

## Dairy Foods: Cheese and Products Processing

**66 Influence of proteolysis and amino acid release on bitterness and texture of reduced-fat Cheddar cheese.** M. W. Børsting<sup>1</sup>, K. B. Qvist<sup>\*1</sup>, J. Vindeløv<sup>1</sup>, F. K. Vogensen<sup>2</sup>, and Y. Ardö<sup>2</sup>, <sup>1</sup>*Chr. Hansen A/S, Hørsholm, Denmark*, <sup>2</sup>*Department of Food Science, Faculty of Life Sciences, University of Copenhagen, Copenhagen, Denmark*.

In spite of much research, it remains difficult to produce high quality reduced-fat Cheddar cheese. The objective of this study was to investigate the effects of 2 rennets, bovine (BC) and camel chymosin (CC), with different proteolytic activity, and 2 starter cultures with different ability to release amino acids on texture and flavor development. One starter (O) contained strains of *Streptococcus lactis* and *cremoris*; the other (OLb) additionally contained a proteolytic *Lactobacillus delbrueckii* strain. Cheeses with all 4 combinations of coagulants and cultures were produced in 4 replicates. During manufacture essentially identical acidification profiles were obtained, and cheeses were analyzed during 28 wk for composition of casein, peptides and free amino acids by capillary electrophoresis, LC-MS and HPLC, and for textural properties by uniaxial compression. Sensory evaluation of the ripened cheeses was made as well. BC cheeses showed more extensive hydrolysis of  $\alpha_{s1}$ -CN, and of peptides derived from it than CC cheeses. BC cheeses also contained higher levels of the bitter peptide  $\beta$ -CN (f193–209) and obtained higher bitterness scores. In OLb cheeses, peptide degradation was extensive, and peptide profiles of BC and CC cheeses were similar after 28 wk, except for  $\alpha_{s1}$ -CN (f1–9) and  $\beta$ -CN (f193–209). OLb increased the content of free amino acids ca. 3-fold over that obtained with O. After 28 wk CC cheeses had higher sensory hardness, stress at fracture and modulus of deformability than BC cheeses. OLb cheeses had higher stress but lower strain at fracture, and higher modulus of deformability than O cheeses. Overall, CC reduced problems with bitterness in reduced-fat Cheddar, compared with BC, but the associated increase in hardness was not compensated for by the addition of a proteolytic *Lactobacillus* strain.

**Key Words:** reduced-fat Cheddar, camel chymosin, *Lactobacillus*

**67 Impact of sodium, potassium, magnesium, and calcium salt cations on pH, proteolysis and microbial populations during storage of Cheddar cheese.** D. J. McMahon<sup>\*1</sup>, N. Farkye<sup>2</sup>, L. V. Moyes<sup>3</sup>, and C. J. Oberg<sup>1,3</sup>, <sup>1</sup>*Western Dairy Center, Utah State University, Logan*, <sup>2</sup>*Dairy Products Technology Center, California Polytechnic State University, San Luis Obispo*, <sup>3</sup>*Department of Microbiology, Weber State University, Ogden, UT*.

Sodium reduction in cheese can assist in reducing overall dietary Na intake, yet saltiness is an important aspect of cheese flavor. Our objective was to evaluate the effect of partial Na substitution on survival of lactic acid bacteria (LAB) and nonstarter LAB (NSLAB), pH and extent of proteolysis in full fat Cheddar cheese. Seven full fat Cheddar cheeses with molar salt contents equivalent to 1.7% (wt/wt) NaCl but with different ratios of Na, K, Ca and Mg cations were manufactured. Cheese made using 1.7% NaCl (C) served as a positive control while cheese made using 0.7% NaCl served as a negative control (LC). Cheeses were aged at 6°C for 9 mo. Total LAB, starter lactococci, and NSLAB were enumerated using selective media and varied incubation conditions. Proteolysis was monitored by gel electrophoresis and measuring water-soluble N (WSN). Cheese C had a mean composition of 35.0% moisture, 50.2% FDB, 26.0% protein, and 1.74% ( $\pm 0.05\%$ ) salt. Other full salt cheeses had a similar composition, while the LC cheese had

