Stabilising frozen dairy mousses by low molecular weight gelatin peptides

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ARTICLE INFO

ABSTRACT

The effect of low molecular weight gelatin peptides on the shrinkage of thawed mousses was investigated. Changes promoted by freezing-thawing processes were evaluated through texture and volume measurements and through X-ray analysis of the bubble distribution. Freezing provoked collapse of the standard reference recipe mousse and of the reference recipe mousse with 2% milk powder added, but samples containing 2% gelatin peptides showed no shrinkage. The bubble size and bubble number distribution of the different mousses were measured based on high-resolution X-ray tomography. Results indicated that the volume losses experienced by the controls were almost entirely caused by the disappearance of air bubbles having a diameter smaller than 50 μm. Hence, this fraction of over-pressurised air bubbles is extra stabilised by the matrix due to the additional presence of gelatin peptides. Moreover, gelatin peptides were found to inhibit ice crystal growth, which resulted in smaller ice crystals that are believed to be less destructive to the microstructure of the freeze-thawed mousses.

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1. Introduction

Many food products are frozen to provide long-term stability to the product. The process of freezing and thawing is highly destabilising food products, especially mousses, leading to foam collapse, loss of gas and loss of desired foam structure and texture (Ghosh & Coupland, 2008; Murray & Ettelaie, 2004). The stability and behaviour of food foams such as ice cream, marshmallow and mousses, is closely related to their microstructure, and more exactly, to the air bubble size, distribution and volume fraction (Miquelim, Lannes, & Mezzenga, 2010). Bamforth (1995) and Muller-Fischer and Windhab (2005) noticed that the foams with an even distribution of smaller bubbles were more stable, creamier and more attractive to consumers. Bubble mechanics can be used to estimate shelf life of whipped dairy products, since the textural appearance and mouthfeel are a direct consequence of the complex interactions between bubble mechanics and our senses (Niranjan, 1999).

High-resolution X-ray tomography (X-ray micro-CT) has recently been introduced as a non-destructive material evaluation technique for the microstructure of food products. The fact that micro-CT can provide information about the internal structure and properties of food, is a major advantage in the study of their conservation. With X-ray micro-CT (μCT) the internal structure of most food products can be visualised by measuring the different attenuations for X-rays of the materials in the product. As explained in Kak and Slaney (2001) and for food materials in particular in Verboven et al. (2008) and Herremans et al. (2013), the level of transmission of these rays depends mainly on the mass density and mass absorption coefficient of the material. Because absorption is different in gas and water, gas-filled spaces can be distinguished from the matrix material.

Freezing of mousses induces thinning of the lamellae between air cells, due to the cryoconcentration during ice formation, which directly affects foam stability (Camacho, Martinez-Navarrete, & Chiralt, 2001; Dickinson, 1992). Cryoconcentration implies alteration in the aqueous environment of macromolecules because of the separation of the more concentrated phase from the initial solution. Mechanical damage caused by ice crystals on air cell films can be considerable (Berger, 1990). Studies on ice cream have shown that hydrocolloids (locust bean gum, guar gum, xanthan gum, gelatin and carrageenan) exert a cryoprotective effect mainly due to the inhibition of ice crystal growth in the freezer and also by inhibiting ice recrystallisation throughout frozen storage (Caldwell et al., 1992; Donhowe & Hartel, 1996a, 1996b; Flores & Goff, 1999; Hagiwara & Hartel, 1996; Hartel, 1998; Sutton & Wilcox, 1998a, 1998b). Hydrocolloids increase the viscosity of the aqueous phase, hence reducing the availability of free water, and inhibiting de novo and/or recrystallisation events (Stanley, Goff, & Smith, 1996).

In contrast to these findings, peptides (2000—5000 Da) obtained from proteolytic hydrolysis of gelatin also prevented ice crystallisation in frozen ice cream mixes while not affecting the product's viscosity (Damodaran, 2007; Wang & Damodaran, 2009).

In this work, we aim to investigate the efficacy of low molecular weight gelatin peptides on the shrinkage of frozen mousses. Changes promoted by freezing-thawing processes were evaluated through texture and volume measurements and through X-ray analysis of both air bubbles and ice crystals.

2. Material and methods

2.1. Gelatin peptides

Commercial porcine gelatin peptides with an average molecular weight of 2000 Da were supplied by Rousselot BVBA.

