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Serum release boosts sweetness intensity in gels

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ABSTRACT

This paper describes the effect of serum release on sweetness intensity in mixed whey protein isolate/gellan gum gels. The impact of gellan gum and sugar concentration on microstructure, permeability, serum release and large deformation properties of the gels was determined. With increasing gellan gum concentration the size of the pores present in the protein network, the permeability and the serum release increased, as well as the Young's modulus, the fracture stress and the fracture strain. Increasing the sugar concentration induced an increase of the pore size, but resulted in a decrease of permeability and serum release. The addition of sugar resulted in gels with a higher Young's modulus and a lower fracture strain. This effect was more evident at higher gellan gum concentrations. By changing the protein concentration of the gels, a set of samples was prepared exhibiting constant large deformation properties but varying in serum release and sugar concentration. Serum release significantly boosted sweetness intensity. For example, the sweetness scores for gels with 12% serum release were the same as for gels with 2% serum release but 30% higher sugar concentration. The results indicate that serum release is a tool to compensate for the loss taste intensity related to the reduction of sugar and salt in gelled foods.

1. Introduction

Consumers are highly sensitive to small variations in sweetness. This has been established for several different foods, ranging from sugar solutions to cookies (Drewnowski & Greenwood, 1983; Drewnowski, Nordensten, & Dwyer, 1998; Drewnowski & Schwartz, 1990; Monneuse, Bellisle, & Louissylvestre, 1991; Salbe, DelParigi, Pratley, Drewnowski, & Tataranni, 2004). Therefore, reduction of sugar when developing light foods remarkably affects the taste of the products, and this can have repercussions on the choice of the consumer. Successful strategies to reduce sugar aim at maintaining the taste of the reformulated product unvaried as compared to the original food.

Semi-solid gelled food products are generally complex products containing different ingredients, such as proteins, carbohydrates and fats. Mixed or composite products comprising both proteins and polysaccharides are sensitive to phase separation, either on a macroscopic or on a microscopic level (van den Berg, van Vliet, van der Linden, van Boekel, & van de Velde, 2007a). Macroscopic phase separation is often associated with product flaws as the visual appearance of the product is inhomogeneous. Microscopic phase separation occurs at a smaller length scale and can thereby be present in macroscopically homogeneous products. The microstructure of mixed gels can be classified into homogeneous and phase separated. The latter can be further divided in protein-continuous, bicontinuous, heterogeneous and coarse stranded microstructures. Microphase separation is well studied in mixtures of proteins and polysaccharides. Heat-set whey protein gels have been studied in combination with a wide range of polysaccharides, including carrageenans, galactomannans, pectins, starch and starch derivatives (Beaulieu, Turgeon, & Doublier, 2001; Bryant & McClements, 2000). Recent studies on cold-set whey protein isolate (WPI)/polysaccharide mixed gels showed that minimal variations in the type and concentration of the polysaccharide resulted in a wide ranges of microstructures (van den Berg, van Vliet, van der Linden, van Boekel, & van de Velde, 2007b; de Jong, Klok, & van de Velde, 2009; de Jong & van de Velde, 2007). In these gels only the protein phase was in the gelled state. The concentrations of the polymers added to the protein dispersions were below the gelling concentration. Therefore, between the protein structures originated as a consequence of phase separation only aqueous solutions were present. The empty spaces in which these solutions were contained were described as pores. For these cold-set mixed

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WPI/polysaccharide gels a clear relationship was described between the molecular properties of the polysaccharide and the microstructure of the mixed gels. This relationship between ingredients and microstructure allows precise control over the mechanical properties of the final product. The microstructure of these mixed gels strongly affected their large deformation and sensory properties (van den Berg, van Vliet, van der Linden, van Boekel, & van de Velde, 2008).

Taste–texture interactions have been studied in polymer solutions and pourable model foods, as well as in gelled systems. An inverse correlation between viscosity of fluid foods and taste intensity has often been reported (Morris, 1995; Clarck, 2002). In hydroxyl propyl methyl cellulose (HPMC) solutions an increase of the polymer concentration (i.e. an increase in viscosity) resulted in a decrease of the perceived sweetness (Hollowood, Linforth, & Taylor, 2002). The same effect of polymer concentration on saltiness was observed for HPMC and λ-carrageenan solutions (Cook, Linforth, & Taylor, 2003). In solutions of random-coil polymers a suppression of taste perception with increasing polymer concentration is reported to start at the critical concentration at which coils overlap and entanglements occur (Morris, 1993). The reduced rate of transport of tastants from the interior of the sample, where they cannot be perceived, to the exterior appears the dominant factor in the suppression of taste perception in these systems.

