EFFECT OF SOMATIC CELL COUNT ON PASTEURIZED FLUID MILK QUALITY

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Introduction

Bovine mastitis has been described as the most costly disease in the dairy industry, resulting in reduced milk yield, increased cost of milk production, and reduced milk quality (National Mastitis Council, 1996) and is defined as an inflammation of the mammary gland in the response to invading bacteria. Milk SCC is a commonly used indicator of the incidence of subclinical mastitis in dairy cows (National Mastitis Council, 1996). Due to the inflammatory response during mastitis, secretion of milk components that are synthesized *de novo* is reduced and an influx of blood components into the milk occurs (Kitchen, 1981). These blood components include a variety of hydrolytic enzymes, which alter the milk composition through the breakdown of casein and milk fat (Grieve and Kitchen, 1985). The most important of these enzymes is plasmin, a milk protease that degrades casein (Saeman, et al., 1988). The effects of elevated milk SCC on the yield and the overall quality of milk and dairy products include poor coagulating properties and lower cheese yield (Politis and Ng Kwai Hang, 1988b, Barbano, et al., 1991, Klei, et al., 1998), increased loss of fat and casein in whey (Politis and Ng Kwai Hang, 1988a; Barbano, et al., 1991) and reduced sensory quality and shelf-life (Munro, et al., 1984). Recently, it was demonstrated that mastitis adversely affects the quality of pasteurized fluid milk by accelerating the development of sensory defects such as rancidity and bitterness (Ma, et al., 2000). These defects are caused by lipolysis and proteolysis, respectively.

The threshold for detection of off-flavors caused by lipolysis and proteolysis due to the action of native milk enzymes has been investigated by Santos et al. (2002). They determined that 50% of panelists could detect an off-flavor due to lipolysis in 2% fat milk at a free fatty acid (FFA) concentration of 0.25 meq/kg of milk. Ma et al. (2000) estimated that the sensory threshold for detection of off-flavor related to proteolysis in 2% fat milk was near 4% decrease in casein as a percentage of true protein (CN/TP). Santos et al. (2002) determined that the sensory threshold in skim milk for off-flavor produced by the activity of native milk proteases was near than a 4.76% decrease in CN/TP. These objective measures of lipolysis and proteolysis provide useful chemical bench marks of when off-flavors will be detected and are used in the current study.

The general objective of the present study was to determine the effects of raw milk SCC on the proteolysis and lipolysis of preserved pasteurized milk stored at refrigeration temperatures. The specific objectives were: (1) to measure the time in days for pasteurized homogenized 2% milk to achieve a level of lipolysis and proteolysis caused by native milk enzymes present in milks of different SCC at 0.5 and 6°C that would be sufficient to produce an off-flavor, (2) to determine if milk fat content (i.e., 1, 2, and 3.25%) influences the level of proteolysis or lipolysis caused by native milk enzymes at 6°C, and (3) to determine the time in days for milks containing 2% fat with different SCC to undergo sufficient lipolysis or proteolysis to produce an off-flavor due to the combination of the action of native milk enzymes and microbial growth at 0.5 and 6°C.

Materials and Methods

In experiment 1, pasteurized, homogenized milks, containing 2% fat were prepared from raw milk containing four different SCC levels from <100,000 to >1,000,000 cells/ml. Each of the four milks was stored at 0.5 and 6°C for 61 d. In experiment 2, pasteurized, homogenized milks containing 1, 2, and 3.25% fat were prepared starting from two raw milks containing two different SCC levels, one <100,000 and the other >1,000,000 cells/ml. In experiment 3, pasteurized, homogenized 2% fat milks were prepared starting from raw milks containing two different SCC levels, one <100,000 and the other >1,000,000 cells/ml. For experiments 1 and 2, all milks were preserved with potassium dichromate to prevent microbial growth but to allow the activity of native milk proteases and lipases, during storage. For experiment 3, one set of milk was preserved with potassium dichromate to prevent microbial growth but to allow the activity of native milk proteases and lipases and a second set of the same milk was unpreserved, during storage at 0.5 and 6°C for 29 d.

