

December 19, 2005

Volume XIX No. 4

XIX 23-05 EFFECT OF VACUUM-CONDENSED OR ULTRAFILTERED MILK ON PASTEURIZED PROCESS CHEESE

M. R. Acharya and V. V. Mistry

J. of Dairy Sci. 88(9): 3037. 2005.

Milk was concentrated by ultrafiltration (UF) or vacuum condensing (CM) and milks with 2 levels of protein: 4.5% (UF1 and CM1) and 6.0% (UF2 and CM2) for concentrates and a control with 3.2% protein were used for manufacturing 6 replicates of Cheddar cheese. For manufacturing pasteurized process cheese, a 1:1 blend of shredded 18- and 30-wk Cheddar cheese, butter oil, and disodium phosphate (3%) was heated and pasteurized at 74°C for 2 min with direct steam injection. The moisture content of the resulting process cheeses was 39.4 (control), 39.3 (UF1), 39.4 (UF2), 39.4 (CM1), and 40.2% (CM2). Fat and protein contents were influenced by level and method of concentration of cheese milk. Fat content was the highest in control (35.0%) and the lowest in UF2 (31.6%), whereas protein content was the lowest in control (19.6%) and the highest in UF2 (22.46%). Ash content increased with increase in level of concentration of cheese milk with no effect of method of concentration. Meltability of process cheeses decreased with increase in level of concentration and was higher in control than in the cheeses made with concentrated milk. Hardness was highest in UF cheeses (8.45 and 9.90 kg for UF1 and UF2) followed by CM cheeses (6.27 and 9.13 kg, for CM1 and CM2) and controls (3.94 kg). Apparent viscosity of molten cheese at 80°C was higher in the 6.0% protein treatments (1043 and 1208 cp, UF2 and CM2) than in 4.5% protein treatments (855 and 867 cp, UF1 and CM1) and in control (557 cp). Free oil in process cheeses was influenced by both level and method of concentration with control (14.3%) being the lowest and CM2 (18.9%) the highest. Overall flavor, body and texture, and acceptability were higher for process cheeses made with the concentrates compared with control. This study demonstrated that the application of concentrated milks (UF or CM) for Cheddar cheese making has an impact on pasteurized process cheese characteristics.

XIX 24-05 SMALL-SCALE MANUFACTURE OF PROCESS CHEESE USING A RAPID VISCO ANALYZER

R. Kapoor and L. E. Metzger

J. of Dairy Sci. 88(10): 3382. 2005.

Numerous formulation and processing parameters influence the functional properties of process cheese. Recently, a small-scale (25 g) manufacturing and analysis method was developed using a rapid visco analyzer (RVA), which was designed to evaluate the functional properties of process cheese when subjected to various formulations and processing condi-

tions. Although this method successfully manufactured process cheese, there was a significant difference in the functional properties of the process cheese compared with process cheese manufactured on a pilot scale. In the present study, adjustments in the RVA methodology involving the RVA processing conditions, preblend preparation, and texture profile analysis (TPA) techniques for the final process cheese were investigated. Fourteen samples of pasteurized processed cheese food (PCF) were manufactured from 14 different preblends. Each pre-blend was prepared using 1 of the 14 different natural cheeses and was balanced for moisture, fat, and salt. Each of these 14 preblends was split into 3 portions and each portion was subjected to 3 different manufacturing treatments. The first treatment was manufactured in a pilot-scale Blentech twin screw (BTS) cooker, and the remaining 2 treatments were manufactured in an RVA with different processing profiles. The RVA treatments were produced in triplicate. The resulting process cheeses were analyzed for moisture and functional properties. Texture profile analysis and RVA melt analyses were performed on all PCF treatments. Additionally, for the RVA treatments, the data for time of emulsification and end apparent viscosity during RVA manufacture were collected and recorded. The functional properties of the PCF manufactured using the RVA treatments showed good correlation with the functional properties of the PCF produced on the pilot scale. Additionally, the end apparent viscosity during RVA manufacture was correlated with the functional properties of the process cheese. Consequently, the RVA can be used as a small-scale manufacturing and analysis tool for predicting the functional properties of process cheese, and for evaluating how various formulations and processing parameters affect these functional properties. Moreover, the adjustments in the RVA methodology produced process cheese with functionality similar to process cheese produced in the BTS.

