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Texture design based on chemical-physics knowledge of dairy neutral desserts: Instrumental and sensory characterizations

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ABSTRACT

The aim was to study the influence of different processing steps on the sensory perception of neutral dairy creams of same composition. Chemical-physics interactions between carrageenan, milk proteins and starch, characterized in a previous study, were the starting point for the elaboration of these schemes. A panel assessed 10 products, using a free sorting task followed by a ranking task on free differentiated terms. The rheological properties measured in dynamic conditions and particle size distributions were evaluated. A descriptive 'perceptual map of neutral dairy creams' was obtained. Dairy creams were differentiated through their thicknesses and granularity properties. The sensory map matched very well with the instrumental characteristics map of the products. A comparison of the 10 products' instrumental properties with those of a wide range of market products is proposed, showing that it is possible to build a great variety of textures using the same cream composition and changing only the process scheme.

1. Introduction

The texture of a food product depends on its structure, which influences its mechanical and enzymatic breakdown during oral processing. However, linking structure and texture is not an easy task. Numerous parameters must be taken into account such as parameters of the structure characterization or the expression of a human perception (Bourne, 2004; Nishinari, 2004; Szczesniak, 2002; van Vliet, van Aken, de Jongh, & Hamer, 2009).

On the market, numerous neutral dairy desserts can be found. They are all obtained through thermo-mechanical treatment of a starch suspension in a milk/carrageenan/sucrose mixture. Two product groups are usually differentiated: the dessert creams showing liquid or semi-liquid rheological behaviours and "flans" characterized by solid-like ones (Boudier, 1985; Schuck, Brulé, Jeantet, & Mahaut, 2000). Depending on the mechanical treatment carried out during the cooling process, performed under shear or without shear, sheared gels (dessert creams) or gels are obtained (flans), respectively. Sheared and non-sheared gels are also differentiated on their textures and thus on their structures that would depend on starch, carrageenan and milk proteins interactions. The impact of the components on the structure and/or the texture of neutral dairy desserts were widely studied in literature by means of, mainly, two mains parameters: the ratio of their components (Espinosa-Dzib, Ramirez-Gilly, & Tecante, 2012; Verbeken, Thas, & Dewettinck, 2004) or their nature (de Wijk, Prinz, & Janssen, 2006; de Wijk, van Gemert, Terpstra, & Wilkinson, 2003; Tarrega & Costell, 2006).

When starch is suspended in excess water and is thermo-mechanically treated, the starch granules swell irreversibly and are either dispersed or disrupted. Due to its exclusion effect during swelling, when suspended in a carrageenan/milk proteins solution, starch controls the ratio of carrageenan/milk proteins in the continuous phase (Matignon, Moulin, et al., 2014). The interactions between those two components are well known in literature: milk proteins mixed with carrageenan lead to the formation of casein micelles/carrageenan and carrageenan/carrageenan networks which microstructures depend highly on their ratio (Garnier, Bourriot, & Doublier, 1998; Langendorff et al., 2000). The final structure of dairy desserts is said to be determined by this network

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while starch granules, whatever their states, would act mainly as inert fillers (Arltoft, Madsen, & Ipsen, 2008; Espinosa-Dzib et al., 2012). However, Matignon, Moulin, et al. (2014) observed by confocal laser microscopy that swelled starch granules and amylopectin macromolecular chains had different roles in the building of neutral dairy cream structures. The disruption of starch, through a diminution of the volume reduction but also the release of starch macromolecular components, would highly impact the carrageenan/casein micelles network.

Furthermore, in binary mixtures, starch granules were shown to interact with carrageenan but also with milk proteins. Swelling starch in a carrageenan solution led to starch granules covered with carrageenan chains (Huc et al., 2014; Matignon et al., 2014; Matignon, Moulin, et al., 2014). Swelling starch in milk was shown to impact the dynamics of starch granules swelling under "strong" thermo-mechanical treatments (Matignon et al., 2015). Starch granule characteristics and continuous phase composition were impacted by those interactions. In ternary mixtures, changing the blending of the components of same-formula neutral dairy creams was shown to lead to a change in the interactions set-up and in the resulting products' microstructures (Matignon, Moulin, et al., 2014). However, for a same formula, neither the impact of starch granule disruption nor the change in processing steps is known to have an impact on the sensory properties of the products.

