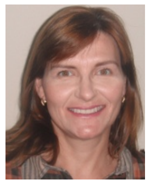
Stability of curcumin encapsulated in blends of maltodextrin, gum Arabic and modified starch



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INTRODUCTION AND OBJECTIVE

Curcumin, the major curcuminoid present in the yellow pigmented fraction of turmeric (*Curcuma longa* L.), has been described as a potent antioxidant and anticarcinogenic agent. Turmeric oleoresin has long been used as a natural colorant, despite being insoluble in water and having poor stability towards light and oxygen. These drawbacks may be overcome by microencapsulation, enhancing curcumin stability and facilitating its use as a natural pigment (Kshirsagar, 2009). Gum Arabic is highly soluble and surface-active, being extensively used as an encapsulation matrix for oils and flavors, however its high cost and irregular availability have motivated research for alternative encapsulation matrices. Maltodextrins have low cost, but lack of emulsifying capacity and lead to low volatile retention. Modified starches partially reproduce the functional properties of gum Arabic and have showed good encapsulation efficiency when blended with gum Arabic and maltodextrin (Krishnan, 2005).

This work aimed to investigate the morphology of turmeric oleoresin microcapsules produced by spray drying with gum Arabic, maltodextrin and modified starch as wall materials, and to evaluate curcumin retention and color stability along storage under light.

MATERIALS AND METHODS

Turmeric oleoresin OS-50 (Agro-Industrial Olimpia Ltda., Brazil) was the core material. Wall materials included maltodextrin DE 10 (Mor-Rex® 1910, Corn Products, Brazil), modified starch HiCap® 100 (National Starch and Chemical Industrial Ltda, Brazil), and gum Arabic (Synth, Brazil). Emulsions containing 30 g dry wall material/100 g total matter and 15 g oleoresin/100 g dry wall material were dried in a spray dryer with 0.7 mm diameter nozzle (B-290, Büchi, Switzerland), with air flow rate of 536 L/h, feed flow rate of 3.9 mL/min, and inlet air at 170 °C.

The yield percentage was calculated as the ratio between the dry powder mass and total solid mass in the emulsion before drying. Encapsulation efficiency (EE) was given by equation (1). Surface curcumin in the microcapsules was determined by extraction with methanol, following mild agitation and centrifugation (20 min, 10.414×g, and 20 °C). The curcumin content in supernatant was quantified by absorbance at 425 nm (SP-22, Biospectro, Brazil) referred to a standard curve. Total curcumin was measured after dissolution of microcapsules in deionized water at 60 °C and intermittent agitation in vortex. After 40 min the dispersion was subjected to extraction with methanol, centrifugation, and absorbance measurement.

$$EE = \frac{\text{Total curcumin - Surface curcumin}}{\text{Total curcumin}} \times 100 \qquad (1)$$

Particle mean diameter was measured using laser light diffraction (Mastersizer 2000 with dry dispersion unit Scirocco 2000, Malvern Instruments, UK) and was expressed as D_{43}, the volume weighted mean diameter. Microcapsule micrographs (SEM) were obtained in a Magellan 400L XHR scanning electron microscope (SEM Electron Microscopy Ltd., US) after sample immobilization in appropriate stubs with conductive adhesive tape and coating with gold/palladium in Polaron SC7620 sputter coater (Ringmer, UK). Color attributes (Hunter L, a, and b values) were measured using a colorimeter (ColorFlex EZ, HunterLab, USA) with D65 illuminant and a 10º observation angle. Total color difference (ΔE) was calculated by equation 2, where the index 0 refers to microcapsules before storage under light. Stability test was performed at 25 °C under light (3500 lx). Samples were packed in sealed low-density polyethylene bags and stored for 8 weeks. Total curcumin and color parameters were measured each 7 days. Curcumin retention was given by equation 3.

$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2} \qquad (2)$$

$$\text{Retention} = \frac{(\text{Total curcumin})_t}{(\text{Total curcumin})_0} \times 100 \qquad (3)$$