higher moisture, 37.3%, and a salt content of 0.68% ( $\pm 0.04\%$ ). Mean water activity of full salt cheeses at 28 d was 0.956 while the LC cheese was 0.975. After salting there was a faster initial drop in cheese pH with K substitution and throughout storage the pH of cheese with 75% K substitution was lower than cheese C. There was no difference in residual casein levels or %WSN levels in the cheeses based on salt content with all cheeses increasing from ~5% WSN at d 1 to ~20% after 6 mo. Cheese C (~4.7% salt-in moisture) exhibited expected changes in bacteria microflora during storage with lactococci gradually decreasing from  $\sim 10^7$  cfu/g after pressing to  $\sim 10^4$  cfu/g after 4 mo, while the NSLAB gradually increased from  $< 10^3$  cfu/g to  $\sim 10^5$  cfu/g to become the dominant portion of total LAB after 4 mo. In cheese LC (~1.8% salt-in-moisture), the lactococci stayed at  $\sim 10^6$  cfu/g through 6 mo of storage and remained the dominant LAB with NSLAB at  $\sim 10^5$  cfu/g. With K substitution for Na, there was a trend for lactococci to remain dominant or be at similar levels as the NSLAB, especially when salt substitution also included 10% Mg or Ca.

**Key Words:** cheese, sodium, potassium

**68 Impact of different types of emulsifiers on the reformability of grated cheese.** C. Akbulut<sup>\*</sup> and J. A. Lucey, *University of Wisconsin-Madison, Madison*.

Reforming the cheese has found several applications in dairy industry. Our objective was to determine the effect of different types of emulsifiers (EM) on the texture and rheological properties of low-fat and full-fat Cheddar cheese after reforming. Cheeses were ground using food processor and then pressed into plastic molds for 1 h using Carver food press. Eight different types of EM at 4% (w/w) level were added to grated cheeses before reforming. These types included anionic: citric acid esters of monoglycerides (CITREM), diacetyl tartaric acid esters of monoglycerides (DATEM), sodium stearoyl lactylate (SSL), zwitterionic: lecithin and non-ionic: distilled monoglycerides (DM), lactic acid esters of monoglycerides (LACTEM), acetic acid esters of monoglycerides (ACETEM) and sorbitan tristearate (STS). Control reformed cheeses were prepared for both low-fat and full-fat cheese made without any EM. Analyses were performed on cheese bases and reformed cheeses that had been stored for 2 wk at 4°C. Rheological properties of cheese were measured using small amplitude oscillatory test during heating from 5 to 85°C. Textural properties were tested with Texture Analyzer. Melt properties were tested using the UW-Melt-profiler. Use of SSL reduced the hardness of low-fat cheese and made it very sticky and soft. The use of CITREM, DATEM and STS resulted in firmer cheese texture. DATEM and SSL exhibited significantly lower loss tangent maximum during heating (less melt) as compared with control cheese. At low measurement temperatures, except for STS, non-ionic EM did not significantly alter the texture of full-fat cheese; however at high temperatures cheese with non-ionic EM differed from control and they had improved meltability. Use of non-ionic EM seemed to make the low-fat cheese more prone to fracture during compression except for the use of STS. It was concluded that the textural properties of the reformed cheese can be modified with the use of different types of EM. The texture and melting characteristics of the reformed cheese were dependent on charge, hydrophilic-lipophilic balance and molecular characteristics of the EM.

**Key Words:** cheese reforming, texture, emulsifiers

**69 Phenotypic factors affecting cheese yield and whey losses from individual cows.** C. Cipolat Gotet,\* M. Penasa, A. Cecchinato, M. De Marchi, and G. Bittante, *Department of Agronomy, Food, Natural Resources, Animals and Environment (DAFNAE), University of Padova, Legnaro, Padova, Italy.*

