EFFECT OF TEMPERATURE ON VISCOELASTIC PROPERTIES OF SEMISOLID DAIRY DESSERTS

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Introduction

The "natillas", semisolid dairy dessert of wide consumption in Spain, is composed of milk, starch, hydrocolloids, sugars, colorants and aromas. The particular characteristics of some ingredients, like fat content of milk, type of starch, and/or type and concentration of hydrocolloids, and their crossed interactions, will be reflected in notable differences in their rheological and sensory properties. Little information is available on the differences to be found in commercial samples of this type of dairy desserts [1]. The rheological properties of this type of products, are due to a biphasic structure defined by the characteristics of the dispersed phase (starch granules) and by the viscosity of the dispersing phase [2]. The effects of starch content on the viscoelasticity of similar products (Dutch "vla" model systems) have been recently reported [3].

The objectives of this work are to characterise the viscoelastic properties of commercial samples of Spanish "natillas" and to study the effect of the consumption temperatures (5 and 25ºC) on them.

Samples

Seven samples of vanilla dairy desserts (*natillas*) of different brands and characteristics covering the commercial range, were purchased from the local market (Table 1, Fig.1). The samples were stored at 4±1ºC prior to testing and all measurements were performed within the shelf-life period of each sample.

Methods

The measurements were carried out in a controlled stress rheometer (RheoStress 1, Karslruhe, Germany) with a serrated parallel plates sensor system (6 cm diameter and 1mm gap). A glass solvent trap was used to limit the amount of moisture evaporation (Fig. 2). All the measurements were made at two temperatures: 5 $\pm$ 0.5 and 25 $\pm$ 0.5 ºC. At least two replicates of each measurement were made. Stress sweeps were run at 1Hz frequency to determine the linear viscoelastic region. Frequency sweeps were performed to determine the values of G', G'', tan δ and η^* as a function of frequency, over the range f = 0.01-10 Hz.

Results

The linear viscoelastic region, determined in previous stress sweeps, was found to be somewhat wider at 5ºC (up to about 1 Pa) than at 25ºC (up to about 0.3 Pa) The frequency sweeps were then run at 0.1 Pa.

Mechanical spectra of the samples at both temperatures showed interesting differences. Two extreme cases (samples 1 and 5) are represented in figure 3. Sample 5 spectrum showed the typical pattern of a well gelled material with G' values clearly higher than G'' values and independent of frequency. In contrast, for sample 1, G' values and, even more, G'' values increased with frequency. Consequently their difference decreased getting to be nule at frequencies over 1 Hz. In both samples tan δ values increased with frequency which indicated a higher contribution of the viscous component at higher frequencies (Fig. 4).

Taking G' and G'' values at 1 Hz as references, these were lower at 25ºC (Table 2) but the differences found varied depending on samples. Considering tan δ and $\eta*$ values at 1 Hz, two groups of samples could be distinguished as to the effect of temperature on their response. In one group (samples 2, 3, 5, and 6) tan δ values were practically the same at both temperatures while in the other group (samples 1, 4, and 7) they were higher at 25º C (Fig. 5). In the latter group the observed increase in $\eta*$ values was relatively larger than in the samples of the former group (Fig. 6). These results show that structure of samples 1, 4, and 7 was more sensitive to temperature changes than that of the rest of samples. Their viscous component was clearly higher and the decrease in complex viscosity with temperature more pronounced.

Acknowledgements

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References

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2. Thebaudin, J. Y., Lefebvre, A. C. & Doublier, J. L (1998). *Lebensmitttel Wissenschaft und Thecnologie*, 31, 354-360

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Table 1. Main composition and price level of commercial vanilla cream dairy desserts samples

Sample	**Dairy ingredients** [1]	**Thickeners** [1]	**pH** [2]	**Soluble solids** [2] **(º Brix)**	**Price**[3]
1	Semi-skimmed milk	Modified starch Carrageenan Xanthan gum	6.81	24.5	1.4
2	Milk Semi-skimmed milk	Modified starch Carrageenan Guar gum	6.76	23.7	1
3	Milk Cream Semi-skimmed milk powder	Acetylated distarch adipate Gelatine	6.61	28.3	2.3
4	Milk Cream Dairy solids	Modified starch Carrageenan Fatty acid esters	6.60	26.3	2.5
5	Milk Cream	Modified starch Carrageenan Guar gum	6.76	23.5	2.5
6	Milk Cream	Modified starch Carrageenan Guar gum	6.72	24.5	1.7
7	Milk Cream Dairy solids	Modified starch Carrageenan Fatty acid esters	6.75	24.5	1.9

(1) Declared in label.
(2) Average value of two measurements
(3) Lower price considered as reference unit

Table 2. Storage modulus (G') and loss modulus (G'') values at 1 Hz for the dairy dessert samples analysed. Identification of samples in table 1.