Gel formation suppresses mixing between thickener and tastants molecules and thus inhibits migration of tastants to the taste buds. Therefore, in gels an extreme suppression of taste perception would be expected. An inverse correlation between taste intensity and the hardness of soft solid foods has been reported (Clarck, 2002). In a study comprising several different types of biopolymer gels and containing 16% sucrose a negative correlation was found between the overall flavour perception and both the mouthfeel attribute thick and gel hardness as measured in compression experiments (Clark, 2006). In κ-carrageenan and gellan gum gels containing both sucrose and aspartame as sweetening agents, a decrease of sweetness perception was observed with increasing polymer concentration (i.e. with increasing Young's modulus and fracture stress) (Bayarri, Izquierdo, & Costell, 2007). Nevertheless, the results found in literature on the relationship between gel hardness and taste and flavour perception are not univocal. In a study carried out with gels covering a wide range of failure properties, taste and flavour perception was negatively correlated to both to yield stress (i.e. perceived firmness) and yield strain (decrease of brittleness). (Morris, 1993) However, for gels with equivalent perceived firmness but higher brittleness the scores for perceived taste and flavour were remarkably higher. It was concluded that taste and flavour perception in gels is not dependent on hardness, but on brittleness. The mechanism proposed for the release of tastants and flavour molecules in these systems would involve the formation of fresh surfaces upon chewing.

The occurrence of serum release from WPI/polysaccharide gels is of importance with respect to the perception of tastants (van den Berg et al., 2007a). Serum release can be related to the juiciness perception in fruits and vegetables, as well as in meat products and meat replacers (van den Berg et al., 2007a). The phenomenon of serum release observed by van den Berg was mainly dominated by the microstructure of the gel, whereby gels with bicontinuous microstructure showed the highest amount of serum release upon compression. As tastants need to be dissolved in saliva before they can be perceived by the taste buds, serum release is likely to improve this process and enhance the perception of tastants in gelled products.

We hypothesize that serum release from cold-set mixed gels can improve and enhance the perception of non-volatile tastants, such as mono- and disaccharides. In order to study this hypothesis, a set of mixed WPI/gellan gum gels with controlled serum release, constant large deformation properties and different sugar concentrations was prepared. With these gels a quantitative descriptive analysis (QDA) study was carried out.

2. Materials and methods

2.1. Materials

Powdered whey protein isolate (WPI, Bipro™) was purchased from Davisco International Inc. (La Sueur, MN, USA). Gellan gum (low acyl, Kelcogel F) was kindly provided by CP Kelco Inc. (Lille Skensved, DK). Glucono-δ-lactone (GDL) was kindly donated by Jungbunzlauer (Marckolsheim, France). Sucrose, glucose and fructose were obtained from local shops. All materials were used without further purification. All samples were prepared with demineralised water.

2.2. Gel preparation

Mixed WPI/gellan gum gels were prepared by acid-induced cold gelation. Reactive WPI aggregated were prepared incubating a 9 wt% WPI solution at 68.5 °C for 2.5 h. After this heat treatment the aggregates dispersion was cooled with tap water to approximately 18 °C and immediately used for gel preparation. Stock solutions of gellan gum (0.6 wt%) were prepared by stirring the polysaccharide in water for 2 h and subsequently heating at 80 °C for 30 min under constant stirring. After heating, the polymer solution was cooled to approximately 18 °C with tap water. For gel preparation, the WPI aggregate dispersion was mixed with varying amounts of the gellan gum solution and with varying amounts of different sugars (sucrose, glucose, fructose) and diluted with water to a typical protein concentration of 3 wt%. To induce cold gelation GDL (0.25 wt% for gels with 3 wt% WPI) was added. An incubation at 25 °C for 17 h followed. The final pH of the gels was about 4.8. The preparation of the gels for the sensory study was optimised to obtain constant large deformation properties for all samples by varying the protein concentration. The composition of the samples with constant large deformation properties is reported in Table 1.

2.3. pH measurements

The pH of the gels was measured with a Knick Portamess 911 pH pH-meter (Knick Elektronische Messgeräte, GmbH & Co. KG, Berlin, Germany), by inserting the electrode directly into the gel and waiting until a constant value was reached. The measurement was performed at room temperature. The experimental error was 0.05 pH units.

2.4. Compression measurements

Uni-axial compression tests were performed approximately 20 h after preparation on cylindrical gel pieces of 25 mm height and 25 mm diameter. An Instron 5543 machine (Instron International

Table 1
Composition of the gels with constant large deformation properties used for the sensory study.

Gellan gum concentration (wt %)	WPI concentration (wt %)	Fructose concentration (wt %)			
0	4.0	0	3	6	12
0.03	3.15	0	3	6	12
0.04	3.0	0	3	6	12