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Influence of casein as a percentage of true protein and protein level on color and texture of milks containing 1 and 2% fat[1]

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ABSTRACT

Combinations of fresh liquid microfiltration retentate of skim milk, ultrafiltered retentate and permeate produced from microfiltration permeate, cream, and dried lactose monohydrate were used to produce a matrix of 20 milks. The milks contained 5 levels of casein as a percentage of true protein of about 5, 25, 50, 75, and 80% and 4 levels of true protein of 3.0, 3.76, 4.34, and 5.0% with constant lactose percentage of 5%. The experiment was replicated twice and repeated for both 1 and 2% fat content. Hunter color measurements, relative viscosity, and fat globule size distribution were measured, and a trained panel documented appearance and texture attributes on all milks. Overall, casein as a percentage of true protein had stronger effects than level of true protein on Hunter L, a, b values, relative viscosity, and fat globule size when using fresh liquid micellar casein concentrates and milk serum protein concentrates produced by a combination of microfiltration and ultrafiltration. As casein as a percentage of true protein increased, the milks became more white (higher L value), less green (lower negative a value), and less yellow (lower b value). Relative viscosity increased and d(0.9) generally decreased with increasing casein as a percentage of true protein. Panelists perceived milks with increasing casein as a percentage of true protein as more white, more opaque, and less yellow. Panelists were able to detect increased throat cling and mouthcoating with increased casein as a percentage of true protein in 2% milks, even when differences in appearance among milks were masked.
Key words: microfiltration, casein, serum protein

INTRODUCTION

The possibility of adjusting protein level of fluid milk using the UF system has been studied (Poulsen, 1978; Rattray and Jelen, 1996; Quiñones et al., 1997, 1998) and acceptable sensory characteristics have been demonstrated. By using UF permeate and retentate of skim milk to either reduce or increase the protein content of milk with different fat levels, Poulsen (1978) concluded that the protein level in skim milk can range between 3.1 to 6.4% without noticeable sensory differences. Poulsen (1978) also found that texture, surface gloss, and differences in translucency played more prominent roles in differentiating among milks rather than taste or flavor in lower fat milks. Rattray and Jelen (1996) used UF permeate of skim milk to lower the protein level of skim milk. They found that untrained panelists began to detect differences among milks when protein level was decreased more than 1% from the control skim milk. Visual cues and translucency of the samples rather than taste or odor were the key factors in differentiating between milks of lower fat content.

Quiñones et al. (1997, 1998) determined the effect of altering true protein (**TP**) and fat level on objective measures of color, relative viscosity (**RV**), and sensory attributes of skim, 1, 2, and 3.3% fat milks. Appearance and texture characteristics were found to be the major sensory characteristics that differed among milks with different TP levels. In skim and 1% fat milk, a strong correlation was present between sensory attributes and Hunter L value, especially visual descriptors such as center color, edge color, opacity, and visual hang-up and texture attributes mouthcoating, residual mouthcoating, and thickness (Quiñones et al., 1997). A correlation between Hunter a and b values and sensory descriptors was also detected, indicating a strong relationship between visual and textural characteristics. When the fat level was increased to 2 and 3.3% (Quiñones et al., 1998), the effect of TP was only significant in the appearance scores and thickness. Samples were more similar to each other than at lower fat levels, suggesting that change in protein level at higher fat

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content is less noticeable than at lower fat levels. At all fat levels, change in RV was not a good indicator of differences in texture detected by sensory analysis of milks. Perceived texture differences among milks of different TP concentration were influenced by increased whiteness. In general, panelists will give a milk that is whiter a higher score for thickness because of their previous experience with differences in whiteness and viscosity among milks with increasing fat content (Phillips et al., 1995a).

