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Thermal Behaviour of Strawberry Cream Fillings in Presence of Trehalose Studied by Differential Scanning Calorimetry

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Abstract. The objective of this study was to investigate influence of trehalose addition (3, 5 or 10 %) in strawberry cream fillings during preparation of the samples on thermal behaviour (glass transition temperatures, melting temperature and enthalpy of melting). Samples were prepared by evaporation and freeze-drying. Addition of trehalose and preparation process strongly influenced thermal behaviour of strawberry cream fillings. Glass transition temperatures increased with increase of trehalose addition, in both freeze-dried and evaporated samples. Higher values were determined in freeze-dried samples. Melting temperatures were higher in evaporated samples in contrast to freeze-dried samples. In freeze dried samples with addition of trehalose, melting temperatures decreased, also enthalpy of melting decreased. In evaporated samples melting temperatures didn’t depend on trehalose addition, and values were almost the same for all samples. Enthaply of melting for those samples had the lowest value in sample without trehalose addition, while other samples had similar values.

Keywords: phase transition, trehalose addition, preparation process, strawberry cream filling

1. Introduction

Trehalose (α,α-trehalose) is a disaccharide formed by α 1,1 linkage of two d-glucose molecules [1]. It is a non-reducing sugar that is not easily hydrolysed by acid, and the glycosidic bond is not cleaved by α-glucosidase. The molecular formula and weight are $C_{12}H_{22}O_{11}$ and 342.31, respectively [1], [2]. Due to its natural functions, mechanisms of action and technical qualities, trehalose could be applied in the food, cosmetic and medical industries [3], [4]. The only limiting factor to the generalised use of trehalose in the food industry was cost [4]. After development of a new manufacturing process, the production costs of trehalose were dramatically reduced. In the early 1990s the cost of 1 kg of commercialised trehalose could reach US$ 700 but after development of enzymatic process of trehalose production price was reduced [5], [6]. These production costs reductions led its use in a wide variety of cost sensitive applications, including foods. Trehalose has also been introduced commercially as an ingredient in the US by Cargill Health & Food Technologies, and is recognized as a GRAS material by the Food and Drug Administration. The remarkable ability of trehalose to completely protect cryptobiotic plants and animals from desiccation damage can be applied in drying foods on an industrial scale [7].

Most food products are very complex matrices due to their chemical composition and structure. They are often multi-component materials and present several phases. Food products are composed of volatile and non-volatile constituents and interactions between those constituents strongly affect the quality of food products. Influence of trehalose addition on colour, aroma and texture of some food products were already proven [8]-[11]. In this study influence of trehalose addition, as well as preparation process of strawberry cream fillings on thermal phase transitions of samples were investigated.

2. Materials and methods

2.1. Sample preparation

Raw material for preparation of strawberry cream fillings without and with trehalose addition (3, 5 and 10 % as sucrose replacement) were obtained from food company Fructal d.d. (Ajdovščina, Slovenia) where ingredients (commercial frozen strawberry puree, starch, vegetable fat, sucrose, glucose syrup, sorbitol) were mixed together according to industrial recipe. The total solids of the mixture of ingredients were 40 %. Strawberry cream fillings were prepared by evaporation and freeze-drying of mixture of ingredients until 76 % of total solids was achieved. Preparations of strawberry cream fillings were done in triplicate. After preparation, strawberry cream fillings were left to stabilise for 10 days.

Evaporated samples were prepared by evaporation under the vacuum. Evaporation of samples was conducted with laboratory rotavapor (Büchi Rotavapor R-114, Switzerland) under the vacuum (Büchi Vac V-500 and Büchi Vacuum Controller B-721, Switzerland) at 80 °C. The pressure was gradually decreased until 30 mbar was achieved. The rotavapor was equipped with water bath (Büchi Watherbath B-480, Switzerland) which was used for controlling temperature. To achieve 76 % of total solids 1 hour and 40 minutes were needed.

Freeze drying of samples was performed in Christ Freeze Dryer (Gamma 2–20, Germany). It required a drying time of 50 h. The following conditions were used: freezing temperature was –20 °C, the temperature of sublimation was from –20 to 0 °C and the vacuum of 0.630 mbar. The temperature of an isothermal desorption was from 0 to 20 °C under the vacuum of 0.01 mbar.