The aims of this study were to assess sources of variation of several individual cheese yields obtained by using a micro-cheese making method. Traits were: [1] weight (g) of fresh curd ( $CY_{\text{curd}}$ ) or curd total solids ( $CY_{\text{solids}}$ ) or curd water ( $CY_{\text{water}}$ ) divided by weight (g) of milk processed; [2] weight (g) of total solids ( $REC_{\text{solids}}$ ) or fat ( $REC_{\text{fat}}$ ) or protein ( $REC_{\text{protein}}$ ) recovered in curd divided by weight (g) of constituent in milk. A total of 1,271 Brown Swiss cows from 85 herds were sampled. The cheese making procedure consisted of the heating of raw milk (1.5L), the acidification by the inoculation of a direct-to-vat starter of selected strains of *S. thermophilus*, the addition of calf rennet, the detection of coagulation time, 2 subsequent cuts of the curd, the rest of the curd, the pressing and the brining. Then, curd was weighed to calculate the aforementioned traits. Means (SD) for  $CY_{\text{curd}}$ ,  $CY_{\text{solids}}$ ,  $CY_{\text{water}}$ ,  $REC_{\text{solids}}$ ,  $REC_{\text{fat}}$  and  $REC_{\text{protein}}$  were 0.150 (0.019), 0.072 (0.009), 0.078 (0.013), 0.521 (0.036), 0.899 (0.036) and 0.781 (0.024), respectively. The linear model considered effects of herd, vat, parity, days in milk and milk yield. The effect of days in milk was relevant for all traits:  $CY_{\text{curd}}$ ,  $CY_{\text{solids}}$ ,  $CY_{\text{water}}$  and  $REC_{\text{solids}}$  showed a decrease after parturition and an increase thereafter;  $REC_{\text{fat}}$  showed a decrease till mid lactation and a slow increase afterward, whereas an opposite trend was detected for  $REC_{\text{protein}}$ . Increasing parity decreased  $CY_{\text{curd}}$ , despite the inclusion of milk yield in the model, mainly because of a decrease of  $CY_{\text{water}}$  rather than as a consequence of the variation of  $CY_{\text{solids}}$ . The effect of milk yield was negative on  $CY_{\text{curd}}$  because of a decrease of  $CY_{\text{solids}}$ , and not of  $CY_{\text{water}}$ . Large differences were detected among herds suggesting differences in dairy management practices. The micro-cheese making method can be used to investigate variation in individual cheese yield and milk components recovery and for genetic purposes.

**Key Words:** individual cheese yield, whey losses, micro-cheese making

**70 Sensory selection of an antimicrobial for use in string cheese.**

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Sodium has a significant role in the string cheese matrix such as flavor enhancement and inhibition of microbial growth. Recently, there have been government and industry initiatives to reduce the sodium content in a wide variety of foods by 25% within the next 5–10 years. String cheese, often marketed as a healthy snack, has 8% DV of sodium per stick. A lower sodium alternative would need to be safe to eat and taste good; therefore, the antimicrobial used to partially replace the role of salt should be effective against pathogens and have acceptable sensory qualities. The objective of this work was to find an antimicrobial, with demonstrated pathogen protection properties, that is sensory transparent. Three sensory tests were completed using 4 antimicrobials, with confirmed pathogen protection measured using a 5 pathogen cocktail and cheese agar, applied to commercial, unbrined string cheese: 1) A balanced reference duo-trio test was used to determine a difference with and without antimicrobial application ( $n = 38$ ), 2) Twenty-two cheese consumers used a balanced, 9 point hedonic test to evaluate the overall acceptability, aroma, flavor, and after taste, and 3) A 2<sup>2</sup> design was used to determine the interaction of antimicrobial contact time (30 s and 3 min) and concentration (recommended concentration  $\pm$  50%).

Differences were evaluated using a duplicated, balanced reference duo-trio test ( $n = 15$ ). The results showed: 1) 3 potential antimicrobials could be sensory transparent and protect unbrined string cheese from potential pathogens, 2) consumers found no significant difference ( $\alpha > 0.05$ ) for any of the antimicrobials tested for overall acceptability, flavor, or after taste; however, the aroma of 2 antimicrobials were found to be significantly different ( $\alpha < 0.05$ ), and 3) the 3 min contact time and concentration + 50% was found to be significantly different ( $\alpha < 0.05$ ) than the rest of the combinations tested. The outcomes indicate that the perceived sensory aspects of unbrined string cheese may change based on the type or method used to apply the antimicrobial.

**Key Words:** lower sodium, antimicrobials, consumer testing

**71 Microfiltration of skim milk and modified skim milk using a 0.1- $\mu\text{m}$  ceramic uniform transmembrane pressure system at 50, 55, 60, and 65°C.** E. E. Hurt,\* M. Adams, and D. M. Barbano, *Cornell University, Department of Food Science, Northeast Dairy Foods Research Center, Ithaca, NY.*