XIX 25-05 PREVALENCE OF SALMONELLA ENTERICA IN BULK TANK MILK FROM US DAIRIES AS DETERMINED BY POLYMERASE CHAIN REACTION

J. S. Karns, J. S. Van Kessel, B. J. McCluskey and M. L. Perdue
J. of Dairy Sci. 88(10): 3475. 2005.

Samples of bulk tank milk from dairies across the United States, taken as part of the National Animal Health Monitoring System Dairy 2002 survey, were analyzed for the presence of *Salmonella enterica* using a commercially available real-time polymerase chain reaction (PCR) kit. Samples from 854 farms in 21 states were collected and enriched in tetrathionate broth to amplify any salmonellae present, and DNA was isolated from the resulting biomass. One hundred one samples (11.8%) were shown to contain *Salmonella enterica* using the real-time PCR assay, whereas conventional culture techniques detected the pathogen in only 22 (2.6%) of the samples. A conventional PCR assay targeting a different gene from *Salmonella enterica* confirmed the presence of the organism in 94 of the real-time PCR-positive samples. Thus, assay of milk samples by real-time PCR indicates that the prevalence of *Salmonella enterica* in US bulk tank milk is substantially higher than previously reported.

XIX 26-05 COMPOSITIONAL FACTORS ASSOCIATED WITH CALCIUM LACTATE CRYSTALLIZATION IN SMOKED CHEDDAR CHEESE

P. Rajbhandari and P. S. Kindstedt
J. Dairy Sci. 88(11): 3737. 2005.

Previous researchers have observed that surface crystals of calcium lactate sometimes develop on some Cheddar cheese samples but not on other samples produced from the same vat of milk. The causes of within-vat variation in crystallization behavior have not been identified. This study compared the compositions of naturally smoked Cheddar cheese samples that contained surface crystals with those of samples originating from the same vat that were crystal-free. Six pairs of retail samples (crystallized and noncrystallized) produced at the same cheese plant on different days were obtained from a commercial source. Cheese samples were 5 to 6 mo old at the time of collection. They were then stored for an additional 5 to 13 mo at 4°C to ensure that the noncrystallized samples remained crystal-free. Then, the crystalline material was removed and collected from the surfaces of crystallized samples, weighed, and analyzed for total lactic acid, L(+) and D(-) lactic acid, Ca, P, NaCl, moisture, and crude protein. Crystallized and noncrystallized samples were then sectioned into 3 concentric subsamples (0 to 5 mm, 6 to 10 mm, and greater than 10 mm depth from the surface) and analyzed for moisture, NaCl, titratable acidity, L(+) and D(-) lactic acid, pH, and total and water-soluble calcium. The data were analyzed by ANOVA according to a repeated measures design with 2 within-subjects variables. The crystalline material contained 52.1% lactate, 8.1% Ca, 0.17% P, 28.5% water, and 8.9% crude protein on average. Both crystallized and noncrystallized cheese samples contained significant gradients of decreasing moisture from center to surface. Compared with noncrystallized samples, crystallized samples possessed significantly higher moisture, titratable acidity, L(+) lactate, and water soluble calcium, and significantly lower pH and NaCl content. The data suggest that formation of calcium lactate crystals may have been influenced by within-vat variation in salting efficacy in the following manner. Lower salt uptake by some of the cheese curd during salting may have created pockets of higher moisture and thus higher lactose within the final cheese. When cut into retail-sized chunks, the lower salt, higher moisture samples contained more lactic acid and thus lower cheese pH, which shifted calcium from the insoluble to the soluble state. Lactate and soluble calcium contents in these samples became further elevated at the cheese surface because of dehydration during smoking, possibly triggering the formation of calcium lactate crystals.

XIX 27-05 GAS-FLUSHED PACKAGING CONTRIBUTES TO CALCIUM LACTATE CRYSTALS IN CHEDDAR CHEESE

S. Agarwal, M. Costello and S. Clark
J. Dairy Sci. 88(11): 3773. 2005.

Gas-flushed packaging is commonly used for cheese shreds and cubes to prevent aggregation and loss of individual identity. Appearance of a white haze on cubed cheese is unappealing to consumers, who may refrain from buying, resulting in lost revenue to manufacturers. The objective of this study was to determine whether gas flushing of Cheddar cheese contributes to the occurrence of calcium lactate crystals (CLC). Cheddar cheese was manufactured using standard methods, with addition of starter culture, annatto, and chymosin. Two different cheese milk compositions were used: standard (lactose:protein = 1.47, protein:fat = 0.90, lactose = 4.8%) and ultrafiltered (UF; lactose:protein = 1.23, protein:fat = 0.84, lactose = 4.8%), with or without adjunct *Lactobacillus curvatus*. Curds were milled when whey reached 0.45% titratable acidity, and pressed for 16 h. After aging at 7.2°C for 6 mo, cheeses were cubed (1 x 1 x 4 cm) and either vacuum-packaged or gas-flushed with carbon dioxide, nitrogen, or a

