Effect of different ratios of maltodextrin/gelatin and ultrasound in the microencapsulation efficiency of turmeric oleoresin

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ABSTRACT

Despite of turmeric oleoresin having many advantages over ground turmeric roots, its sensitivity to light, heat and oxygen is a disadvantage. One approach to overcome this problem is microencapsulation. The objective of this work was to investigate the influence of different ratios of maltodextrin/gelatin used as wall materials, as well as the use of ultrasound during the emulsification step on encapsulation efficiency of turmeric oleoresin by freeze drying. The results showed that increasing gelatin concentration in the polymeric matrix increased the encapsulation efficiency of turmeric oleoresin (p < 0.05), whereas the maltodextrin content in the wall material did not show significant effect at a 5 % level of significance. On the other hand, the effectiveness of ultrasound to improve encapsulation efficiency was more pronounced for a higher content of maltodextrin in the wall material: for the encapsulant matrix formulated with 18 % maltodextrin and 6 % gelatin, the encapsulation efficiency increased from (81.1 ± 0.3) % without ultrasound to (90.4 ± 1.0) % when applying ultrasound. In the case of the encapsulant matrix formulated with 12 % maltodextrin and 6 % gelatin, the increase in the encapsulation efficiency was lower: (77.6 ± 0.4) % without ultrasound to (80.6 ± 0.1) % when applying ultrasound. These results indicate the effectiveness of gelatin as an encapsulant for turmeric oleoresin and that ultrasound may be particularly effective for improving the emulsification properties of maltodextrin.

Keywords: encapsulation; maltodextrin; gelatin; ultrasound; turmeric oleoresin

INTRODUCTION

Microencapsulation is a process in which one or more ingredients or additives are coated with a small and edible capsule. It can protect sensitive ingredients, such as flavoring materials, vitamins, oils and oleoresins, from deteriorative reactions or adverse environmental conditions. This technique seems to be useful to overcome limitations in the use of food ingredients, such as those concerning turmeric oleoresin, which despite having numerous advantages over the turmeric powder, is sensitive to light, heat, oxygen and pH variations [1].

The main emphasis of microencapsulation has been concentrated on improving the encapsulation efficiency and extending shelf-life of the products. The properties of the wall and core material as well as the emulsion characteristics and drying parameters are the factors that can affect the efficiency of encapsulation [2].

There are mainly two classes of wall materials available for use as encapsulating agents: carbohydrates, including modified starches and maltodextrins, cellulose derivatives, gums and cyclodextrins; and proteins, including whey proteins, caseinates and gelatin. Taking into account the selection of wall materials for encapsulation, maltodextrins represents good compromise between cost and effectiveness, in spite of presenting major shortcomings such as a virtual lack of emulsifying capacity and low retention of volatile compounds [3]. On the other hand, gelatin, when compared to maltodextrin, posses all the properties of an effective entrapping agent: high emulsifying activity, high stabilizing activity, and a tendency to form a fine dense network upon drying [4]. The screening of polymer blends that could result in higher encapsulating efficiency and lower cost than the individual biopolymers has been object of increasing interest [1].

The emulsification technique can influence and determine the final properties of the encapsulated powders in a number of different ways, including emulsion size, emulsion stability, powder particle size and size distributions [5]. Generally, emulsification is performed using mechanical agitation; however the emulsions can also be prepared with the aid of ultrasonic apparatus. The main advantages observed in emulsions obtained by application of ultrasound are good stability without addition of surfactants and the small size of the particles in suspension [6].
The objective of this work was to study the influence of different ratios of maltodextrin/gelatin used as wall materials and the effect of ultrasound application during the emulsification step on the encapsulation efficiency of turmeric oleoresin by freeze drying.

MATERIALS & METHODS

Material. The used wall materials included maltodextrin 10 DE (MorRex® 1910, Corn Products, Brazil) and bovine gelatin bloom value 240 (Gelita®, Brazil); the core material was turmeric oleoresin (OC-500, Agro-Industrial Olimpia Ltda., Olimpia, Brazil).

Preparation of homogenised emulsions. An experimental design was used to obtain the different proportions of maltodextrin and gelatin to study the turmeric oleoresin encapsulation by freeze-drying (Table 1). Maltodextrin and gelatin were dispersed in distilled water and mixed to form aqueous solutions containing different ratios of maltodextrin and gelatin. The gelatin was dissolved in distilled water at 60 °C. The solutions were cooled to room temperature, mixed and turmeric oleoresin was added into the solution at a 15% level (based on the weight of carrier materials). The mixtures were emulsified in a shear homogenizer (Turratec TE-102, Tecnal, Brazil) operating at 18,000 rpm for 15 min. After mechanical homogenization, the samples subjected to ultrasonic frequency were placed in ultrasonic bath for 15 min.

