Differential Scanning Calorimetry as a tool for optimizing vegetables freezing and storage conditions

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Objective

In this study DSC was used to analyse thermal events observed due to freezing and blanching processes, and frozen storage (at -18ºC, during 6 months) of three different vegetables: pumpkin, broccoli and carrots, as a tool for optimizing vegetal quality.

Introduction

Studies on food products behaviour make usually use of a large set of complementary analytical methods, which together may tackle the problem of chemical and physical changes during processing and storage.

Water is the major vegetables component, and its presence, in terms of amount and dynamics, affects many important properties, such as texture, biochemical reactions and microbiological activity. Water dynamics during vegetables freezing and storage plays an important role in determining product final quality, safety and shelf-life.

Differential Scanning Calorimetry (DSC) has become a useful analytical tool for studying many physical and reactive properties of materials, during their heating or cooling.

Materials & Methods

Vegetal Samples: Fresh vegetables pumpkin (*Cucurbita máxima* L.), broccoli (*Brassica oleracea* L.) and carrots (*Dancus carrot* L.) were provides by an orchard near Lisbon.

Samples preparation: Fresh p, b and c were cut and divided in two sub groups. The first set was immediately frozen in an air blast freezer at –25ºC during 30 min and stored at -18 ºC. The second one, was blanched in water (p 95ºC – 2 min, b 90 ºC – 1 min and c 95 ºC – 0.5 min), cooled for 2 min, frozen and stored. Fresh (S_0), blanched/frozen and unblanched/frozen samples were randomly collected and analysed at day zero (S1), and after three (S2) and six (S3) month of storage.

Samples analysis:

Humidity determination: The humidity of samples (%) was determined by the NP 784 - 1970 (data presented are averages from 4 measurements).

DSC analysis:

Equipment_ 823ᵉ Mettler Toledo equipped with a TSO800GC1 gas unit and a Intercooler Thermo HAAKE EK 45/ MT.

Purge gas_ Nitrogen (20 ml min^{-1})

Calibration_ Indium (m.p.156.6ºC, ΔH = 28.4J g-1) and deionised water (m.p.: 0 ºC, ΔH = 334.5 J g^{-1}), as standard procedure.

Pan_ aluminium sealed pan (ca. 40 μl). An empty, sealed aluminium pan was used as the reference.

Parameters definition_ Glass transition temperature: was taken as two different criteria, Tg` middle, the temperature at which the specific heat variation was half of the total value at the transition; Tg onset: the temperature of departure from the specific heat line of the glassy state before the transition; Crystallization heat (Hc): area of the peak during cooling run (1º peak); Melting heat (Hm): area of the peak during heating run (2º peak); Crystallization and melting temperature, Tc and Tm, the highest point in 1º and 2º peak, respectively.

Duplicated samples were subjected to the following heating programme related with the measurements needs:

Tg´: From 20º to -60º C at a rate of 5º C min-1 and reheating at the same rate.

Crystallization / melting Heat and temperature of crystallization (Tc) and melting (Tm): From 10º to -25º C at a rate of 1.20ºC min-1, holding for 10 min at -25ºC for stabilizing, and reheating at the same rate.

Data analysis: Analysis of variance (ANOVA) was performed to determine significant effects (p<0.05) of heat and temperature of crystallization/melting.

Results & Discussion

Tg´

The glass transition temperature (Tg´) is the temperature below which the physical properties of amorphous materials vary in a manner similar to those of a solid phase (glassy state), and above which amorphous materials behave like liquids (rubbery state), showing the temperature turning point below which molecules have little relative mobility.

Fig 1, shows Tg´ parameter determination, for the different vegetables studied. All the fresh vegetables denote a similar Tg´ values, at c.a -32 ºC.

