J. Dairy Sci. 101:1–7
https://doi.org/10.3168/jds.2017-13742

The effect of rework content addition on the microstructure and viscoelastic properties of processed cheese

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ABSTRACT

The aim of this work was to add various amounts of rework (0.0 to 20.0% wt/wt) to processed cheeses with a dry matter content of 36% (wt/wt) and fat with a dry matter content of 45% (wt/wt). The effect of the rework addition on the viscoelastic properties and microstructure of the processed cheeses was observed. The addition of rework (in this case, to processed cheese with a spreadable consistency) in the amounts of 2.5, 5.0, and 10.0% (wt/wt) increased the firmness of the processed cheese. With the further addition of rework, the consistency of the processed cheeses no longer differed significantly. The conclusions obtained by the measurement of viscoelastic properties were supported by cryo-scanning electron microscopy, where fat droplets in samples with added rework of over 10.0% (wt/wt) were smaller than fat droplets in processed cheeses with lower additions of rework.
Key words: processed cheese, rework, rheology, cryo-scanning electron microscopy

INTRODUCTION

Processed cheeses (**PC**) are produced at an increased temperature and under moderate underpressure, from basic raw materials (cheeses, butter, water, emulsifying salts) to which other ingredients of a dairy or nondairy origin can be added. The consistency of PC is affected by several different factors, which we can divide into the following groups: (1) raw material composition (content of cheeses of various types and maturity, DM and fat in DM contents, concentration and composition of emulsifying salts, presence of hydrocolloids, rework content, and so on), (2) technological production parameters (agitation speed, agitation duration, cooling time and rate, and so on), (3) storage conditions (storage length and temperature, packaging characteristics; Kapoor and Metzger, 2008; Salek et al., 2015; Černíková et al., 2017).

Rework is a PC that has already been processed once and in which creaming has already occurred; it is used as a raw material for the production of PC. Therefore, its consistency is affected by all of the aforementioned factors. Rework is created in industry either (1) intentionally (production of PC for rework or residue of PC in production equipment) or (2) unintentionally (production of PC originally intended for the market network, but was ultimately not released for market, for example, due to unsuitable packaging or incorrect DM or fat in DM content). Rework is usually used fresh (PC residue in production equipment) or 3 to 14 d old (PC unsuitable for the market network due to unsuitable fat or DM content, or an incorrect packaging weight). Meyer (1973) and Guinee et al. (2004) defined 3 types of rework: (1) from young cheese with long protein chains (unripened raw material used for processing), (2) regular PC with a creamy structure, and (3) over-creamed product with a delicate structure. In Kaláb et al. (1987), 3 types of rework were also used: (1) fresh rework (produced and rapidly frozen immediately after production), (2) regular rework from previous processes, and (3) the so-called hot melt, which simulates PC subjected to extreme stress (cooled from 82 to 4°C in 5 h), which Meyer (1973) refers to as overcreamed. All of the aforementioned types of reworks are processed under industrial conditions to prevent economic losses (Kaláb et al., 1987). The reasons for using rework can be economic (see above), but it is also used to increase viscosity (with the increasing age of the rework and with its increasing concentration) after production, increase firmness, improve meltability, or reduce the emulsifying salt content, as rework already contains emulsifying salt (Lauck, 1972; Meyer, 1973; Kaláb et al., 1987; Pluta et al., 2000; Kapoor and

Received August 25, 2017.
Accepted December 2, 2017.
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Metzger, 2008). However, individual types of reworks are added in different quantities for various reasons. If we use the division as per Meyer (1973), then fresh rework is used in a concentration of 1 to 2% (wt/wt) to increase the creaming of PC spreads, which contain a high proportion of ripened or very ripened cheeses in their raw material composition with intact casein content approximately 70%, or more precisely, less than 65%. The second type of rework (regular PC with a creamy structure) is used for block-type PC, to increase firmness and elasticity, in a quantity of 2 to 30% (wt/wt). Meyer (1973) recommended that the third type of rework (over-creamed product with a delicate structure) be used only in a quantity of less than 1%, as it has a very strong creaming effect and could easily lead to over-creaming. Lauck (1972) wrote about the addition of rework, usually in a quantity of 2 to 15% (wt/wt). Explanations of the applications of individual types of reworks are listed by Guinee et al. (2004), who claims that the additional heating of preprepared PC can cause a higher degree of temperature-induced dehydration and paracasein aggregation, particularly in the third type of rework (over-creamed product with a delicate structure), which increases the elasticity of the resulting product. The more effective dispersion of the emulsifying salts in rework (due to a longer contact period) leads to the faster hydration of paracasein and the high concentration of proteins, thanks to the high degree of emulsification and in the third type of rework (over-creamed product with a delicate structure), which leads to increased viscosity, the effective dispersion of fat, and the emulsification of the fresh melting mixture.