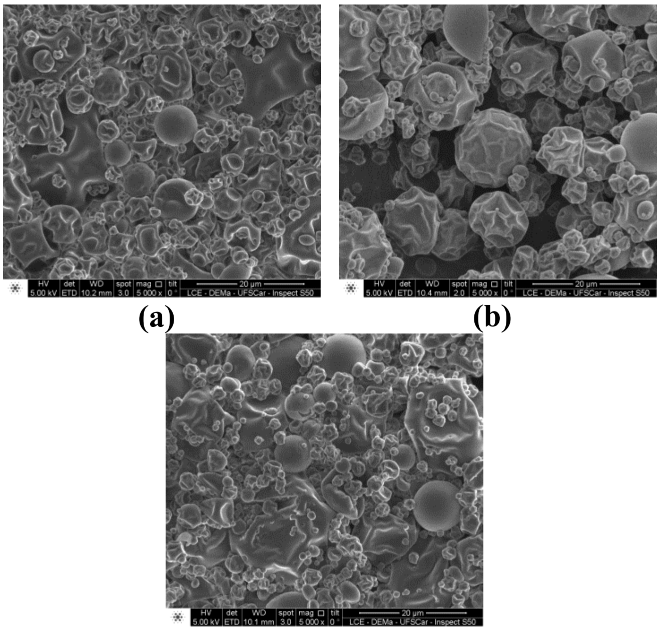
RESULTS AND DISCUSSION

Turmeric oleoresin microcapsules were produced with the following wall matrices: pure gum Arabic (GA); 75 % maltodextrin + 25 % modified starch (MD:MS); and 0.33 % gum Arabic + 0.33 % maltodextrin + 0.33 % modified starch (GA:MD:MS). The ternary blend resulted in the higher encapsulation efficiency, as well as in values of yield and particle size between those of samples GA and MD:MS (Table 1), indicating that the ternary blend had a better performance than pure gum Arabic. The blend MD:MS presented the lowest EE value and highest D_{43}, showing that the presence of gum Arabic in the matrix is important, probably due to its surface activity.

Microcapsules produced with GA and GA:MD:MS had smooth and continuous surfaces, although some of them presented dent formation, indicating shrinkage (Figure 1a and 1c). The absence of fissures and pores suggests a complete coverage of the core material. The binary blend MD:MS lead to rough external surfaces (Figure 1b).

Table 1: Encapsulation efficiency (EE), yield, and particle size (D_{43}) in different wall matrices

Sample	EE (%)	Yield (%)	D_{43} (μm)
GA	73.92±0.08	29.73	10.57±0.17
MD:MS	63.51±0.97	55.82	21.05±1.10
GA:MD:MS	77.36±0.17	38.64	12.57±0.44



(c)

Figure 1: Micrographs (5000x) of microcapsules with different wall matrices: (a) GA; (b) MD:MS; (c) GA:MD:MS.

Curcumin retention and color stability observed along several weeks under light exposure confirmed the higher encapsulation efficiency of the ternary blend. Capsules produced with GA:MD:MS retained about 84 % of curcumin even after 8 weeks under intense illumination (Figure 2). Further, the total color change was smaller in these samples (Figure 3), mainly compared to ΔE for capsules MD:MS, which also showed the lower curcumin retention: about 42 % after 8 weeks. Krishnan (2005), Vaidya (2006), and Kanakdande (2007) got similar results, respectively, for cardamom, cinnamon, and cumin oleoresins, concluding that a ternary blend of gum Arabic, maltodextrin and modified starch gave higher protection to active material than gum Arabic alone.

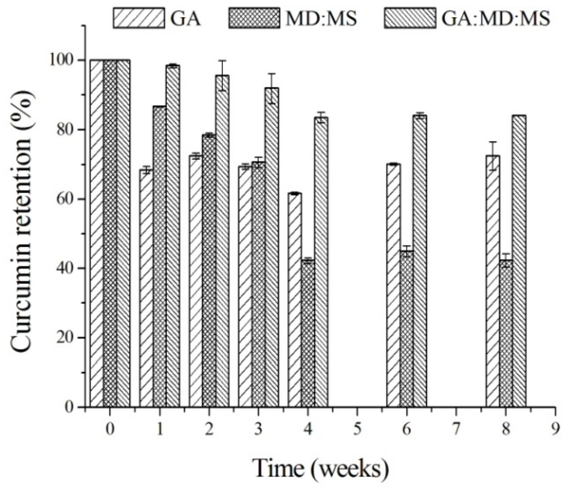


Figure 2: Curcumin retention in different wall matrices along exposure to light.

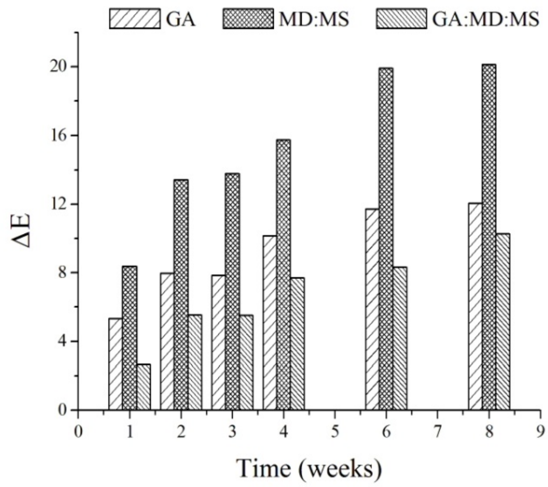


Figure 3: Total color difference in different wall matrices along exposure to light.

CONCLUSIONS

A ternary blend of gum Arabic, maltodextrin and modified starch was more effective to prevent curcumin losses and total color changes in turmeric oleoresin microcapsules than pure gum Arabic or a blend of maltodextrin and modified starch.

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