Our objective was to determine the effect of operating a microfiltration (MF) unit at temperatures up to 65°C on serum protein (SP) removal from skim milk (SM), with and without prior removal of low molecular weight (MW) soluble SM components by ultrafiltration (UF). SM was pasteurized (72°C, 16s) and split into 2 batches. The first batch was ultrafiltered to remove about 90% of the low MW soluble SM components. After UF, the UF retentate was diluted back to the protein concentration of SM. The diluted UF retentate (DUR) and unaltered SM were then microfiltered. The MF system was operated at a concentration factor of 3X and a flux of 54 kg/m<sup>2</sup> per h. After flushing the system with SM or DUR to remove water, the MF retentate and permeate were recycled to the feed tank. The MF system was run in recycle mode at 50, 55, 60 and 65°C for 1h at each temperature. Samples were taken of the retentate and permeate after each hour. The experiment was repeated 3 times. As temperature increased from 50 to 65°C the retentate recirculation pump frequency required to maintain a flow of 648L/min decreased from 59.0 to 57.7Hz ( $P < 0.05$ ) for SM and from 58.6 to 57.3Hz ( $P < 0.05$ ) for DUR indicating reduced pump energy requirements. No permeate pressure decreases indicative of fouling were seen, suggesting an increase in flux may be possible. Between 50 and 65°C there was a decrease in SP removal from 66.39 to 57.76% ( $P < 0.05$ ) for SM and from 67.47 to 54.84% ( $P < 0.05$ ) for DUR. The decrease in SP removal was likely caused by heat denaturation of SP and interaction with casein. SP removal did not vary significantly between SM and DUR ( $P > 0.05$ ). It may be possible to operate a MF system to remove SP from SM at temperatures above 50°C. The decrease in pumping costs and possible increase in flux has to be balanced with a decrease in SP removal as temperature increases. It does not appear that low MW soluble materials in SM such as lactose, NPN or calcium caused fouling that reduced SP removal at temperatures up to 65°C.

**Key Words:** microfiltration, serum protein removal, processing temperature

**72 Leveraging existing processing lines for yogurt product innovation through the use of advanced texturizing systems.** M. E. Yildiz,\* S. Mutz-Darwell, M. Yurgec, A. Perez, and H. Simpson, *National Starch, Bridgewater, NJ.*

The objective of the current work was to test new ingredients to show that using ingredients with different functionalities, it is possible to formulate texturally very different products such as blended yogurt, Greek yogurt

and European set dessert using a common stirred yogurt lines. This will leverage existing capabilities, avoid investment in costly specialized equipment and capabilities and help dairy manufacturers produce variety of new products. In this study several texturally different products were made using Microthermix. Liquid ingredients were added to the Likwifier. Dry ingredients were slowly added while mixing at 500 rpm and hydrated for 30 min before processing in Microthermix. Preheating temperature range of between 140 to 150F and homogenizer pressure range between 50 to 250 bars were studied to find optimal conditions. Final heat and hold time was constant at 208F/6 min. Products made under optimal processing conditions were characterized using rheological and sensory analysis. Rheological methods included dynamic and steady tests whereas descriptive sensory analysis included characterization of several key fundamental texture attributes. In this presentation case studies on developing consumer preferred blended yogurts, producing Greek style yogurts without straining will be presented. For blended preferred yogurts, benchmark texture was quantified to have an elastic modulus ( $G'$ ) of 163 Pa and shear viscosity ( $\text{Eta}$ ) of 6.6 Pa.s. Formulated yogurts had elastic modulus of 218 and shear  $\text{Eta}$  of 5.5. However, sensory analysis revealed that key attributes such as spoon indentation meltaway, thickness in the mouth and residual mouthcoating there were very similar. For Greek yogurt, commercial strained benchmark had  $G'$  of 2220 Pa and  $\text{Eta}$  of 13 Pa.s while formulated Greek yogurts had elastic modulus of 1535 Pa and  $\text{Eta}$  of 9.51 Pa.s. However, sensory analysis revealed that key attributes such as spoon indentation meltaway, thickness in the mouth and residual mouthcoating there were very similar. We conclude that it is possible to leverage existing stirred yogurt lines by only changing the key parameters for dairy unit operations to develop texturally very different products some of which are traditionally made with specialized equipment.

**Key Words:** dairy, processing, texturizers

**73 Gravity separation of fat, somatic cells, and bacteria in raw and pasteurized milks.** Z. Caplin, C. Melilli, and D. M. Barbano,\* *Cornell University, Department of Food Science, Northeast Dairy Foods Research Center, Ithaca, NY.*

