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# The effect of the pH at cooking on the properties of processed cheese spreads containing whey proteins

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ABSTRACT

Processed cheese spreads were made with and without whey proteins under varying cooking pH conditions. The processed cheeses were cooked at one pH value and at the end of the cooking process the pH was adjusted to the final product pH of 5.7. The rheological properties and whey protein denaturation levels of the processed cheese spreads were measured. The rheological properties and texture of the processed cheeses containing whey proteins could be markedly modified by varying the cooking pH during processing, whereas those without whey proteins were unaffected. These textural modifications could not be explained solely by the changes in whey protein denaturation during cooking. It is proposed that the interactions of the whey proteins during cooking affect the processed cheese texture, and that these interactions are affected by the pH of the processed cheese during processing.


## 1. Introduction

Traditionally processed cheese is made by mixing and heating natural cheese, salts, calcium chelating salts (also commonly known as melting or emulsifying salts), water and fat. The conversion of natural cheese into processed cheese was originally developed in the late nineteenth to early twentieth centuries, and was used as a preservation measure, extending the shelf life of the cheese. Nowadays, processed cheeses are made for reasons other than preservation, such as for versatility, convenience and cost reduction. With the advances in dairy technologies, new ingredients such as milk powders, whey powders, milk protein concentrates, caseins and caseinates are now available as ingredients for incorporation into processed cheese (Berger, Klostermeyer, Merkenich, & Uhlmann, 1998; Guinee, Caric, & Kaláb, 2004; Lee, Anema, & Klostermeyer, 2004). The composition and properties of some of these ingredients can be used to manipulate the textural and functional properties of the resultant processed cheese.

There are limited reports on the study of the effects of whey proteins on processed cheese properties. Ernstrom, Sutherland, and Jameson (1980) reported that the effect of cheese base (which contains whey proteins) in processed cheese resulted in excessively firm product, but the effect on processed cheese food was satisfactory. Gupta and Reuter (1993) investigated the effect of whey protein concentrate (WPC) on the properties of processed cheese and processed cheese foods. They reported a slight increase in hardness at 10% protein replacement level, but a more significant increase at 20% protein replacement level. The melt properties of the processed cheese containing WPC were markedly reduced. This reduction of the melt properties of processed cheese by the addition of whey proteins has been reported on a number of occasions (Gupta & Reuter, 1993; Schulz, 1976; Strandholm, Prochnow, Miller, Woodford, & Neunaber, 1989).

Savello, Ernstrom, and Kalab (1989) reported on the addition of native and denatured whey proteins in processed cheese made from rennet casein or acid casein. Though a general trend of melt reduction was observed, high levels of whey protein inclusion (4.5%) in the rennet casein system showed an increase in meltability. On addition of native whey proteins to the rennet casein system, oiling off was observed when the whey protein level was increased above about 1.5%. Abd El-Salam, Khader, Hamed, Al-Khamy, and El-Garawany (1997) indicated that the use of WPC in processed cheese may be complex and possibly confounded by the use of different types and levels of calcium chelating salts. Mounsey, O'Kennedy, and Kelly (2007) showed that the whey protein isolate (WPI) significantly decreased the meltability of processed cheese, but the hardness increased and then decreased above 2.6% w/w WPI. At low levels of WPI addition, there was no significant change in hardness or meltability compared with the control (no WPI).

Despite the different results reported, the general trend is that whey protein addition to processed cheese tends to decrease the meltability of the cheese (Collinge & Ernstrom, 1988; Gigante, Antunes, Petenate, & Roig, 2001; Gupta & Reuter, 1993; Mounsey et al., 2007; Savello et al., 1989; Schulz, 1976; Sood & Kosikowski, 1979), with variable effects on the firmness (Abd El-Salam et al., 1997; Ernstrom et al., 1980; Gupta & Reuter, 1993; Mounsey et al., 2007).

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Recent studies on heating milk have shown that the manipulation of the pH at the time of heating can markedly influence the interactions of the denatured whey proteins with the caseins (Anema & Li, 2003; Donato & Dalgleish, 2006; Rodriguez del Angel & Dalgleish, 2006), and that these interactions have an effect on the rheological properties of acid gels prepared from the heated milks (Anema, Lee, Lowe, & Klostermeyer, 2004; Rodriguez del Angel & Dalgleish, 2006). On heating milk (90 °C/30 min) at a relatively low pH (pH 6.5) most of the denatured whey proteins interacted with the casein micelles, and on acidification, these heated milks produced acid gels with a relatively low firmness. As the pH at heating was increased from pH 6.5 to pH 7.1, less denatured whey protein interacted with the casein micelles, the whey proteins remaining in the serum as complexes with κ-casein. The firmness of acid gel prepared from the heated milks increased as the pH of the heated milks was increased, so that acid gels prepared from milk heated at a heating pH of ~pH 7.1 had a firmness that was more than double that of acid gels prepared from milk heated at pH 6.5 (Anema et al., 2004; Rodriguez del Angel & Dalgleish, 2006). These changes in the rheological properties of the acid gels were related to the denaturation and interaction of the whey proteins, and these interactions were markedly affected by small changes in the pH at the time of heating the milk (Anema et al., 2004; Rodriguez del Angel & Dalgleish, 2006).