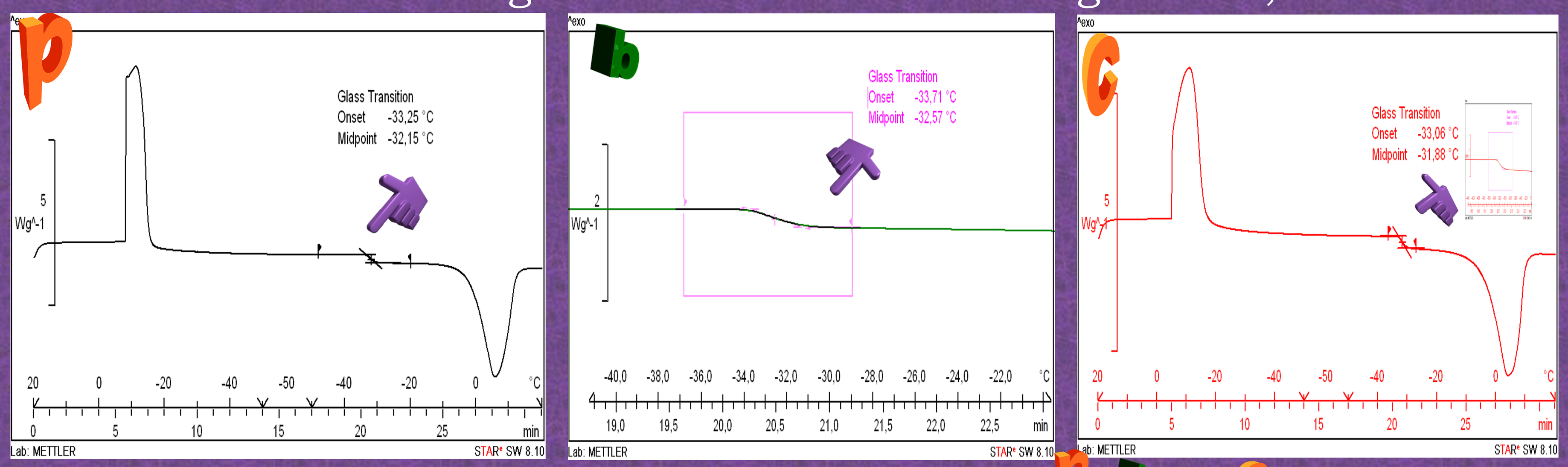
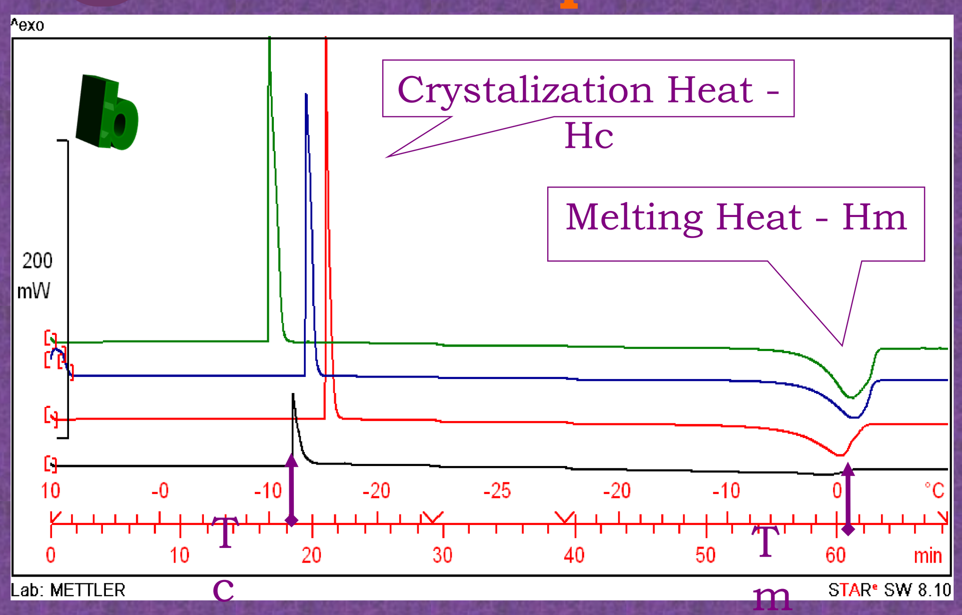


Fig 1. Tg´ parameter determination for fresh p, b, and c

Heat and temperature of crystallization / melting



Broccoli results of heat (crystallization (Hc) and melting (Hm)) and temperature (crystallization (Tc) and melting (Tm)) were presented in termogram (Fig 2). It was possible to note the different behaviour of samples during storage.

Fig 2. Broccoli thermogram: Fresh samples (S0 ----), frozen samples at zero day (S1---), frozen samples at month 3th (S2 ---) and frozen samples at month 6th (S3 ---).

For all vegetables, Hm and Hc (Wg^{-1}), results presented similar values (data not shown), confirming that the heat needed to crystallization and melting of the vegetable water was the same.

Comparison ANOVA results for melting heat values in pumpkin samples, are presented in Fig 3. The Hm [or Hc] values for frozen and blanched/frozen samples, showed a non significant variation decrease (p>0.05) during storage, in relation to fresh condition. However, the decrease trend observed in samples at 6th month, reflected the influence of storage time on the water content and its migration.