Freeze-drying of homogenized emulsions. The homogenised emulsions were frozen in Petri dishes at -38 °C for 24 hours and freeze-dried using a freeze-dryer (L101, Liobras, Brazil) at < -40 °C for 48 hours. For further experiments, the dried emulsions were converted into a fine powder by use of a pestle and mortar, packaged to prevent light incidence and stored over silica gel in desiccators at room temperature.

Moisture content. Moisture content of encapsulated powders was determined gravimetrically by oven drying at 105 °C for 6 hours [7].

Solubility. The powder solubility in water was determined according to Wang et al. [8]. The mixture of the powder in the water solution (0.3 % w/v) was gently stirred until solid solubilisation. The powder was considered soluble when the time of solubilisation was not greater than 5 min. The time necessary for complete microcapsule solubilisation was recorded.

Analysis of total curcumin content. The total curcumin content was determined following the method described by Chauhan, Singh and Agarwal [9]. A solution of turmeric oleoresin (0.01 mg/ml) in methanol was prepared and analyzed for curcumin content by measuring the absorbance at 425 nm with a spectrophotometer (SP-22, Biospectro, Brazil). Seven milligrams of microcapsules were taken in a 25 ml standard volumetric flask and the volume was completed using methanol. The solution was homogenized in a Vortex for 5 min, followed by centrifugation at 704 g for 10 min. The supernatant was then taken for measurement of absorbance at 425 nm. The curcumin content was determined using the standard curve.

Encapsulation efficiency. The encapsulation efficiency (EE%) was expressed as the curcumin retention in the freeze-dried powder and was calculated by using the following expression:

\[ EE\% = \frac{(C_e/C_0)}{100} \]  

where \( C_e \) is the curcumin content in the freeze-dried powder and \( C_0 \) is the theoretical curcumin content in the emulsion, before freeze-drying.

Statistical analysis. The response surface regression was carried out using MINITAB 16 (Minitab Inc., USA). All experiments were done in duplicate and average values are reported.

RESULTS & DISCUSSION

The resulting moisture contents, solubility in water and encapsulation efficiencies of freeze-dried powders are shown in Table 1. Moisture contents varied from 1.1 to 4.1 % (wet basis) and it is possible to observe that the samples with the highest gelatin content (6 %) presented the highest moisture percentages. The observed trend of increasing final moisture content in samples containing higher gelatin proportions may be related to the ability of gelatin to form a sponge-like structure when submitted to mechanical agitation and subsequent freeze-drying [10]. In fact, such a kind of structure was obtained when pure gelatin was tested as a wall material for turmeric oleoresin encapsulation.

In the solubility experiments, only the samples with higher gelatin percentage (formulations 10 and 11) were not soluble in water within 5 minutes of agitation. Both required approximately 15 minutes to become fully solubilized in water. The other samples (formulations 1 to 10) were completely soluble in water up to 4
...minutes. There was no solids deposition in solution after solubilisation and the colour of solutions was yellow and vivid. Data obtained in this study for the solubility in water may considered positive, since according to Meyers [11] encapsulated powders show a high performance when they release about 60 - 70% of the core material within 15 minutes of agitation.

The application of ultrasound was only significant for the encapsulating matrix consisting of 18% maltodextrin and 6% gelatin, reducing the solubilization time from 15.5 minutes (without ultrasound) to 12 minutes (with ultrasound).

The encapsulation efficiency varied from 50.8 to 81.1%. The results showed that increasing gelatin concentration in the polymeric matrix increased the encapsulation efficiency of turmeric oleoresin (p < 0.05), whereas the maltodextrin content in the wall material did not show significant effect at a 5% level of significance.

The maltodextrin does not have influence in the encapsulation efficiency probably due to its lack of emulsification and low film-forming capacity. Generally, in samples formulated with the same maltodextrin content, the encapsulation efficiency increased with the increase in gelatin content. Thus, the curcumin retention depended on the gelatin concentration in the emulsion (Figure 1).

