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Effect of milk centrifugation and incorporation of high-heat-treated centrifugate on the composition, texture, and ripening characteristics of Maasdam cheese

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ABSTRACT

This study investigated the effect of centrifugation (9,000 × *g*, 50°C, flow rate = 1,000 L/h), as well as the incorporation of high-heat-treated (HHT) centrifugate into cheese milk on the composition, texture, and ripening characteristics of Maasdam cheese. Neither centrifugation nor incorporation of HHT centrifugate into cheese milk had a pronounced effect on the compositional parameters of any experimental cheeses, except for moisture and moisture in nonfat substance (MNFS) levels. Incorporation of HHT centrifugate at a rate of 6 to 10% of the total milk weight into centrifuged milk increased the level of denatured whey protein in the cheese milk and also increased the level of MNFS in the resultant cheese compared with cheeses made from centrifuged milk and control cheeses; moreover, cheese made from centrifuged milk had ∼3% higher moisture content on average than control cheeses. Centrifugation of cheese milk reduced the somatic cell count by ∼95% relative to the somatic cell count in raw milk. Neither centrifugation nor incorporation of HHT centrifugate into cheese milk had a significant effect on age-related changes in pH, lactate content, and levels of primary and secondary proteolysis. However, the value for hardness was significantly lower for cheeses made from milk containing HHT centrifugate than for other experimental cheese types. Overall, centrifugation appeared to have little effect on composition, texture, and ripening characteristics of Maasdam cheese. However, care should be taken when incorporating HHT centrifugate into cheese milk, because such practices can influence the level of moisture, MNFS, and texture (particularly hardness) of resultant cheeses. Such differences may have the potential to influence subsequent eye development characteristic, although no definitive trends were observed in the present study and further research on this is recommended.

Key words: centrifugation, heat-treatment, Maasdam cheese, texture, ripening characteristic

INTRODUCTION

Various milk pretreatment methods have been applied before cheesemaking to enhance quality, consistency, and functionality of different cheese varieties (Kelly et al., 2008; Johnson, 2017). Centrifugation of milk using a special centrifuge (also called Bactofuge, Alfa Laval, Richmond, VA) at a centrifugal force of ∼9,000 × *g* (at 50°C) is a pretreatment method widely used by the cheese industry for removal of *Clostridium* spores before cheesemaking. After centrifugation, milk is divided into 2 streams, namely (1) centrifuged milk containing low bacterial cells and spores count, which account for ∼97% of the feed volume, and (2) centrifugate containing high bacterial cells and spores count, which account for ∼3% of the feed volume (Kosikowski and Mistry, 1990).

Some cheese producers apply high heat treatment to the centrifugate to inactivate bacterial cells and spores and recycle the stream back into centrifuged milk before cheesemaking to minimize protein losses, as it contains ∼7% protein (Kosikowski and Mistry, 1990). High heat treatment of milk results in denaturation of whey proteins (Rynne et al., 2004), which can form complexes with whey proteins (in the serum phase) and casein micelles (Donato and Guyomarc'h, 2009). Such complexes are believed to hinder the aggregation of destabilized casein micelles during rennet-induced coagulation of milk (Vasbinder et al., 2003), and thus reduce the ability of the gels to undergo syneresis, leading to cheese curd with higher levels of moisture and moisture in nonfat substance (**MNFS**). Moisture in the cheese matrix acts as a plasticizer between the protein strands and softens the cheese texture (Lamichhane et al., 2018a). Moreover, the higher moisture and MNFS content within the cheese matrix can enhance

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the microbial and enzymatic activities (Beresford et al., 2001), which can alter the ripening characteristics of cheese (Rynne et al., 2004, 2007).

Some *Clostridium* spp. have been reported to be associated with late blowing defect of cheese, which is manifest as production of gas (e.g., CO_2 and H_2) and formation of high levels of butyric acid, resulting in downgraded cheeses (Klijn et al., 1995; Le Bourhis et al., 2007; Garde et al., 2011). Although the effect of centrifugation on efficacy of removal of *Clostridium* spores from milk and late blowing defect of cheese have been a research focus for several studies (Langeveld, 1971; Su and Ingham, 2000), its effect on composition, texture, and ripening characteristics of cheese has to date received little attention. As well as removal of *Clostridium* spores from milk, centrifugation also removes indigenous milk bacterial cells and somatic cells from milk by ~87 and 75 to 95% of the total count, respectively (Te Giffel and Van Der Horst, 2004; Wieking, 2004).