	5ºC		25ºC	
Sample	**G' (Pa)**	**G'' (Pa)**	**G' (Pa)**	**G'' (Pa)**
1	8.1	5.0	3.0	2.5
2	37.6	9.7	19.9	5.1
3	50.3	11.6	35.4	7.9
4	87.1	25.6	35.8	11.7
5	82.2	17.3	51.3	11.1
6	71.7	16.2	52.6	11.8
7	88.8	24.4	31.0	10.7

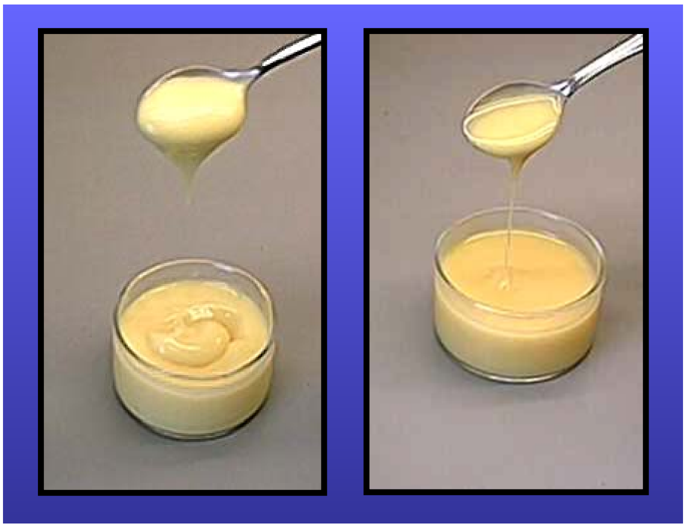

Figure 1. Samples of vanilla dairy dessert analysed.

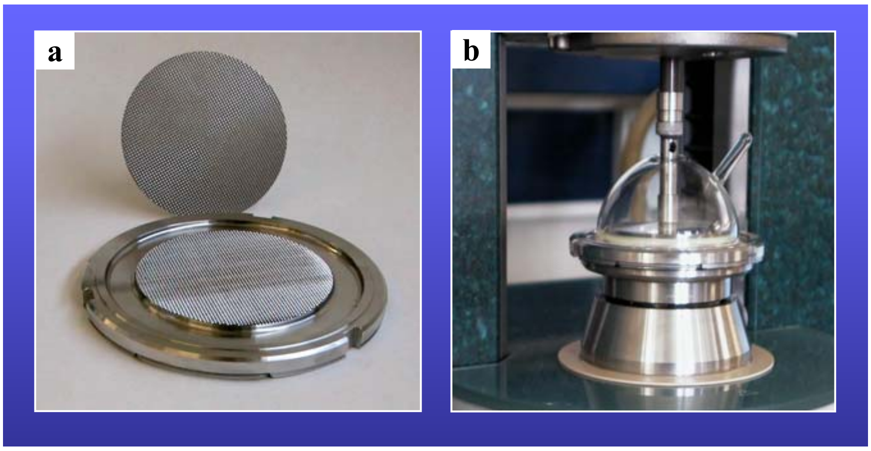

Figure 2. Serrated parallel plates sensor system (a) and glass solvent trap (b) used in the oscillatory rheological measurements.

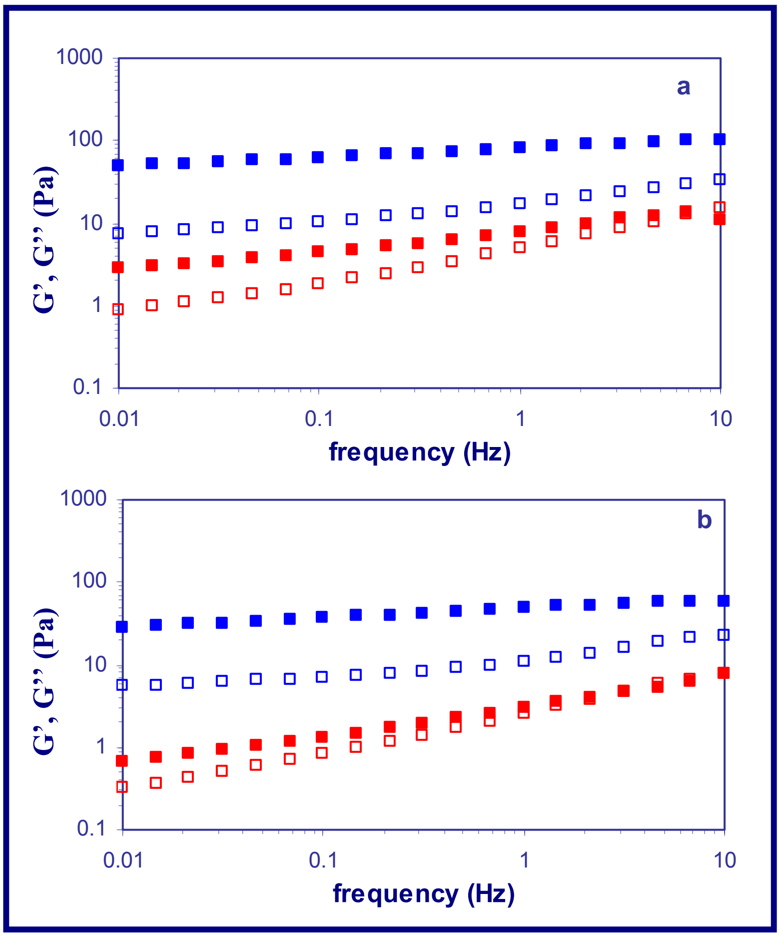

Figure 3. Mechanical spectra at 5ºC (a) and at 25ºC (b) for samples 1 (■) and 5 (■). G' (filled symbols) and G'' (empty symbols)