2.2. Determination of thermal behaviour

Thermal behaviour were determined using differential scanning calorimeter DSC 822^e (Mettler Toledo) equipped with STAR^e software for evaluation thermograms. All measurements were performed at a heating rate of 10 °C/min. Samples (7-10 mg) were put in hermetically sealed 40 μl pans and an empty pan served as a reference. Measurements were done in triplicate.

3. Results and discussion

Typical thermal curve of investigated samples is given at Fig. 1. Phase transition I would be glass transition and phase transition II melting of samples. Glass transition is presented with glass transition temperatures (T_{go} - onset, T_{gm} - midpoint and T_{ge} - endpoint) and depended on preparation process of strawberry cream fillings as well as on trehalose addition (Table 1). Increase of T_{gm} in samples with trehalose addition was observed in both, freeze-dried and evaporated samples. In freeze-dried T_{gm} was lower than in evaporated samples. In samples without trehalose addition T_{gm} was -36.28 and -32.21 °C in freeze-dried and evaporated samples, respectively. With increase of trehalose addition T_{gm} increased in freeze-dried and evaporated samples. In samples with 10 % of trehalose addition T_{gm} was -27.99 and -24.65 °C in freeze-dried and evaporated samples, respectively. T_{go} and T_{ge} of freeze dried samples without trehalose addition were -40.42 and -35.55 °C, respectively. T_{go} i T_{ge} temperatures of freeze-dried sample increased with trehalose addition, up to -32.41 and -23.34 °C in samples with 10 % of trehalose addition. T_{go} and T_{ge} of evaporated samples without trehalose addition were -36.19 and -27.65 °C, respectively. In samples with 3% of trehalose addition, T_{go} slightly decreased (-37.08) in comparison to samples without trehalose addition, but in samples with 5 and 10 % of trehalose addition decrease of T_{go} occurred (-31.40 and -27.68, respectively). T_{ge} of evaporated samples decreased with increase of amount of trehalose addition.

Melting temperatures (T_o - onset, T_m - midpoint and T_e - endpoint) and enthalpy are presented in Table 2. It was observed that preparation process and trehalose addition had influence on melting of strawberry cream fillings. T_m was higher in evaporated samples in contrast to freeze-dried samples. T_m in freeze-dried and evaporated samples without trehalose addition was 36.34 and 36.85 °C, respectively. In freeze-dried samples with addition of trehalose, T_m decreased. In evaporated samples T_m slightly varied from 36.81 to 37.01, and it didn't depend on trehalose addition. T_o slightly varied in both freeze-dried (28.73 – 29.42 °C) and evaporated samples (29.54 – 30.02 °C), and values didn't depend on trehalose addition. T_e of evaporated samples was ~42 °C in contrast to freeze-dried samples where T_e was from 37.52 to 45.42 °C. Enthalpy (ΔH) of melting for samples without trehalose addition was 4.10 and 3.58 J/g for freeze-dried and evaporated samples. Enthalpy decreased in the freeze-dried samples with increase of trehalose addition (3.75, 2.89 and 1.90 for 3%, 5% and 10% of trehalose addition). In evaporated samples without trehalose addition enthalpy of melting was lower (3.58 J/g). In samples with trehalose addition enthalpy of melting was from 3.74 to 3.91 J/g, showing that increase of trehalose addition didn't have the same impact as in freeze-dried samples.

The physico-chemical behaviour of foods strongly depends on their composition, especially on the thermal characteristics of the major food constituents: carbohydrates, lipids, proteins, water [12].