Table 1. Influence of the wall material formulation on turmeric oleoresin encapsulation efficiency

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Maltodextrin (%)</th>
<th>Gelatin (%)</th>
<th>Powder moisture* (wt %)</th>
<th>Solubilization time* (min)</th>
<th>EE%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.6</td>
<td>0.9</td>
<td>1.8 ± 0.13</td>
<td>1.2 ± 0.20</td>
<td>57.8 ± 0.30</td>
</tr>
<tr>
<td>2</td>
<td>20.6</td>
<td>2.6</td>
<td>2.2 ± 0.12</td>
<td>3.0 ± 0.00</td>
<td>79.7 ± 0.30</td>
</tr>
<tr>
<td>3</td>
<td>28.1</td>
<td>0.9</td>
<td>1.2 ± 0.10</td>
<td>2.0 ± 0.13</td>
<td>50.8 ± 2.00</td>
</tr>
<tr>
<td>4</td>
<td>28.1</td>
<td>2.6</td>
<td>1.1 ± 0.07</td>
<td>3.6 ± 0.34</td>
<td>64.1 ± 0.30</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>1.8</td>
<td>1.5 ± 0.05</td>
<td>2.5 ± 0.09</td>
<td>58.6 ± 1.50</td>
</tr>
<tr>
<td>6</td>
<td>29.7</td>
<td>1.8</td>
<td>1.3 ± 0.06</td>
<td>3.8 ± 0.50</td>
<td>62.5 ± 2.50</td>
</tr>
<tr>
<td>7</td>
<td>24.4</td>
<td>0.5</td>
<td>1.4 ± 0.06</td>
<td>2.3 ± 0.11</td>
<td>65.3 ± 1.20</td>
</tr>
<tr>
<td>8</td>
<td>24.4</td>
<td>3</td>
<td>1.8 ± 0.00</td>
<td>1.3 ± 0.26</td>
<td>56.3 ± 3.10</td>
</tr>
<tr>
<td>9</td>
<td>24.4</td>
<td>1.8</td>
<td>1.4 ± 0.02</td>
<td>3.0 ± 0.00</td>
<td>54.8 ± 1.00</td>
</tr>
<tr>
<td>10</td>
<td>12</td>
<td>6</td>
<td>3.6 ± 0.04</td>
<td>15.1 ± 0.19</td>
<td>77.6 ± 0.40</td>
</tr>
<tr>
<td>11</td>
<td>18</td>
<td>3</td>
<td>4.1 ± 0.01</td>
<td>15.5 ± 0.22</td>
<td>81.1 ± 0.30</td>
</tr>
</tbody>
</table>

*Mean values ± standard error (n=2)

Figure 1. Effect of maltodextrin/gelatin proportions in (a) moisture content and (b) encapsulation efficiency of turmeric oleoresin.
Gelatin plays two major roles in the emulsification: on the one hand it lowers the surface tension between the interfaces that are formed during emulsification process and, on the other hand, it forms a macromolecular layer surrounding the dispersed particles which structurally stabilises the emulsions by reducing the rate of coalescence [4]. Furthermore, the blending of maltodextrin with an effective emulsifier, such as gelatin, results in a smaller droplet size in the emulsion and, consequently, the better encapsulation efficiency [12].

The increase in curcumin retention (EE%) in samples subjected to ultrasound during the emulsification step are shown in Figure 2. Emulsions obtained by the combination of mechanical homogenization and ultrasound resulted in higher curcumin retentions during freeze-drying.

The effectiveness of ultrasound in improving encapsulation efficiency was more pronounced when a higher content of maltodextrin was used in the wall material. For an encapsulant matrix formulated with 18 % maltodextrin and 6 % gelatin, the encapsulation efficiency increased from (81.1 ± 0.3) % without ultrasound to (90.4 ± 1.0) % when applying ultrasound, i.e. an increase of 11.5 %. In the case of an encapsulant matrix formulated with 12 % maltodextrin and 6 % gelatin, the increase in the encapsulation efficiency was lower: (77.6 ± 0.4) % without ultrasound to (80.6 ± 0.1) % when applying ultrasound, what represents an increase of only 3.9 %.

![Figure 2. Influence of application of ultrasound during turmeric oleoresin encapsulation in matrices of maltodextrin and gelatin.](image)

As previously reported, the use of ultrasound improves emulsion quality when the support has low emulsifying properties and a weak viscosity, such as maltodextrin [13]. This fact, coupled with the presence of emulsifier (gelatin) and the higher solid content (24%) may explain the higher retention in the sample formulated with 18 % maltodextrin and 6 % gelatin compared to sample formulated with 12 % maltodextrin and 6 % gelatin.

**CONCLUSION**

- The encapsulation efficiency was significantly affected by gelatin content, indicating the effectiveness of gelatin as an encapsulant for turmeric oleoresin.
- The application of ultrasound in the emulsification step of turmeric oleoresin and maltodextrin/gelatin appeared to improve emulsion quality and stability, increasing the curcumin retention in the freeze-dried powders.

**ACKNOWLEDGEMENT**

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