Results

Based on the previous work, an off-flavor due to proteolysis was detected by 50% of panelists when the decrease in CN/TP was > 4.76% (Santos et al., 2002). In experiment 1, we estimated (assuming 50% of consumers would detect an off-flavor when CN/TP decreases 5%) that pasteurized milk containing 2% fat would have an off-flavor at about >>61 and 54 d for low SCC milk, and at about 54 and 19 d for high SCC, at 0.5 and 6^{o}C, respectively, when microbial growth was blocked by an inhibitor.

Previous research by Santos et al. (2002) found that 50% of panelists could detect an off-flavor in milk containing 2% fat due to lipolysis at a FFA concentration of 0.25 meq/kg of milk. Based on these results, we estimated in experiment 1, that 50% of panelists would detect an off-flavor in a 2% fat pasteurized milk with low SCC at about >>61 and >61 d at 0.5 and 6^{o}C, respectively, while for milk with high SCC an off-flavor would be detected by 50% of panelists at about >61 and 35 d at 0.5 and 6^{o}C, respectively, when microbial growth was blocked by an inhibitor. Thus, in experiment 1, proteolysis would be expected to produce a detectable off-flavor before lipolysis when microbial growth is minimized.

In experiment 2, proteolysis was higher for milk containing 1% fat than milk containing 3.25% fat at both low and high milk SCC. Proteolysis was faster in high SCC milk. Similar results were obtained by Valero et al. (2001). They reported higher levels of proteolysis for skim milk than for whole UHT milk.

In experiment 2, fat concentration in milk had a significant impact on lipolysis in both low and high SCC milk, with both the level and the rate of increase of FFA content increasing with increasing fat content.

In experiment 3, for milks with low SCC at both temperatures of storage, the rate of proteolysis was similar between preserved and unpreserved milks until d 29, even though the PBC were high at 6°C. The combined effect of microbial growth plus native milk enzymes on proteolysis was larger at 6 than 0.5°C. The rapid growth of bacteria in the unpreserved milk at 6°C after 22 d of storage in the high SCC milk may have been stimulated by the availability of proteolysis products produced by the action of proteases associated with high milk SCC. An off-flavor in the high SCC milk at 6°C would be detected at about 15 d of storage due to the combination or microbial growth and SCC related proteolysis, while in the low SCC no off-flavor would be expected at 28 d of storage if microbial growth was controlled.

In experiment 3, lipolysis was higher for high SCC milk at both temperatures of storage (0.5 and 6°C) in both preserved and unpreserved milks. The use of preservative had no effect on lipolysis, indicating that the microbial growth had little effect on the total lipolysis up to day 19 of storage at 6°C, when the PBC was < 30,000 cfu/ml. An off-flavor due to lipolysis in the high SCC milk at 6°C would be detected between 8 and 12 d of shelf-life, even though PBC was < 70,000 cfu/ml, while an off-flavor due to lipolysis in the low SCC would not be detected at 28 d of storage at 6°C, when microbial growth was minimized.

Conclusions

We estimated in the present study (assuming 50% of consumers would detect an off-flavor when CN/TP decreases by about 5%) that pasteurized milk containing 2% fat would have an off-flavor at about >> 61 and 54 d for the low SCC milk with bacteria counts < 100,000 cfu/ml, and at about 54 and 19 d for the high SCC with bacteria counts < 100,000 cfu/ml, at 0.5 and 6°C, respectively. We estimated in the present study that 50% of panelists would detect an off-flavor in the 2% fat pasteurized preserved milk with low SCC at about >> 61 and > 61 d at 0.5 and 6°C, respectively, while for milk with high SCC an off-flavor would be detected by 50% of panelist at about > 61 and 35 d at 0.5 and 6°C, respectively when bacteria counts < 100,000 cfu/ml. If pasteurized milk PBC starts out low (i.e., < 1 cfu/ml), then the combination of low SCC milk (i.e., < 100,000 cells/ml) and low storage temperature provide the potential for production of HTST fluid milk with a shelf-life of > 61 d. The development of off-flavors was faster when microbial count exceeded 100,000 cfu/ml, but the effect of SCC was still apparent. The combination of low SCC milk and low storage temperature when combined with processing technology to produce very low initial bacteria count in fluid milk can produce fluid milk that will maintain flavor quality for more than 61 d.

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