50:50 mixture of carbon dioxide and nitrogen, then aged for an additional 3 mo. Heavy crystals were observed on surfaces of all cubed cheeses that were gas-flushed, but not on cheeses that were vacuum-packaged. Cheeses without *Lb. curvatus* exhibited L(+)-CLC on surfaces, whereas cheeses with *Lb. curvatus* exhibited racemic mixtures of L(+)/D(-)-CLC throughout the cheese matrices. The results show that gas flushing (regardless of gas composition), milk composition, and presence of nonstarter lactic acid bacteria, can contribute to the development of CLC on cheese surfaces. These findings stress the importance of packaging to cheese quality.

XIX 28-05 CHARACTERIZATION OF DRIED WHEY PROTEIN CONCENTRATE AND ISOLATE FLAVOR

M. E. Carunchia Whetstine, A. E. Croissant and M. A. Drake
J. Dairy Sci. 88(11): 3826. 2005.

The flavor of whey protein concentrates (WPC 80) and whey protein isolates (WPI) were studied using instrumental and sensory techniques. Four WPC 80 and 4 WPI were collected in duplicate from 6 manufacturers. Samples were rehydrated and evaluated in duplicate by descriptive sensory analysis. Duplicate samples with internal standards were extracted with diethyl ether. Extracts were then distilled to remove nonvolatile material using high vacuum distillation. Volatile extracts were analyzed using gas chromatography/olfactometry with post peak intensity analysis and aroma extract dilution analysis. Compounds were identified by comparison of retention indices, odor properties, and gas chromatography/mass spectrometry against reference standards. Whey proteins exhibited sweet aromatic, cardboard/wet paper, animal/wet dog, soapy, brothy, cucumber, and cooked/milky flavors, along with the basic taste bitter, and the feeling factor astringency. Key volatile flavor compounds in WPC 80 and WPI were butanoic acid (cheesy), 2-acetyl-1-pyrroline (popcorn), 2-methyl-3-furanthiol (brothy/burnt), 2,5-dimethyl-4-hydroxy-3-(2H)-furanone (maple/spicy), 2-nonenal (fatty/old books), (E,Z)-2,6-nonadienal (cucumber), and (E,Z)-2,4-decadienal (fatty/oxidized). This baseline data on flavor and flavor sources in whey proteins will aid ongoing and future research.

XIX 29-05 INFLUENCE OF CALCIUM, PH, AND MOISTURE ON PROTEIN MATRIX STRUCTURE AND FUNCTIONALITY IN DIRECT-ACIDIFIED NONFAT MOZZARELLA CHEESE

D. J. McMahon, B. Paulson and C. J. Oberg
J. Dairy Sci. 88(11): 3826. 2005.

Influence of calcium, moisture, and pH on structure and functionality of direct-acid, nonfat Mozzarella cheese was studied. Acetic acid and citric acid were used to acidify milk to pH 5.8 and 5.3 with the aim of producing cheeses with 70 and 66% moisture, and 0.6 and 0.3% calcium levels. Cheeses containing 0.3% calcium were softer and more adhesive than cheeses containing 0.6% calcium, and flowed further when heated. Cheeses with the same calcium content (0.6%), the same moisture content, but set at different pH values (pH 5.3 and 5.8), exhibited no significant differences in melting or firmness. Increasing cheese moisture content from 66 to 70% produced a softer cheese but did not

increase meltability. Such differences in functionality corresponded with differences in structure and arrangement of proteins in the cheese protein matrix. Microstructure of cheese with 0.6% calcium had an increase in protein folds and serum pockets compared with the 0.3% calcium cheeses that had a more homogeneous structure. Protein matrix in the low-calcium cheese appeared less dense indicating the proteins were more hydrated. In the 0.6% calcium cheeses, the proteins appeared more aggregated and had larger spaces between protein aggregates. Thus, between pH 5.3 and 5.8, calcium controls cheese functionality, and pH has only an indirect affect related to its influence on the calcium in cheese.