2.2. Preparation of whipped mousses

Commercial mousse recipes containing whole milk, sugar, cream, gelatin, modified starch, mono- and diglycerides of fatty acids, lactic acid esters of mono- and diglycerides of fatty acids, sodium phosphates, carrageenan, vanilla flavour and beta carotene were prepared either or not including 2% gelatin peptides or 2% milk powder. The sample containing 2% milk powder was used as a control sample to have the same dry matter as the recipe with 2% gelatin peptides. After mixing the ingredients, the mixes were heated (5 s, 120—130 °C) and homogenised (downstream, 2-steps, 85 bar/25 bar), cooled and whipped in a kitchen aid (Hobart; Ohio, US) during 30 s at stand 2 and 4 min 30 s at stand 3. Mousses were stored in the freezer at −24 °C in 0.20 l plastic cups with lid. Cups were completely filled and remainders were scraped away with a knife. Mousses were analysed after 1, 3, 6, 9 and 12 months. Before analysis, samples were removed from the freezer and thawed for 24 h at 2 °C. The test was repeated once.

2.3. Texture of whipped mousses

Texture of the whipped mousses was performed at 2 °C before freezing and after thawing, 1, 3, 6, 9 and 12 months after frozen storage. Hardness of the samples was measured by penetration of a vertical sheet with 2 grooves of 15 mm (stainless steel; 33 × 33 mm) into the mousse to a depth of 20 mm at a constant speed of 120 mm/min with a Texture Analyser (LF-Plus; Lloyd Instruments Ltd., Hants, UK). For every batch, minimum 3 different samples were analysed. In order to test the effect on hardness (dependent variable), a linear regression was performed with time,

treatment and the interaction as categorical independent variables. Post hoc comparison was done with tukey post hoc test.

2.4. Volume of whipped mousses

Volume measurements were performed at 2 °C after thawing, 1, 3, 6, 9 and 12 months after frozen storage. Volume loss during frozen storage was calculated by measuring the new height and diameter of the product. Height loss was measured at 6 different locations by measuring the distance between the surface of the product and a ruler placed on top of the recipient. Loss in diameter was measured at 6 different points as the distance of the edge of the shrunk mousse to the wall of the recipient. From these measurements, the dimensions of the shrunk cylinder was calculated providing the best estimation of the remaining volume. Remaining volume for each sample was calculated using the following equation:

$$Remaining volume(\%) = 100 - \frac{V_1 - V_2}{V_1} \cdot 100$$

where V_1 is the volume before freezing of whipped mousse and V_2 the volume after freezing and thawing of whipped mousse. For every batch, 3 different samples were analysed. Volume was found not to be normally distributed. Therefore, non-parametric analyses was performed with time and treatment as categorical independent variables.

2.5. Overrun of whipped mousses

The overrun is a parameter which gives information on the percentage of gas in the whipped mousse. Volume ratio of air incorporated in mousse during whipping was measured in newly whipped mousse. Overrun was measured for each sample using the following equation:

$$Overrun(\%) = \frac{M_1 - M_2}{M_2} \cdot 100$$

where M_1 is the weight of a fixed volume of unwhipped mousse and M_2 the weight of the same volume of whipped mousse. In order to test the effect of treatment on overrun (dependent variable), a linear regression was performed with treatment as categorical independent variable. Post hoc comparison was done with tukey post hoc test.

2.6. Air bubble distribution of whipped mousses

The air bubble distribution was studied using optical microscopy and X-ray μCT.

In the experiment with the optical microscope (Olympus BH-2, Tokyo, Japan), a small sample of mousse was placed on a microscope glass slide and covered with a glass coverslip. Images were acquired using an Olympus Camera (Camedia C-3040 Zoom).

X-ray μCT was performed at the Centre for X-ray Tomography of the Ghent University (UGCT; www.ugct.ugent.be) using the Environmental CT-scanner (EMCT), a custom-built gantry-based laboratory μCT scanner (Dierick et al., 2014). Samples of 1 × 1 × 1 cm were used for the μCT experiments. The Hamamatsu L9181-2 X-ray tube was operated at 65 kV and a power of 11.7 W and 1500 projections were taken over 360° with an exposure of 500 ms using a Teledyne Dalsa Xineos-1313 high-speed flat-panel detector. The EMCT was upgraded with a custom-made freezing stage which can control and monitor a sample's temperature with an accuracy of ±0.4 °C (De Schryver et al., 2015), making it possible to scan a