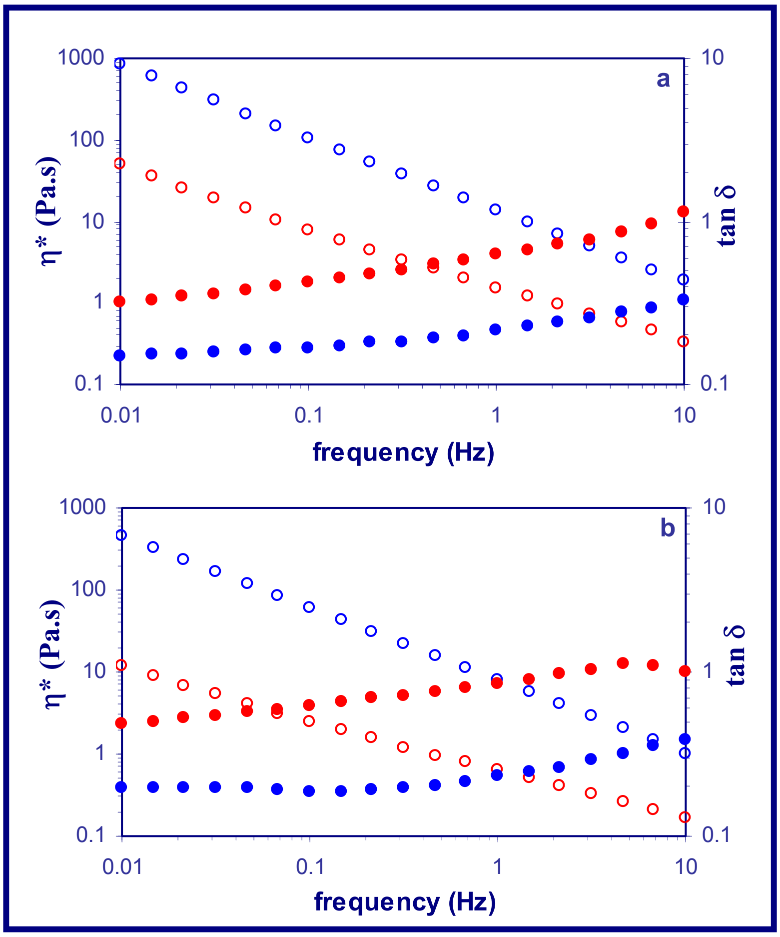

Figure 4. Complex viscosity (empty symbols) and tan δ (full symbols) as a function of frequency at 5ºC (a) and at 25ºC (b) for samples 1 (●) and 5 (●).

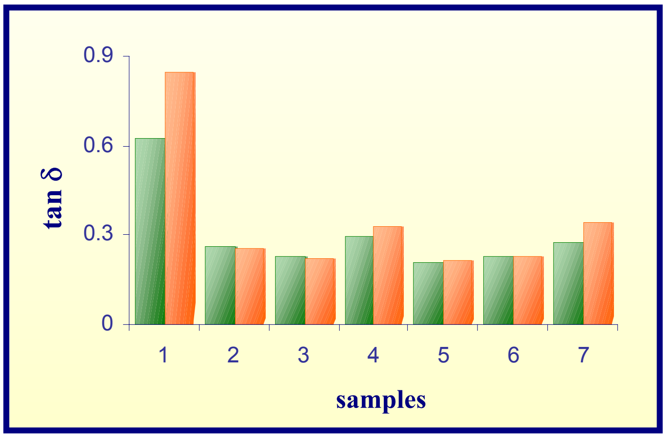

Figure 5. Values of tan δ at 1 Hz, at 5ºC (green) and at 25ºC (orange). Identification of samples in table 1.

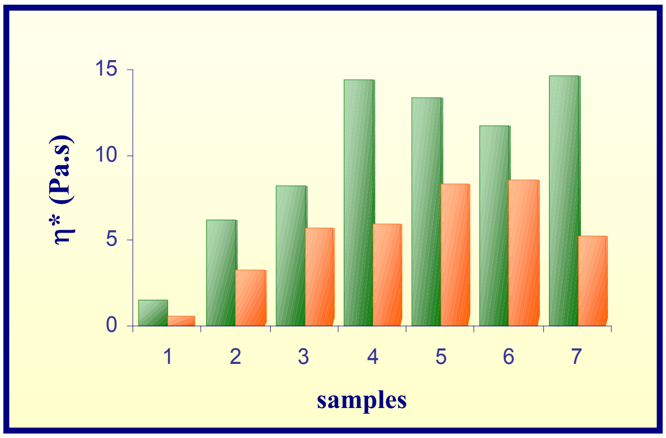

Figure 6. Values of complex viscosity at 1Hz, at 5ºC (green) and at 25ºC (orange). Identification of samples in table 1.