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Effect of basil seed gum (BSG) on textural, rheological and microstructural properties of model processed cheese

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ABSTRACT

This study focuses on the textural, rheological and microstructural properties of a model processed cheese (44–48% wt/wt dry matter and 30% fat content) developed with different concentrations of rennet casein (6–10% wt/wt) and basil seed gum (BSG) (0–1% wt/wt). The frequency sweep test showed the η^*, G' and G'' values increased with increasing BSG concentration in all formulations with the same protein/solid content. Increasing levels of BSG also led to more elastic behaviour in the structure of processed cheeses. Regardless of the protein content, the "sol–gel transition" temperature of the model processed cheeses increased significantly ($p < 0.05$) when the concentration of the added BSG was increased. The concentration of added BSG had much more effect on meltability of the processed cheese than the protein content. However, flowability of the samples was dependent mainly on the protein content. The particle size data and confocal laser scanning microscopy (CLSM) images showed that BSG contributed to the emulsification of the oil and both the oil droplets and BSG chains were dispersed in a continuous protein phase. Similar to the BSG/milk proteins aqueous systems, the BSG chains possibly created a web network throughout the protein matrix of the processed cheese and strengthened the network formed by casein strands. By adding BSG, it was possible to make processed cheeses with higher firmness but slightly lower meltability, and at lower cost owing to the lower protein and higher moisture contents.

1. Introduction

Processed cheese/imitation cheese products can be described as stable oil-in-water emulsions. They are manufactured by blending natural cheeses/dairy proteins and edible oils/fats, in the presence of emulsifying salts and other dairy and nondairy ingredients, followed by heating and continuous mixing, to form a smooth homogeneous product. As processed cheeses/imitation cheeses are used mainly as an ingredient in prepared foods such as pizzas, burgers and toasted sandwiches, their rheological properties such as firmness and meltability during heat treatment are very important (Guinee, Caric, & Kalab, 2004; Lazaridis & Rosenau, 1980; Rohit Kapoor & Metzger, 2008). Rheological properties of processed cheeses have been studied extensively as function of ingredients and processing conditions using various determination methods, e.g. small strain and large strain rheological tests (Bowland & Foegeding, 1999, 2001; Brighenti, Govindasamy-Lucey, Lim, Nelson, & Lucey, 2008; Dimitreli & Thomareis, 2007, 2008; Guinee et al., 2004; Gupta & Reuter, 1993; Lee & Anema, 2009; Lee & Klostermeyer, 2001; Shirashoji, Jaeggi, & Lucey, 2006).

Hydrocolloids such as starch, xanthan, carrageenan, guar, pectin, alginate, locust bean gum, gelatin, inulin and gum Arabic are among the ingredients that have been used in formulation of low fat natural and processed cheeses.

Basil seed gum (BSG) is a novel hydrocolloid extracted from *Ocimum basilicum* L. seeds. It has shown promising stabilizing and emulsifying properties, which makes it a potential functional ingredient for the food industry (Hosseini-Parvar, 2009; Hosseini-Parvar, Matia-Merino, Goh, Razavi, & Mortazavi, 2010; Osano, Hosseini-Parvar, Matia-Merino, & Golding, 2014; Razavi et al., 2009). BSG is a surface-active hydrocolloid that can form small emulsion droplets (<1.0 μm) and stabilize 30% O/W emulsions against phase separation for at least one month by using as little as

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0.3% (wt/wt) (Osano et al., 2014). BSG mainly composed of two major fractions: the glucomannan which is the hydrophobic segment and the xylan fraction that is responsible for its hydrophilic behaviour (Anjaneyalu & Channe Gowda, 1979; Hosseini-Parvar, Matia-Merino, Mortazavi, & Razavi, 2014). BSG have also been compared to gum arabic for ultrasound-assisted emulsification of mint essential oil (Hosseini-Parvar, Alimardani, Shahidi, & Matia-Merino, 2013). It has a heat-resistant nature and exhibits higher zero-shear viscosity and yield stress than xanthan, konjac and guar gum at similar concentrations (Hosseini-Parvar, 2009; Hosseini-Parvar et al., 2010). The interactions between BSG and milk proteins have been shown synergistic in dispersions (Sarabi Aghdam, Hosseini-Parvar, Motamedzadegan, & Matia-Merino, 2013a, 2013b), O/W emulsion (Khorrami, Hosseini-Parvar, & Motamedzadegan, 2014) and gel systems (Rafe, Razavi, & Farhoosh, 2013; Rafe, Razavi, & Khan, 2012). These interactions create a weak gel throughout the system and thereby stabilise the systems. It has also been reported that BSG chains can create web network inside the protein matrix and led to decrease the amount of syneresis and hysteresis area as well as to increase the firmness of low-fat set yoghurt (Afshar Nik, Raftani Amiri, & Hosseini-Parvar, 2011).

The present study explores another potential application for BSG, through investigating its effect on the rheology, melting properties and microstructure of a model processed cheese. Large strain and small strain dynamic rheological measurements were used to understand the macro-structural properties of the model processed cheese. The thermo-physical properties of the model processed cheese (e.g. meltability and flowability) were also investigated. Confocal laser scanning microscopy and particle size determination were also used to examine any changes in the microstructural properties of the processed cheese.