In the current study, further investigation of the effect of the characteristics of the protein portion of fluid milk on sensory properties was performed by altering the ratio of CN to TP using fresh liquid products of microfiltration and ultrafiltration of skim milk where casein micelles are intact. Such studies are useful for laying the groundwork for milk beverage innovation. Results using dried microfiltration (**MF**) ingredients or various forms of dried caseinates and whey proteins might produce different effects on the sensory characteristics of beverage products. Factors influencing the efficiency of commercial ceramic MF membranes for separation of casein and serum proteins (**SP**) in skim milk have been identified (Hurt and Barbano, 2010) and 3-stage, 3× MF of skim milk has been demonstrated to be capable of removing 95% of SP from skim milk using uniform transmembrane processing (Hurt et al., 2010) and using graded permeability MF membranes (Zulewska and Barbano, 2014). Further improvement can be achieved by optimization of processing temperature (Hurt et al., 2015), membrane channel geometry (Adams et al., 2015), and membrane channel diameter (Adams and Barbano, 2016). The objective of our research was to measure the effect of differences in casein as a percentage of true protein (**CN%TP**) and TP concentration on Hunter L, a, and b values, RV, fat globule particle size distribution, appearance and textural properties of pasteurized, homogenized milks containing a background of either 1 or 2% fat when using fresh liquid micellar casein and milk SP produced by microfiltration of skim milk.

MATERIALS AND METHODS

Study Design

The experiment was conducted over 8 wk as four 2-wk cycles, with the first week for processing and formulation followed by a second week of analytical and sensory analysis of formulated milks. Within each 2-wk cycle, 20 milks were prepared that included 5 levels of CN%TP (approximately 5, 25, 50, 75, 80%) within each of 4 TP levels (about 3, 3.67, 4.34, and 5%). During the first 2 of the 2-wk cycles, a matrix of 20 milks with different CN%TP and TP levels was made with a constant background of 1% fat and 5% lactose, whereas during the third and fourth 2-wk cycles, the milk had a background of 2% fat and 5% lactose. All milks were pasteurized and homogenized. Objective (Hunter L, a, b values, RV, and fat globule size distribution) and trained panel measures of visual and textural sensory and physical properties were done.

Milk Processing

Pasteurization and Microfiltration. On d 1 of processing, raw skim milk and raw cream were obtained from the Cornell University dairy plant and MF of skim milk was done on that day. Eight hundred kilograms of raw skim milk was pasteurized at 74°C with a holding time of 16 s using a pilot-scale HTST pasteurizer (model 080-S, AGC Engineering, Manassas, VA) and cooled to 4°C. A continuous MF process produced 3× MF retentate (i.e., micellar casein concentrate) from skim milk that was used directly in sample formulation and MF permeate that would be further processed by UF the next day (i.e., d 2 of processing).

A portion (about 230 kg) of the pasteurized skim milk was heated in a plate heat exchanger to 50°C and pumped into the feed tank of the MF unit. Additional pasteurized skim milk was heated to 50°C and added to the MF feed tank as needed during the processing run. The total amount of skim milk processed was about 800 kg. Skim milk was concentrated continuously to 3× at 50°C using a pilot-scale, uniform transmembrane pressure MF system (Tetra Alcross M7 Pilot Plant Type, Tetra Pak, Denmark) equipped with ceramic Membralox membranes with a nominal pore diameter of 0.1 μm and total membrane surface area of 1.7 m^2. The MF retentate flow rate was set at 45 L/h and permeate flow rate set at 90 L/h and periodically checked to maintain transmembrane pressure in the range of 22 to 28 kPa (flux of about 53 L/m^2h). The inlet retentate pressure was approximately 420 kPa and outlet pressure 230 kPa. The system was continuously producing 3× retentate for 6 h. The MF permeate and retentate were collected and cooled to 3°C. This processing was done on Tuesday of wk 1 of the 2-wk cycle.

Ultrafiltration. Batch UF of the MF permeate was performed the day after the MF permeate was produced. Fractionation of the MF permeate into UF retentate and UF permeate was done using a plate-and-frame UF system (model Dorr-Oliver Iopor Series S; Amicon, Beverly, MA) equipped with 21 S-10 polysulfone membrane plates with a mean molecular weight cut off of 10,000 Da and an effective area of 0.067 m^2 per plate. The UF inlet pressure was 3.1 bar and outlet