XIX 30-05 IMPROVEMENT OF FUNCTIONAL PROPERTIES OF WHEY PROTEIN ISOLATE THROUGH GLYCATION AND PHOSPHORYLATION BY DRY HEATING

C. P. Li, H. Enomoto, S. Ohki, H. Ohtomo and T. Aoki
J. Dairy Sci. 88(12): 4137. 2005.

Whey protein isolate (WPI) was glycated with maltopentaose (MP) through the Maillard reaction, and the MP-conjugated WPI (MP-WPI) was then phosphorylated by dry heating in the presence of pyrophosphate. Glycation occurred efficiently, and the sugar content of WPI increased approximately 19.9% through the Maillard reaction. The phosphorylation of MP-WPI was enhanced with an increase in the dry-heating time from 1 to 5 d, and the phosphorus content of WPI increased approximately 1.05% by dry heating at pH 4.0 and 85°C for 5 d in the presence of pyrophosphate. The electrophoretic mobility of WPI increased with an increase in the phosphorylation level. The stability of WPI against heat-induced insolubility at pH 7.0 was improved by conjugation with MP alone, and further improved by phosphorylation. Although the emulsifying activity of WPI was barely affected by glycation and phosphorylation, the emulsifying stability of phosphorylated MP-WPI (5 d), was 2.2 times higher than that of MP-WPI. Gelling properties such as hardness, resiliency, and water-holding capacity of heat-induced WPI gel were markedly improved, and the gel was rendered transparent by phosphorylation. The calcium phosphate-solubilizing ability of WPI was enhanced by phosphorylation. These results suggested that phosphorylation by dry heating in the presence of pyrophosphate after conjugation with MP is a useful method for improving the functional properties of WPI.

XIX 31-05 YIELD AND AGING OF CHEDDAR CHEESES MANUFACTURED FROM MILKS WITH DIFFERENT MILK SERUM PROTEIN CONTENTS

B. K. Nelson and D. M. Barbano
J. Dairy Sci. 88(12): 4183. 2005.

Whey proteins in general and specifically β -lactoglobulin, α -lactalbumin, and immunoglobulins have been thought to decrease proteolysis in cheeses manufactured from concentrated retentates from ultrafiltration. The proteins found in whey are called whey proteins and are called milk serum proteins (SP) when they are in milk. The experiment included 3 treatments; low milk SP (0.18%), control (0.52%), and high milk SP (0.63%), and was replicated 3 times. The standardized milk for cheese making of the low milk SP treatment contained more casein as a percentage of true protein and more calcium as a percentage of crude protein, whereas the nonprotein nitrogen and total calcium content

was not different from the control and high SP treatments. The nonprotein nitrogen and total calcium content of the milks did not differ because of the process used to remove the milk SP from skim milk. The low milk SP milk contained less free fatty acids (FFA) than the control and high milk SP treatment; however, no differences in FFA content of the cheeses was detected. Approximately 40 to 45% of the FFA found in the milk before cheese making was lost into the whey during cheese making. Decreasing the milk SP content of milk by 65% and increasing the content by 21% did not significantly influence general Cheddar cheese composition. Higher fat recovery and cheese yield were detected in the low milk SP treatment cheeses. There was more proteolysis in the low milk SP cheese and this may be due to the lower concentration of undenatured β -lactoglobulin, α -lactalbumin, and other high molecular weight SP retained in the cheeses made from milk with low milk SP content.

