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The effect of cheese maturity on selected properties of processed cheese without traditional emulsifying agents

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ABSTRACT

The aim of this work was to compare selected properties (hardness, cohesiveness, adhesiveness, characteristics of fat globules, pH, meltability and sensory characteristics – homogeneity, rigidity and flavour) of processed cheeses (dry matter content 40 g/100 g; fat in dry matter content 50 g/100 g) made with traditional emulsifying salts (sodium salts of phosphates) and products in which the traditional emulsifying salts were replaced with 1 g/100 g κ-carrageenan. The development of the above-mentioned properties was studied in dependence on the maturity level of cheese (raw material; 1–16 weeks' maturity). The samples made without the use of traditional emulsifying salts were nearly five times as hard as the products with phosphates regardless of the maturity level of cheese. In both types of samples, hardness was decreasing and adhesiveness was rising with the increasing maturity level of cheese. Meltability of the samples without traditional emulsifying salts was very low and remained practically unchanged with the increasing maturity level of cheese. On the other hand, in the processed cheeses with phosphates, meltability was increasing with the rising maturity level of cheese.

1. Introduction

Traditional processed cheese is made from a mixture of cheeses, fat, water and emulsifying salts (usually sodium salts of citrates, phosphates or polyphosphates). The mixture of ingredients is stirred under partial pressure and heated until the melting temperature (usually between 90 and 100 °C) is reached. This temperature is then kept for a certain period of time. The hot melted mixture is poured into cups and subsequently cooled down usually below 8 °C (Alves, Van Dender, Jaime, Moreno, & Pereira, 2007; Guinee, Carić, & Kaláb, 2004; Lee & Anema, 2009). Emulsifying salts (both of phosphate- and also citrate-type) are added because of their ability to sequestrate calcium from the protein matrix. This leads to the formation of sodium paracaseinate, which can function as an emulsifier within the given system (Awad, Abdel-Hamid, El-Shabrawy, & Singh, 2002; Carić & Kaláb, 1997). Guinee (2003) mentions that heating the mixture of ingredients without emulsifying salts would lead to a chain of reactions resulting in separation of hydrophilic and hydrophobic phases. Emulsifying salts are also significant factors influencing the melting and texture properties of processed cheeses (Lee, Klostermeyer, Schrader, & Buchheim, 1996; Lu, Shirashoji, & Lucey, 2008; Mizuno & Lucey, 2005, 2007).

From the viewpoint of the human nutrition, an ideal ratio of calcium and phosphorus absorbed is 1:1. However, in processed cheeses this ratio is usually decreased to 1:1.5–3.0 due to the use of phosphate emulsifying salts (Schäffer, Lörinczy, & Belágyi, 1999; Schäffer, Szakály, Lörinczy, & Schäffer, 2001). A decrease in the amount of phosphorus in processed cheeses would lead to a better nutritious rating of this popular dairy product (Černíková et al., 2010). Sodium salts of citrates are also used as the traditional emulsifying salts, especially for processed cheese blocks or slices with very good meltability (Guinee et al., 2004; Lu et al., 2008).

Complete or at least partial substitutes for traditional emulsifying salts (both phosphate and citrate) have been studied in many works, most of which used different polysaccharides or monoacylglycerols as substitutes (Carić & Kaláb, 1997; Černíková et al., 2010; Pluta, Ziarno, & Smolinska, 2000; Schäffer et al., 1999; Schäffer et al., 2001).

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Černíková et al. (2010) used the addition of 1 g/100 g κ-carrageenan (high molecular linear anionic polysaccharide usually extracted from red seaweed of *Rhodophyceae* family) as a complete substitute for traditional emulsifying salts. The samples (manufactured from cheese of constant maturity) appeared to be macroscopically and microscopically homogeneous. Černíková et al. (2010) explained that mainly by the ability of the complexes of hydrophilic carrageenan with hydrophobic casein particles to act as fat emulsifiers.

The degree of cheese maturity significantly influences texture parameters of the final product as well as its meltability (Brickley, Auty, Piraino, & McSweeney, 2007; Piska & Štětina, 2004). The dependence of texture parameters (measured within the large deformation area) and meltability of the products with a complete substitute for traditional emulsifying salts on the maturity of cheese (raw material) has not been described in literature.

The aim of this study was to observe the influence of the maturity degree of cheese on the texture properties and meltability of processed cheeses made with the addition of 1 g/100 g κ-carrageenan without traditional phosphate- and citrate-based emulsifying salts. A secondary aim was to compare the development of the above-mentioned parameters with the control sample into which traditional phosphate-based emulsifying salts were applied.