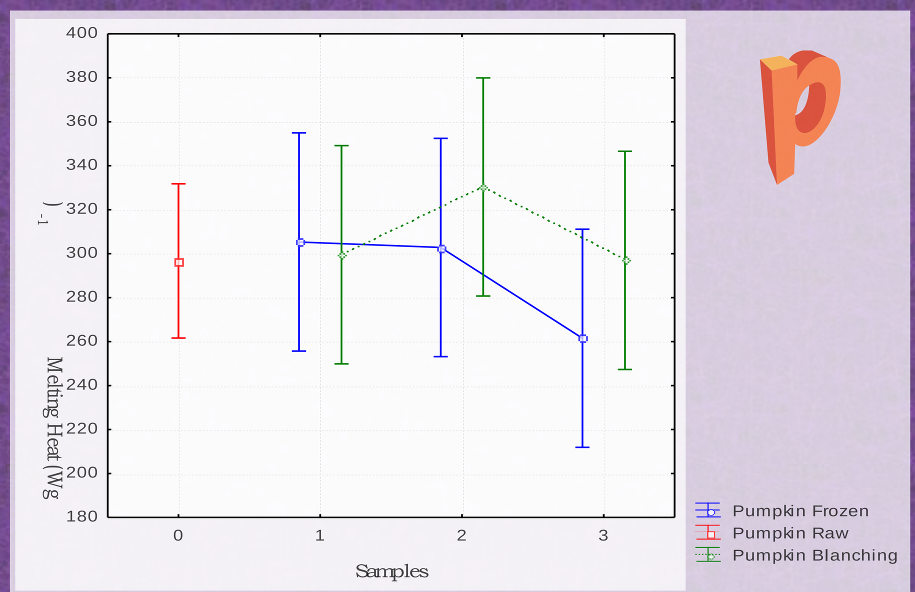


Fig 3. Effect of storage on melting heat (wg^{-1}) of Pumpkin samples.

All the blanched/frozen samples presented higher heat values than non blanched frozen samples reflecting the upper water content, which corroborated with humidity results (Table 1).

The influence of blanching could be also proved in Fig 4, which shows a significant difference (p<0.05) in Tc values between blanched/frozen samples and unblan/frozen samples, presenting the second ones similar values to fresh samples (S0). However, this behaviour showed a tendency to diminish with time storage, probably due to water migration.

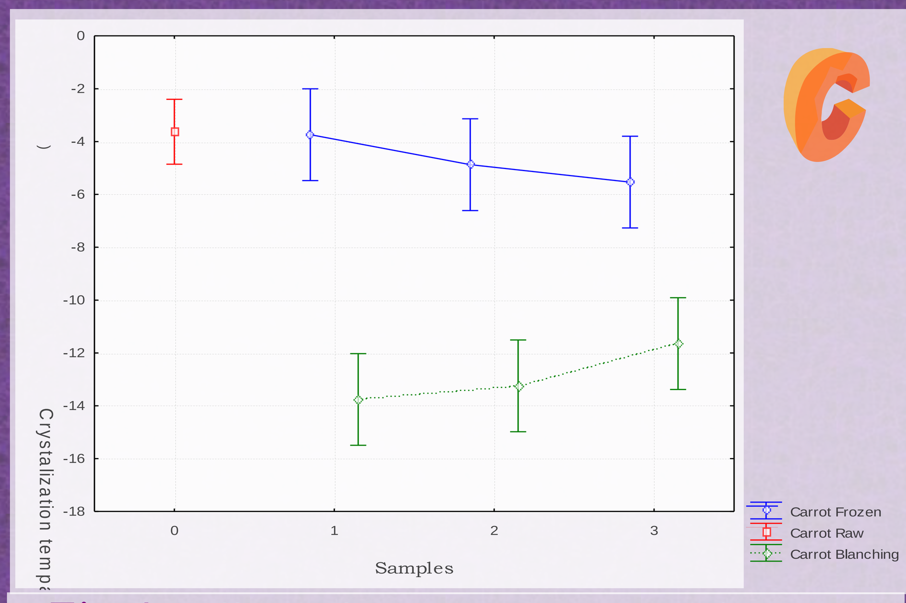


Fig 4. Effect of storage on Crystalization temperature (ºC) of Carrots samples.

Further studies would be of interest to show if an equilibrium is attained.

Humidity

		Pumpkin	Broccoli	Carrots
Humidity (%)	Fresh	96.01±0.05	87.71±0.07	88.01±0.09
	Blanching	98.69±0.01	90.39±0.04	90.76±0.06
	Frozen	96.11±0.02	88.13±0.05	88.00±0.05

Conclusions

Results demonstrate the blanching vs. freezing operation and storage conditions importance and contribute to explain the phenomena that happens during frozen storage. The testes methodology is effective to monitor those changes. Moreover, DSC analyses may be useful as a quicker and efficient method, eventually detecting changes earlier than conventional techniques.

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