XIX 32-05 APPLICATION OF EXOPOLYSACCHARIDE-PRODUCING CULTURES IN REDUCED-FAT CHEDDAR CHEESE: COMPOSITION AND PROTEOLYSIS

S. Awad, A. N. Hassan and F. Halaweish
J. Dairy Sci. 88(12): 4195. 2005.

Proteolysis during ripening of reduced fat Cheddar cheeses made with different exopolysaccharide (EPS)-producing and nonproducing cultures was studied. A ropy strain of *Lactococcus lactis* ssp. *cremoris* (JFR1) and capsule-forming nonropy and moderately ropy strains of *Streptococcus thermophilus* were used in making reduced-fat Cheddar cheese. Commercial Cheddar starter was used in making full-fat cheese. Results showed that the actual yield of cheese made with JFR1 was higher than that of all other reduced-fat cheeses. Cheese made with JFR1 contained higher moisture, moisture in the nonfat substance, and residual coagulant activity than all other reduced-fat cheeses. Proteolysis, as determined by PAGE and the level of water-soluble nitrogen, was also higher in cheese made with JFR1 than in all other cheeses. The HPLC analysis showed a significant increase in hydrophobic peptides (causing bitterness) during storage of cheese made with JFR1. Cheese made with the capsule-forming nonropy adjunct of *S. thermophilus*, which contained lower moisture and moisture in the nonfat substance levels and lower chymosin activity than did cheese made with JFR1, accumulated less hydrophobic peptides. In conclusion, some EPS-producing cultures produced reduced-fat Cheddar cheese with moisture in the nonfat substance similar to that in its full-fat counterpart without the need for modifying the standard cheese-making protocol. Such cultures might accumulate hydrophobic (bitter) peptides if they do not contain the system able to hydrolyze them. For making high quality reduced-fat Cheddar cheese, EPS-producing cultures should be used in conjunction with debittering strains

XIX 33-05 APPLICATION OF EXOPOLYSACCHARIDE-PRODUCING CULTURES IN REDUCED-FAT CHEDDAR CHEESE: TEXTURE AND MELTING PROPERTIES

S. Awad, A. N. Hassan and K. Muthukumarappan
J. Dairy Sci. 88(12): 4204. 2005.

Textural, melting, and sensory characteristics of reduced-fat Cheddar cheeses made with exopolysaccharide (EPS)-producing and nonproducing cultures were monitored during ripening. Hardness, gumminess, springiness, and chewiness significantly increased in the cheeses as fat content decreased. Cheese made with EPS-producing cultures was the least affected by fat reduction. No differences in hardness, springiness, and chewiness were found between young reduced fat cheese made with a ropy *Lactococcus lactis* ssp. *cremoris* [JFR1; the culture that produced reduced-fat cheese with moisture in the non-fat substance (MNFS) similar to that in its full-fat counterpart] and its full-fat counterpart. Whereas hardness of full-fat cheese and reduced-fat cheese made with JFR1 increased during ripening, a significant decrease in its value was observed in all other cheeses. After 6 mo of ripening, reduced fat cheeses made with all EPS-producing cultures maintained lower values of all texture profile analysis parameters than did those made with no EPS. Fat reduction decreased cheese meltability. However, no differences in meltability were found between the young full-fat cheese and the reduced-fat cheese made with the ropy culture JFR1. Both the aged full- and reduced-fat cheeses made with JFR1 had similar melting patterns. When heated, they both became soft and creamy without losing shape, whereas reduced-fat cheese made with no EPS ran and separated into greasy solids and liquid. No differences were detected by panelists between the textures of the full-fat cheese and reduced-fat cheese made with JFR1, both of which were less rubbery or firm, curdy, and crumbly than all other reduced-fat cheeses.

XIX 34-05 APPLICATION OF EXOPOLYSACCHARIDE-PRODUCING CULTURES IN REDUCED-FAT CHEDDAR CHEESE: CRYO-SCANNING ELECTRON MICROSCOPY OBSERVATIONS

A. N. Hassan and S. Awad
J. Dairy Sci. 88(12): 4214. 2005.

The microstructure of reduced- and full-fat Cheddar cheeses made with exopolysaccharide (EPS)-producing and nonproducing cultures was observed using cryo-scanning electron microscopy. Fully hydrated cheese samples were rapidly frozen in liquid nitrogen slush (-207°C) and observed in their frozen hydrated state without the need for fat extraction. Different EPS-producing cultures were used in making reduced-fat Cheddar cheese. Full-fat cheese was made with a commercial EPS-nonproducing starter culture. The cryo-scanning electron micrographs showed that fat globules in the fully hydrated cheese were surrounded by cavities. Serum channels and pores in the protein network were clearly observed. Young (1-wk-old) full-fat cheese contained wide and long fat serum channels, which were formed because of fat coalescence. Such channels were not ob-

served in the reduced-fat cheese. Young reduced-fat cheese made with EPS-nonproducing cultures contained fewer and larger pores than did reduced-fat cheese made with a ropy strain of *Lactococcus lactis* ssp. *cremoris* (JFR1), which had higher moisture levels. A 3-dimensional network of EPS was observed in large pores in cheese made with JFR1. Major changes in the size and distribution of pores within the structure of the protein network were observed in all reduced-fat cheeses, except that made with JFR1, as they aged. Changes in porosity were less pronounced in both the full-fat and the reduced-fat cheeses made with JFR1.