Though the ingredients, processing methods and equipment used in processed cheese manufacture are versatile (Berger et al., 1998; Guinee et al., 2004), processed cheese is usually prepared (cooked) at the pH of the finished product. Due to the solubility, interaction, and as well as the hydrolysis of the calcium chelator salts, the final pH of processed cheese products usually ranges from pH 5.4 to pH 5.9, depending on the processed cheese type, but is usually around pH 5.7 (Guinee et al., 2004; Lu, Shirashoji, & Lucey, 2007). It is possible that, in processed cheese samples with added whey proteins, the rheological properties and textural properties of the processed cheese may be able to be manipulated by changing the pH of the system during cooking. This work therefore reports on the effect of processing conditions, especially the pH at cooking, on the textural properties of model processed cheese spreads containing whey proteins; these are compared with processed cheese samples that did not have whey proteins added. Therefore, this work examined the effect of altering the pH at cooking on the visual and rheological properties of processed cheese spreads containing whey proteins ($PC_{whey}$), in comparison to those that contained no whey proteins ($PC_{control}$).

## 2. Materials and methods

### 2.1. Materials

The whey protein concentrate (WPC) used was ALACEN 392, and the rennet casein used was ALAREN 799 (90 mesh). Both were supplied by Fonterra Co-operative Group, New Zealand. Sodium chloride (NaCl), trisodium citrate (TSC) and citric acid (CA) were supplied by BDH Laboratory Supplies, Poole, England. Sunflower oil (AMCO brand) was obtained from Goodman Fielder, East Tamaki, New Zealand.

### 2.2. Preparation of model processed cheese samples

#### 2.2.1. Preparation of processed cheese samples with added whey proteins

WPC (15.36 g) was added to water (67.64 g) and stirred for ~30 min to form a well dispersed solution. Rennet casein (55.08 g) and NaCl (6 g) were added to a calcium chelator solution containing water (170 g), TSC and CA to achieve different pH's of the processed cheese during cooking (see Table 1 for levels of TSC and CA added and the cook pH achieved). The mixture was rapidly stirred for a few minutes at room temperature where the slurry set into a gel-like material. The WPC and gelled rennet casein solutions were allowed to hydrate for 12 h in a refrigerator set to ~5 °C.

Model processed cheese spreads were prepared using a 2 l capacity Vorwerk Thermomix TM 21 blender cooker (Vorwerk Australia Pty. Ltd., Granville, N.S.W., Australia) as described by Lee et al. (2004). The Vorwerk cooker has temperature and speed settings which were used to heat and stir the mixtures. The sunflower oil (192 g) was heated for 1 min at a temperature setting of 100 °C and a speed setting of 1 (100 rpm). This brings the oil temperature to ~60 °C. The hydrated rennet casein, WPC and additional water (48.7 g, which includes ~11 g that evaporates during cooking) were added to the warm oil and the mixture was cooked at a temperature setting of 90 °C for 2 min at speed 4 (~2000 rpm), after which the temperature setting was lowered to 80 °C and held at this setting for 5 min. The remaining CA or TSC (as shown in Table 1) was dissolved in water (20 g) and added to the mixture. The mixture was then cooked for a further 2 min at 80 °C at speed 4 (~2000 rpm). This late addition of CA or TSC shifts the processed cheese from its cook pH (see Table 1) to a final pH of 5.7. The final temperature of the molten processed cheese was ~85 °C. The molten processed cheese was poured into plastic screw-cap containers (volume 50 ml), inverted and then stored at 5 °C. The target composition of the processed cheese spreads was 52.1% moisture, 10.1% protein (80% casein from rennet casein, 20% whey protein from WPC), 33.2% fat, 2.6% calcium chelating salts (ratio TSC:CA = 3.20:1) and 2.0% minerals. This composition is typical of processed cheese spread products (Berger et al., 1998; Guinee et al., 2004; Lee et al., 2004).

#### 2.2.2. Preparation of processed cheese samples with no added whey proteins

Samples that contained no whey proteins were also prepared. Rennet casein (69.5 g) was hydrated with TSC, CA (see Table 2

**Table 1**
Levels of trisodium citrate (TSC) and citric acid (CA) added to processed cheese to attain cook pH and final pH for processed cheese samples containing whey proteins.

| Required cook pH | TSC added to attain cook pH (g) | CA added to attain cook pH (g) | TSC added to attain final pH of 5.7 (g) | CA added to attain final pH of 5.7 (g) |
|---|---|---|---|---|
| 5.62 | 8.64 | 3.57 | 2.79 | 0 |
| 5.71 | 11.43 | 3.57 | 0 | 0 |
| 5.87 | 11.43 | 3.20 | 0 | 0.37 |
| 6.07 | 11.43 | 2.80 | 0 | 0.77 |
| 6.27 | 11.43 | 2.42 | 0 | 1.15 |
| 6.55 | 11.43 | 1.85 | 0 | 1.72 |
| 6.66 | 11.43 | 1.66 | 0 | 1.91 |
| 6.80 | 11.43 | 1.47 | 0 | 2.10 |
| 6.97 | 11.43 | 1.09 | 0 | 2.48 |
| 7.60 | 11.43 | 0 | 0 | 3.57 |