Maasdam is a brine-salted, large-eye forming, semihard cheese combining the traits of both Swiss and Dutch-type cheeses. Both lactic and citric acid fermentation occur during the first 24 h of manufacture and propionic acid fermentation occurs during warm-room ripening. Very little research has been published on the physicochemical properties and ripening characteristics of Maasdam and similar cheese types, such as Jarlsberg.

The aim of our study was to evaluate the effect of (1) centrifugation and (2) the incorporation of the high-heat-treated (**HHT**) centrifugate into cheese milk on the composition, pH, primary and secondary proteolysis, lactic acids levels, and texture of Maasdam cheese during ripening. In our study, centrifugation refers to the separation of bacteria and spores at a centrifugal force of ~9,000 × *g* (at 50°C with a flow rate of 1,000 L/h), whereas centrifugal separation refers to separation of milk into cream and skim milk. A parallel study was conducted investigating the effect of milk centrifugation and incorporation of HHT centrifugate on microbial composition and the levels of volatile organic compounds of Maasdam cheese (Lamichhane et al., 2018b).

MATERIALS AND METHODS

Milk Supply and Treatments

Raw whole milk was obtained from a local dairy company. From raw milk, 3 different cheese milk streams were prepared (Figure 1). Part of the raw milk was separated at 55°C (centrifuge disc separator, GEA Westfalia, Oelde, Germany) to give skim milk and cream. Control cheese milk (**CT**) was prepared by adding a portion of the resultant cream to skim to achieve a protein-to-fat ratio of 1.13:1. The remaining whole milk was centrifuged (Bactofuge disc separator, type: D3187M, Alfa Laval, Richmond, VA) at a centrifugal force of ~9,000 × *g* (at 50°C with a flow rate of 1,000 L/h) to provide centrifuged whole milk and centrifugate (also called sludge or bactofugate), which accounts for approximately 3 to 6% of the total milk

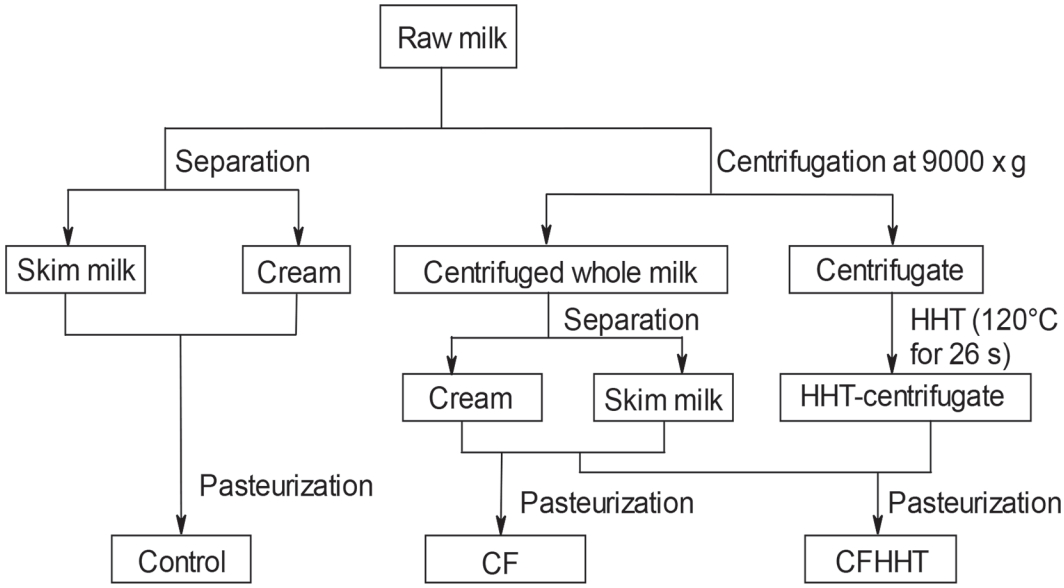

Figure 1. Flowcharts of the preparation of cheese milks [i.e., control, centrifuged (CF), and centrifuged milk containing high-heat-treated centrifugate (CFHHT)]. HHT = high heat treatment; HHT-centrifugate = high-heat-treated centrifugate.