2. Materials and methods

2.1. Materials

Basil seeds were obtained from a local market in the city of Isfahan, Iran. The Basil seed gum (BSG) was extracted according to the procedure of Hosseini-Parvar et al. (2010). The chemical composition of BSG on a dry weight basis (wt/wt) was: 1.32 ± 0.09% protein, 6.5 ± 0.21% ash, 4.38 ± 0.14% fat, 79.63 ± 0.73% total carbohydrate, 0.55 ± 0.07% soluble sugars and 1.53 ± 0.15% starch. The moisture content of BSG was 9.1 ± 0.17% (wt/wt) (Hosseini-Parvar et al., 2010). The other ingredients included Milli-Q water, rennet–casein (ALAREN 779, Fonterra Co-operative Group Ltd, Auckland, New Zealand), soya oil (Davis Trading Co., Palmerston North, New Zealand), lactose (New Zealand Milk Products, Auckland, New Zealand), sodium chloride (Pacific Salt NZ Ltd, Auckland, New Zealand), trisodium citrate (TSC) and citric acid (Jungbunzlauer, Basel, Switzerland). Rennet casein, which does not suffer from proteolysis or variations in composition (Pereira, Bennett, Hemar, & Campanella, 2001), has a calcium level similar to that of young cheese and is able to form a stable structure, was used as a source of protein in the formulation of model processed cheese. All other chemicals used were of analytical grade and were obtained from either Sigma Chemical Co. (St. Louis, MO, USA) or BDH Chemical (BDH Ltd, Poole, UK).

2.2. Manufacturing procedure of model processed cheese

A Rapid Visco Analyser (RVA Super 4, Newport Scientific Ltd, Warriewood, NSW, Australia) was used to manufacture the model processed cheese in triplicate. The RVA machine was used previously to mimic the manufacture of processed cheese in the laboratory scale (Kapoor, Lehtola, & Metzger, 2004; Kapoor & Metzger, 2005). The basic formulation used for the model processed cheese was 10% rennet casein, 30% oil, 52% moisture, 3.5% lactose, 2.8% TSC, 1% sodium chloride and 0.7% citric acid.

The rennet casein, TSC, BSG, lactose and water were weighed and put into an RVA canister then thoroughly mixed and allowed to hydrate for at least 40 min at room temperature. After hydration, salt, citric acid, and soya oil were added and the canister was set into the RVA machine. The mixture was then heated to 85 °C over 4 min and was held at 85 °C for 6 min at a shear rate of 1500 rev min^{-1}. The shearing profile of the RVA in five steps were: a) 0–100 rev min^{-1} for 0.5 min; b) 100–200 rev min^{-1} for 0.5 min; c) 200–500 rev min^{-1} for 1 min; d) 500–1000 rev min^{-1} for 2 min; e) 1000–1500 rev min^{-1} for 6 min.

The processing conditions (e.g. processing time, temperature and mixing speed) were the same for all the formulations. The molten sample was cast into a slice with uniform thickness of 2.2 mm and a cylindrical mould (for textural analysis), sealed in a plastic bag, cooled down to 4 °C and then stored at 4 °C for further analysis.

BSG was added to the model processed cheese formulations with three levels of rennet casein concentration (6, 8 and 10%) at additional rates of 0%, 0.1%, 0.3%, 0.5% and 1% of the total weight. For the sake of simplicity, the rennet casein will be called protein throughout this article. We could not prepare the sample containing 10% protein and 1% BSG, as its viscosity was higher than the viscosity range of RVA machine.

The total solids were maintained at a consistent level through the addition of lactose when BSG was added to the formulation. The samples with the same protein concentration had the same total solids content. Therefore, the effect of BSG concentration on properties of the model processed cheese was investigated only for the samples with the same protein/solid content. The final lactose content of the formulations in this work was less than the maximum amount suggested by previous research (7.48% for processed cheese foods containing 44% moisture content and 10.20% for processed cheese spreads containing 60% moisture content) (Kapoor & Metzger, 2008). The loss of moisture content for the samples during the RVA processing and cooling down was less than 1%.

2.3. pH measurement

The pH of the samples was estimated 24 h after the production, at 20 °C with the direct insertion of a glass electrode into the sample, using a previously standardized digital pH meter (Mettler-Toledo pH meter, Mettler-Toledo Inc., USA).

2.4. Rheological measurements

The dynamic rheological properties of the model processed cheese were measured after 24 h storage at 4 °C, using a controlled-stress rheometer (Physica MCR 301, Anton Paar GmbH, Stuttgart, Germany) fitted with a 25 mm diameter parallel plate with a 2.0 mm gap. Cheese samples were carefully cut to 25 mm diameter discs using a cylindrical cutter and glued to the surface of the lower plate. The upper serrated plate was lowered until it reached a 2 mm gap distance and the sample was trimmed. A thin layer of low-density mineral oil was used around the periphery of the sample to prevent evaporation during the measurement. A strain sweep (0.01–100%) at 20 °C and frequency of 1 Hz was used to determine the limits of linear viscoelastic behaviour of the model processed cheese. A frequency sweep test was performed at 5 °C and a strain amplitude of 0.5%, with the frequency varied from 0.01 to 10 Hz. A temperature sweep test was performed at a constant frequency of 0.1 Hz and a constant strain amplitude of 0.5%, with the