To characterize a set of products from a sensory point of view, different methods exist. The most commonly used method is the Quantitative Descriptive Analysis (Stone, Sidel, Oliver, Woolsey, & Singleton, 1974) – or QDA®– a sensory profile method using a trained panel. QDA® allows obtaining consensual, quantitative and precise identity cards of the tested products. However, it involves numerous preliminary training sessions and could lead to erase inter-individual differences and impoverish the description of the products (Dairou & Sieffermann, 2002). To evaluate the differences of a set of products in a more spontaneous and global way, other methods exist such as free sorting task, which is a similarity-based method (Valentin, Chollet, Lelièvre, & Abdi, 2012). Easy to understand, this type of tests can be performed by untrained assessors (Faye et al., 2004). A unique sensory experience allows highlighting the clusters or categories of products that may exist through the obtaining of a "perceptual map of products". To help the description of the product differences, a free verbalization can follow the sorting. Still, as no common criteria are determined, the quantification and the description of the groups' differences are difficult to achieve (Faye et al., 2004; Valentin et al., 2012). To overcome this limit, Lawless, Sheng, and Knoops (1995) developed an interesting method. Following a free sorting and a free verbalization on cheeses, the authors listed and chose the most frequent terms and asked the same subjects to rank the same cheeses on those terms without defining them. A good relationship between both data (free sorting and ranking) was found, and allowed obtaining a descriptive 'perceptual map of cheeses' (Lawless et al., 1995). This study suggested that the terms listed by the subjects for the free sorting were relevant to explain the differences between the sorted out groups. Since the terms were chosen by the authors, they may not be completely relevant for some of the subjects.

The main objective of this work was to investigate the influence of neutral dairy cream processing steps on their sensory perception. To reach this goal, the study was separated in two parts. The first step was to determine if sets of neutral dairy creams (sheared gels) of similar formula but obtained through different processing steps were sensed different by untrained assessors, and how their differences were described across the assessors. The second step was to understand and explain those sensory differences through a comparison with the textures of the products characterized instrumentally. The results were then discussed in terms of relevant structure parameters influencing the sensory perception of neutral dairy cream.

2. Materials and methods

2.1. Materials

Stabilized (acetylated) and cross-linked (adipate distarch) waxy maize starch and commercial carrageenan were provided by Cargill (Baupte, France). The starch was composed of at least 99% amylopectin (*i.e.* less than 1% of amylose), of a maximum 0.4 wt % endogenous proteins and of 8.0 (± 0.5) wt % water. The carrageenan sample was composed of a mix of kappa (73%), iota (24%) and lambda (3%) chains. It corresponds to kappa-carrageenan C2 in our previous paper (Huc et al., 2014; Matignon et al., 2014). Milk permeate powder and milk proteins isolate were kindly provided by IDI SAS (Arras). The milk permeate powder was composed of 81–86 wt % lactose, 4–5 wt % proteins and 5.2 (± 0.2) wt % water. The milk proteins isolate was composed of at least 81 wt % proteins and 5.9 (± 0.2) wt % water. The caseins were in the form of micelles.

The products used in this study were compared to eleven commercially-available vanilla neutral dairy desserts selected as representative of the diversity of textures available on the European market. Products from this market included "flans", dessert creams, custards and vlas. No particular focus on their compositions was put but they were all composed of starch, carrageenan and sucrose.

2.2. Preparation of the neutral dairy desserts

2.2.1. Strategy

The aim of the developed strategy was to determine processing steps impacting the structure set-up of the neutral dairy desserts without modifying their formulas. The formula used is detailed in Table 1. No fat and no flavouring were added in order to limit the risk of taste and aroma influencing texture perception (Lethuaut et al., 2005).

First, the starch pasting medium was modified to evaluate the impact of binary interactions, *i.e.* starch/milk proteins and starch/carrageenan, on the resulting product, as opposed to a pasting in milk permeate only. Thus starch was pasted in the stock solution, in the stock solution with milk proteins isolate or in the stock solution with carrageenan.

Then, to differentiate the impact of the starch phase from that of the carrageenan/milk proteins isolate phase, three methods of incorporation were used (Cf. Table 2). Method 1 (M1) consisted of adding the complementary components in the pasting medium of starch. For those products both the swelled starch granules and the continuous medium characteristics depended on the interactions of starch with its pasting medium during swelling. Method 2 (M2) consisted of isolating the different swelled starch granules (pasted in the three different media) and blending them with the same carrageenan/milk proteins isolate solution. For those products, only the characteristics of the swelled starch granules could be different, depending on their interactions with the components of their

Table 1
Composition of the neutral dairy desserts.

Components	g/100 g
Stock solution:	93.3
Permeate solution	*85.3*
Sucrose	*8.0*
Starch	3.0
Carrageenan	0.1
Milk proteins isolate	3.6