The literature has not described the effects of various concentrations of rework on the consistency of PC in detail, and in practice rework is added exclusively on the basis of empiricism. The aim of the work was to observe the effect of adding various quantities of rework to the raw material composition on the resulting consistency of the PC. Model samples with a DM content of 36% and fat in DM content of 45% were produced with an addition of 0.0, 2.5, 5.0, 10.0, 15.0, and 20.0% (wt/wt) rework under industrial conditions. The consistency was examined using dynamic oscillatory rheometry over a 60-d storage period. Individual analyses were performed on d 1, 7, 14, 30, and 60 after production.

MATERIALS AND METHODS

The model samples of PC were produced under industrial conditions, from raw materials manufactured by the PC producer. The following were used: Dutch-type cheese [50% (wt/wt) DM content, 30% (wt/wt) fat in DM content, Lacrum, PLC, Velké Meziříčí, Czech Republic; 8-wk maturity], unsalted butter [84% (wt/wt) DM content and 82% (wt/wt) fat content, Lacrum, PLC, Velké Meziříčí, Czech Republic], water, emulsifying salts [3% (wt/wt) calculated per total weight, composition of emulsifying salts (% relative)]: 34% Na_2HPO_4, 26% NaH_2PO_4, 20% $Na_4P_2O_7$, and 20% sodium polyphosphate; Fosfa PLC, Břeclav, Czech Republic), and rework. The effect of individual emulsifying salts on pH shift in a model environment of deionized water, liquid dairy system, and PC was presented in Nagyová et al. (2014) and Salek et al. (2015). The rework added to the raw material composition was produced from the same raw material composition as the control sample (without the addition of rework) and added after 3 d of storage at a temperature of 6 ± 2°C (72 h), in quantities of 0.0, 2.5, 5.0, 10.0, 15.0, and 20.0% (wt/wt). The samples were produced using Stephan UM 130 equipment (Stephan Machinery GmbH, Hameln, Germany), at a melting temperature of 90°C (the holding time was 1 min and direct heating was used) and a blade revolution speed of 1,500 rpm. The total producing time was about 9 to 10 min. Before the manufacture, slight underpressure was generated in the kettle (using a vacuum pump). Each PC with the certain rework concentration was manufactured 3 times (3 repetitions × 6 concentrations of rework = 18 manufactured batches). After production, the samples were packaged in plastic jars closed with lids, cooled to 6 ± 2°C, and stored for a period of 2 mo. The samples of each manufactured batch were analyzed after 1, 7, 14, 30, and 60 d of storage.

The DM content and the fat content of the PC samples were gravimetrically determined according to ISO 5534 (ISO, 2004a) and ISO 1735 (ISO, 2004b), respectively. The pH values were measured at ambient temperature using the glass tip electrode of a pH meter (pH Spear, Eutech Instruments Europe B.V., Landsmeer, the Netherlands), by directly inserting the spear into the PC samples in 3 randomly selected spots (in each packaging).

The rheological analysis of the PC samples was performed using a dynamic oscillatory shear rheometer (RheoStress 1, Haake, Bremen, Germany) with a plate-plate geometry (diameter 35 mm, gap 1.0 mm) at 20.0 ± 0.1°C. Storage (**G′**) and loss (**G″**) moduli [determined as functions of frequency (ω) ranging from 0.1 to 100.0 Hz] were monitored (shear stress amplitude 20 Pa). The complex modulus (**G***) was calculated using the following formula:

$$G^{*} = \sqrt{\left(G'\right)^{2} + \left(G''\right)^{2}}. \quad [1]$$