The objective of experiment 1 was to determine if the extent of gravity separation of milk fat, bacteria, and somatic cells is influenced by time and temperature of gravity separation or the level of contaminating bacteria present in the raw milk. The objective of experiment 2 was to determine if there was an effect of different temperatures of milk heat treatment on the gravity separation of milk fat, bacteria, and somatic cells. In raw milk, fat, bacteria, and somatic cells rose to the top of columns during gravity separation. About 50 to 80% of the fat and bacteria were present in the top 8% of the milk after gravity separation of raw milk. Gravity separation for 7 h at 12°C produced equivalent separation of fat, bacteria, and somatic cells as did separation for 22 h at 4°C. The completeness of gravity separation of fat was influenced by the level of bacteria in the milk before separation. Milk with high bacteria count had less (about 50 to 55%) gravity separation of fat than milk with low bacteria count (about 80%) in 22 h at 4°C. Gravity separation caused fat, bacteria, and somatic cells to rise to the top of columns for raw whole

milk and HTST pasteurized (72.6°C, 25 s) whole milk. Pasteurization at >76.9°C for 25 s prevented all 3 components from rising, possibly due to denaturation of native bovine immunoglobulins that normally associate with fat, bacteria, and somatic cells during gravity separation. Gravity separation can be used to produce reduced fat milk with low bacteria and somatic cell counts, and may be a critical factor in the history of safe and unique traditional Italian hard cheeses produced from gravity separated raw milk. A better understanding of the mechanism of this natural process could lead to the development of new nonthermal thermal technologies to remove bacteria and spores from milk or other liquids.

**Key Words:** gravity separation, bacterial removal, somatic cell removal

**74 Effect of PEF and UV and their combination on selected microorganisms and physico-chemical properties in whey.** A. Dave\*<sup>1</sup>, M. Walkling-Ribeiro<sup>1</sup>, O. Rodríguez-González<sup>2</sup>, M. W. Griffiths<sup>1</sup>, and M. Corredig<sup>1</sup>, <sup>1</sup>*Canadian Research Institute for Food Safety, Department of Food Science, University of Guelph, Guelph, ON, Canada,* <sup>2</sup>*Rodríguez-González Services, Toronto, ON, Canada.*

Pulsed electric field (PEF) and UV irradiation (UV) are emerging food processing technologies that could represent an alternative to conventional high-temperature short-time pasteurization (HTST) for whey preservation. This study looked into effects of both PEF and UV individually and combined for inactivation of *Listeria innocua* and *Zygosaccharomyces bailii* compared with HTST and change in whey qualitative aspects (pH, electrical conductivity, and color) was also investigated. Inoculated whey was PEF-processed at electric field strengths of up to 40 kV/cm, using treatment times up to 4937  $\mu\text{s}$ , and resulting in energy densities up to 173 kJ/L, while UV was applied for treatment times of up to 7.7 s and dosages up to 229 mJ/mL. Thermal controls were obtained by pasteurizing whey at 72 and 90°C for respective holding times of 15 (HTST72) and 30 s (HTST90). *L. innocua* and *Z. bailii* loads in whey were reduced by up to 3.1 and 3.0  $\log_{10}$  cfu/mL, respectively, with PEF, whereas, UV inactivated up to 6.0 and 5.9  $\log_{10}$  cfu/mL, respectively ( $P < 0.05$ ). With HTST higher *L. innocua* and *Z. bailii* inactivation of  $\geq 8.9$  and  $\geq 7.8 \log_{10}$  cfu/mL ( $P < 0.05$ ) was obtained, correspondingly, at 72 and 90°C. However, PEF/UV proved to be comparably effective for bacteria and yeast inactivation of  $\geq 8.8$  and  $\geq 7.9 \log_{10}$  cfu/mL ( $P \geq 0.05$ ) in whey, while lower reductions of up to 6.9 and 7.1  $\log_{10}$  cfu/mL of *L. innocua* and *Z. bailii* were obtained after UV/PEF ( $P < 0.05$ ). For physico-chemical analysis whey was PEF/UV-treated at 2 selected processing intensity levels, low (PEF/UVL) and high (PEF/UVH), used during the microbial analysis. No significant differences were found in pH ( $P \geq 0.05$ ) while colorimetry indicated HTST72 < PEF/UVH < PEF/UVL < HTST90 ( $P < 0.05$ ). No significant differences in conductivity were obtained between HTST72 and PEF/UVL ( $P < 0.05$ ) in contrast to HTST90 and PEF/UVH ( $P \geq 0.05$ ). Findings showed comparable treatment efficacy with UV- and PEF-based hurdle technologies and HTST for contaminated whey. Overall similar or better product quality was obtained with PEF/UV compared with HTST, thus, indicating PEF/UV as effective non-thermal processing strategy for acid whey.

**Key Words:** UV irradiation, pulsed electric field (PEF), HTST