2. Materials and methods

2.1. Production of processed cheese products and basic chemical analysis

Model processed cheeses without the addition of traditional emulsifying salts had 40 g/100 g dry matter content and 50 g/100 g fat in dry matter content (hereafter called KC). The mixture of ingredients consisted of Edam cheese block (Dutch type cheese with different maturity – see below; 50 g/100 g dry matter, 30 g/100 g fat in dry matter), butter (84 g/100 g dry matter, 82 g/100 g fat), water and 1 g/100 g κ-carrageenan (Sigma–Aldrich, St. Louis, MO, USA). Processed cheeses without the addition of κ-carrageenan made by means of traditional emulsifying salts (2.5 g/100 g; sodium phosphate and polyphosphate salts – JOHA HBS, JOHA S9S and JOHA S4SS in a ratio of 1:4:1; Benckiser-Knapsack, Landenburg, Germany) were used as control samples (hereafter called ES). The formulation of various processed cheese batches was always appropriately changed (by means of water or butter amount used) to keep constant dry matter content and fat in dry matter content in all batches. For the production of model and control samples, Vorwerk Thermomix TM 31-1 (Vorwerk & Co., GmbH, Wuppertal, Germany) was used. The same apparatus was also used for the production of processed cheeses in the work by Černíková et al. (2010). A melting temperature of 90 °C was used for 1 min (the total melting time was 10–12 min) at 4000 rpm. Afterwards, the hot melt was poured into rectangular polystyrene cups (for a microscopic and sensory analysis; dimensions: width 66 mm, length 96 mm, height 17 mm) and cylindrical polypropylene cups (for an analysis of texture properties and meltability; dimensions: diameter 52 mm, height 50 mm) and decked with appropriate aluminium lids. The samples were cooled down within 2 h after the production to a temperature of 6 ± 2 °C. Each model and control sample was repeated twice within one batch of cheese (see below).

Edam cheese block (2.5–2.7 kg blocks packed in Cryovac packagings) was used at a different degree of maturity. In order to eliminate the external factors, a sufficient number of cheese blocks were taken (from a batch) and put into a ripening cellar of the producer at 9–10 °C. The material was taken from the cellar after 1, 2, 4, 6, 8, 10, 12, 14 and 16 weeks of ripening. The degree of maturity (the extent of proteolytic changes) was observed by determining the content of free amino acids (part 2.2.). The whole experiment was done with 2 batches of cheeses, i.e. each model and control sample was made four times (4 lots – 2 batches of cheeses and each sample made twice from each batch).

Edam cheese blocks during ripening (after 1, 2, 4, 6, 8, 10, 12, 14 and 16 weeks) and also model (KC) and control (ES) samples (after 14 days of storage at 6 ± 2 °C) were analysed for pH, dry mater, fat, total protein and ash content (each analysis was carried out at least eight times). Dry matter content in the samples was determined according to ISO 5534 (2004) and pH was measured (Sper pH-meter with an electrode, Eutech Instruments, Oakton, Malaysia) at 16 ± 1 °C (the sample was tempered in a thermal chamber for 4 h). Ash content was analysed by burning of 1 g of sample in muffle furnace at 550 ± 5 °C for 5 h and fat content was determined by the acidobutyric method of van Gulik (Dimitreli & Thomareis, 2007; ISO 3433, 2008). Total protein content was assayed by analysis of total nitrogen amount (TN) by Kjeldahl method and calculating total protein content as TN × 6.38 (Dimitreli & Thomareis, 2007).

2.2. Analysis of the total free amino acid content

Before the analysis, the cheese block was cut into approximately 2 × 2 × 2 cm and mixed. Afterwards, 200 g of the sample was grated and mixed again. One gram of the grated and mixed cheese sample was put into 15 mL test tubes and free amino acids were extracted using lithium-citrate buffer (pH 2.2). Three replicate extractions were carried out. The extraction and chromatographic determination (AAA400 Amino Acid Analyser, ion-exchange chromatography; Ingos, Prague, Czech Republic) were described in Pachlová et al. (2011) and Buňková et al. (2009). Each extract was analysed twice. In each degree of maturity, the analysis of cheese was performed twelve times (4 lots of model samples, 3 extractions and 2 analysis of an extract).

The total free amino acid content was determined as the sum of concentrations of twenty two free amino acids or their derivates (aspartic acid, threonine, serine, asparagine, glutamic acid, glutamine, proline, glycine, alanine, valine, methionine, cysteine, isoleucine, leucine, tyrosine, phenylalanine, lysine, histidine, arginine, ornithine, citrulline, γ-aminobutyric acid) and expressed as a ratio of total protein content (g/100 g).

2.3. Texture analysis

The texture analysis was performed on the day of production (6 h after cooling), on the 7th and on the 30th day of storage (6 ± 2 °C). The texture properties of the samples were evaluated using a texture analyser TA.XT.plus (Stable Micro Systems Ltd., Godalming, UK). Before the measurement, the samples (in cylindrical cups) were tempered at 16 °C in a thermal chamber for 4 h. The texture analyses were carried out by two sequential penetration events (a penetration depth of 10 mm, a probe speed 2 mm s^{-1}, a trigger force of 5 g). The test was performed using a 20 mm stainless steel cylinder probe P20 (20 mm diameter). The following parameters were observed: hardness (force needed to attain a given deformation – maximum force during the first penetration cycle; N), adhesiveness ratio (relative strength of adhesiveness between the cheese and the probe surface – ratio of the absolute value of the negative force area to the positive force area of the first peak; unitless) and cohesiveness (strength of the internal bonds of cheese – ratio of the positive force area of the second peak to that of the first peak; unitless) (Breuil & Meullenet, 2001; Fiszman & Damásio, 2000; Genovese, Ye, & Singh, 2010; Piska & Štětina, 2004). Each variety of model samples was analysed twelve times (4 lots of model samples, 3 texture analysis per a lot).