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Glass transition temperatures and some physical and sensory changes in stored spray-dried encapsulated flavors

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Abstract

Commercial spray-dried powder flavors (strawberry and orange) encapsulated in different amorphous matrices (maltodextrin and maltodextrin-sucrose) were stored for 20 days under constant relative humidities of 32%, 43%, 58% and 75%. Glass transition temperatures (T_g) of the different powders and maltodextrin DE 12 were measured using differential scanning calorimetry (DSC). Caking/collapse visual observations and aroma strength (measured by a trained sensory panel) were recorded and correlated with the glass transition temperature of the different spary-dried flavors. Glass transition data explained collapse occurrence and loss of aroma strength in encapsulated strawberry and orange flavors after storage at various relative humidities.

The presence of sucrose in the carrier formulation negatively affects storage stability of the encapsulated flavor.

Keywords: Spray dried; Encapsulated flavors; Glass transition; Collapse; Caking; Orange flavor

1. Introduction

Flavor has today become an essential component for food developers: it imparts taste and aroma to a variety of foodstuffs, restores the flavoring lost during processing and allows the development of new products with novel tastes.

There are three major purposes for encapsulating flavors. The first one is to convert liquid flavors into a dry form and free-flowing powder form. Flavor compounds easily undergo oxidation leading to a decrease in flavor strength or even the development of off-flavor. Encapsulation is an effective way to provide a barrier against undesirable environmental factors and thereby minimize the changes. Finally, microencapsulated flavors offer the possibility for controlled flavor release during processing or final food preparation (Beristain, Azuara, & Vernon-Carter, 2002; Cadwallader, Brehart, Schnmidt, & Huda, 2002; Madsen, Grypa, & Pratt, 2001).

Spray drying is the most common technique to produce flavor powders from food flavor emulsion; recipes for spray-dried flavors contain in addition to the liquid flavor, carrier materials such as maltodextrin (MD), gum arabic, modified starch, etc. Ingredients are mixed, emulsified/homogenized and spray dried; water content is reduced to below 5% and the flavor is encapsulated in an amorphous glassy carbohydrate matrix.

Carriers should have specific properties such as high solubility in water, low viscosity at high concentration, bland flavor, and white color, among others; for these reasons maltodextrins are commonly used for this type of spray drying applications. Also, the high glass transition temperature (T_g) of low DE maltodextrins provides good product stability of the dried powder (Beristain et al., 2002; Bhandari & Hartel, 2005).

It is well known that flavor retention during the spray drying process is governed, among other factors, by type of

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carriers (Menting, Hoogstad, & Thijssen, 1970; Thijssen, 1971), and for this reason disaccharides, such as sucrose or lactose are sometimes included with maltodextrin in commercial formulations to improve retention characteristics. However, in addition to flavor retention, the stability of the encapsulated product is also of importance and the low T_g of sucrose (Roos, 1995) may adversely affects stability. It is well known that food powders containing amorphous carbohydrates can undergo several physical changes which lead to deterioration of quality (Roos & Karel, 1991a).

It may be mentioned that interactions between flavor and some starch-derived polysaccharides have been also the subject of studies. For example, polar interactions have been determined which involve hydrogen bonds between the hydroxyl groups of starch and aroma compounds, and in a 10% (w/w) maltodextrin solution (DE 5) it was shown that the retention was influenced by the hydrophobicity of flavor (Madene, Jacquot, Scher, & Desobry, 2006).

An amorphous material undergoes a change from a very viscous "glass" to a "rubber" at the glass transition temperature; at T_g the molecular mobility increases and the viscosity decreases, which may result in structural changes such as stickiness and collapse (Levine & Slade, 1986; Roos, 1995). Sticking, caking and crystallization are related to collapse phenomena; collapse occurs when a matrix can no longer support its own weight leading to structural changes shown by a decrease in volume. Levine and Slade (1986) considered collapse phenomena to include various time-dependent structural transformations, which may occur in amorphous biomaterials above the glass transition temperature (Roos & Karel, 1991b).

Aroma retention in dried foods or release of encapsulated volatiles from amorphous matrices may also occur as the amorphous matrix is transformed from the glassy state into the rubbery state either due an increase in moisture content or to elevated temperatures, leading to system collapse (Chirife & Karel, 1974; Roos & Karel, 1991b). It has to be noted that the glass transition takes place not at a specific temperature but over a temperature range which sometimes depends on the material and its thermal and mechanical histories; thus a single transition temperature is not always well defined (Peleg, 1997; Roos, Karel, & Kokini, 1997) and T_g is usually taken as the onset or midpoint of the glass transition temperature range.

The purpose of present study was to determine the glass transition temperature of commercial spray-dried flavors (strawberry and orange) encapsulated in different amorphous matrices and relate measured values with aroma strength (measured by a trained panel), and collapse phenomena occurring during storage at different relative humidities.

2. Material and methods

2.1. Encapsulated flavors

Commercial spray-dried encapsulated strawberry and orange (N1 and N3) flavors (5% water content) were manufactured in a flavor company located in Buenos Aires, Argentina. Their composition (as informed by the supplier) is shown in Table 1; in strawberry and orange N1 encapsulated powders, maltodextrin DE 12 (MD 12) accounts for most of the amorphous dried matrix, while in orange N3 sucrose is also present in a large amount. Maltodextrin DE 12 was from Productos de Maíz SA, Buenos Aires, Argentina. Processing conditions during emulsification of the flavor oils (which may affect emulsion size) were similar for all samples; also for operating conditions of the atomizer during spray drying, to minimize effects on the particle size distribution of the spray-dried powder.

A thin layer of the spray-dried encapsulated flavors and MD DE 12, were placed in 100mL flasks in desiccators over saturated salt solutions at the following constant relative humidities (RH%), 33% (magnesium chloride), 43% (potassium carbonate), 58% (sodium bromide) and 75% (sodium chloride), for 20 days at room temperature. These relative humidities were selected because they represent likely environmental conditions during storage and handling of the dried flavors in food industries.

2.2. Sensory evaluation of aroma strength

A Triangle Test-Degree of difference (ASTM, 1977) was used to evaluate the intensity of aroma in encapsulated flavors after 20 days storage at different relative humidities. Samples were evaluated with regard to a control (encapsulated flavor kept dried at −18 °C), one sample for session in duplicate (four triangles). The judges took the triangle test in the usual way and then were asked to rate the aroma intensity of the perceived difference, using an unstructured 10 cm line, with verbal expressions (e.g. low intensity, high intensity); three replicates were used for these evaluations. The triangle test results were interpreted in the usual way in terms of the percentage of correct responses, and the scale results were analyzed separately, using only the ratings associated with correct judgments.

A panel of 14 judges composed of undergraduate students of food science/engineering (three men and 11 women, with an average age of 22) participated in this study. Prior to the participation in the experiment, the panelists were given a training (6 h) about recognition and quantification of aromas. Before evaluation, encapsulated flavor samples were diluted to 0.5% in water, put in plastic

Table 1
Composition (% dry basis) of spray dried flavors

Component	Strawberry (F)	Orange	
		N1	N3
Maltodextrin DE 12	84.9	78.4	40
Modified starch	5	5.4	3.6
Flavor	9.8	15.8	13
Sucrose	—	—	40.6