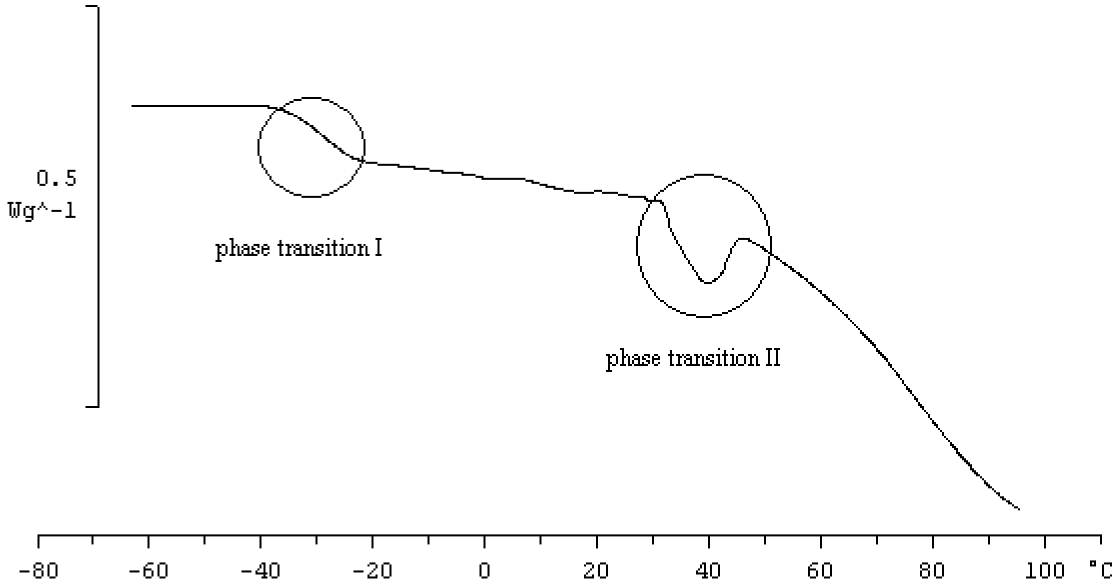

Fig. 1: Typical thermal curve of strawberry cream fillings.

Table 1: Glass transition temperatures in strawberry cream fillings.

	T_{go} (°C)	T_{gm} (°C)	T_{ge} (°C)
	freeze-dried strawberry cream fillings		
0% Tr	-40.42±0.30	-36.28±0.23	-32.55±0.43
3% Tr	-38.19±0.36	-34.19±0.37	-30.59±0.30
5% Tr	-36.30±0.35	-32.39±0.34	-29.30±0.41
10% Tr	-32.41±0.36	-27.99±0.26	-23.34±0.51
	evaporated strawberry cream fillings		
0% Tr	-36.19±0.24	-32.21±0.15	-27.65±0.15
3% Tr	-37.08±0.33	-32.15±0.24	-26.76±0.31
5% Tr	-31.40±0.33	-27.31±0.43	-21.09±0.21
10% Tr	-27.68±0.21	-24.65±0.16	-20.89±0.24

Tr - trehalose; T_{go} - onset of glass transition temperature; T_{gm} - midpoint of glass transition temperature; T_{eo} - endpoint of glass transition temperature

Table 2: Temperatures and enthalpy of melting in strawberry cream fillings.

	Δ H (J/g)	T_o (°C)	T_m (°C)	T_e (°C)
	freeze-dried strawberry cream fillings			
0% Tr	4.10±0.11	28.73±0.31	36.34±0.10	42.51±0.15
3% Tr	3.75±0.07	29.42±0.12	35.01±0.09	45.42±0.20
5% Tr	2.89±0.13	28.74±0.26	34.34±0.09	41.16±0.25
10% Tr	1.90±0.05	28.90±0.21	33.56±0.12	37.52±0.23
	evaporated strawberry cream fillings			
0% Tr	3.58±0.11	30.02±0.21	36.85±0.21	42.40±0.16
3% Tr	3.91±0.23	29.54±0.12	36.81±0.15	42.19±0.14
5% Tr	3.84±0.18	29.66±0.15	37.04±0.19	42.15±0.15
10% Tr	3.74±0.11	29.71±0.17	37.02±0.14	42.06±0.13

Tr - trehalose; T_o - onset of transition temperature; T_m - midpoint of transition temperature; T_o - endpoint of transition temperature; Δ H – enthalpy of melting.

4. Conclusions

The thermal behaviour of foods strongly depends on their composition, thus in this study we demonstrated change of thermal behaviour with respect to trehalose addition and applied process for sample preparation. Trehalose had influence on glass transition temperatures of freeze-dried and evaporated sample, while during melting its influence was more pronounced in freeze-dried samples than in evaporated ones. In evaporated samples, influence of trehalose addition on melting temperatures was very low.

5. Acknowledgments

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