 125.70 ± 0.55 mg gallic acid equivalent 100 g⁻¹. The analysis of the influence of variables in water activity, hygroscopicity, moisture and retention of total phenolics showed that for the variable water activity and moisture reaching close to the ideal values should be used inlet air temperature in the range 110 to 170 °C combined with a feed rate between 0.36 to 0.84 L h⁻¹. In the case of hygroscopic properties and retention of total phenolics only maltodextrin 10 DE concentration showed statistical significance in the range of 14 to 26%. ANOVA show that results are best explained by the determination coefficient and the calculated F, significant at p <0.05 for retaining total phenolics, hygroscopicity and water activity. Indicating that the models showed a good fit to the experimental data, low lack of fit with coefficients of determination (R²) of 0.915, 0.857 and 0.942 for the retention responses of total phenolics, hygroscopicity and water activity, respectively. The response surfaces due to the air inlet temperature, feed flow rate and concentration of maltodextrin DE 10 are shown in Fig. 1, 2 and 3 a-c.

Retention of total phenolics: According to the response surface (Fig. 1 a-c) maltodextrin 10 DE concentration exerted a significant influence on the retention of total phenolic compounds. Concentrations of 14 to 26%, resulted in higher retention of total phenolics from 57.65% to 67.40%. This behavior is due to the maltodextrin ability to seal and hold the active material within its structure during processing or storage and provides maximum protection of the active material against environmental conditions (Desai; Park, 2005). A similar result was observed by Silva et al. (2014) studied spray drying umbu with the encapsulating agent maltodextrin 10 DE. At 190 °C the preservation of phenolic compounds was affected even with application of 20% maltodextrin 10 DE. Silva et al. (2014) and Krishnaiah et al. (2012) reported that the phenolic compounds were preserved with maltodextrin at temperatures around 90 °C to 170 °C.

![Fig. 1](image1.png)  
**Fig. 1 - Effect of concentration of maltodextrin 10 DE, feed flow rate and inlet air temperature on the retention of phenolic compounds**

Hygroscopicity: According to the response surface (Fig. 2 a-c) the only variable that exercised influence on the hygroscopicity was the concentration of maltodextrin 10 DE. Smaller values of 13.62 g.100g⁻¹ to 19.72 g.100g⁻¹ of hygroscopicity are obtained with concentrations of 20% to 26% maltodextrin 10 DE. Demonstrating its effectiveness as a carrier agent being a material that exhibits low hygroscopicity at relative humidities below 50%. Similar results were observed by Tonon et al. (2009), Moreira et al. (2009) and Silva et al. (2014), they studied the spray drying in acai, acerola and umbu pulp, respectively, using maltodextrin 10, 15 and 20 DE.
Fig. 2 - Effect of concentration of maltodextrin 10 DE, feed flow rate and inlet air temperature on the hygroscopicity

Moisture content: The moisture content was not significantly influenced by the inlet air temperature, feed flow rate and concentration of maltodextrin 10 DE, by the analysis of the ANOVA. Results of all tests of umbu were within the established parameters for atomized products. According to Grabowsky et al. (2006) the maximum level desirable for moisture obtained by atomizing powder is 3.5%.

Water activity: The drying air temperature demonstrated significant effect on the water activity in function of the analyze of the response surface (Fig. 3 a-c). Increasing the air inlet temperature resulted in higher heat transfer rate for the particles, allowing quick removal of free water from the umbu powder. Smaller values for this variable was 0.12 to 0.20, obtained with temperature conditions of 110 °C to 170 °C. Demonstrating that this temperature range is ideal for obtaining umbu powder. Silva et al. (2014), Egual et al. (2014) and Fazaeli et al. (2012) studied the process of drying by atomization of umbu juice, hops and blackberry, reported a reduction of free water with increasing air inlet temperature.

Fig. 3 - Effect of concentration of maltodextrin 10 DE, feed flow rate and inlet air temperature on the water activity

4. CONCLUSION

The responses studied (water activity, hygroscopicity and retention of phenolic compounds) were significantly affected by operational conditions. Maltodextrin 10 DE was effective as a carrier because of its drying property and low diffusivity encapsulant moisture, allowing the use of higher temperatures in obtaining products with a lower water activity and more stable. Their addition decreased hygroscopicity and contributed to the preservation of the total phenolic compounds at temperatures of 110 °C to 170 °C, due to its low hygroscopicity at relative humidity less than 50% and the ability to seal and hold the active material within its structure during processing, providing protection to the material.
5. REFERENCES


