

Dairy Foods: Cheese

W213 Effect of Chy-Max M on proteolysis during ripening of natural cheese, and functionality of process cheese. A. C. Biswas*, C. Marella, and L. E. Metzger, *Dairy Science Department, South Dakota State University, Brookings.*

Recombinant bovine chymosin is an enzyme routinely used in cheese manufacture. Recently, recombinant camel chymosin (Chy-Max M) has also been developed and is commercially available as a milk coagulant for natural cheese manufacture. Previous research has determined that recombinant camel chymosin has a higher clotting activity, and is less proteolytic as compared with recombinant bovine chymosin. However, the effect of reduced proteolysis from recombinant camel chymosin on process cheese functionality has not been studied. The objective of this study was to determine the effect of Chy-Max M on proteolysis during ripening of natural cheese, and functionality of process cheese, as compared with cheese manufactured from recombinant bovine chymosin (Chy-Max Extra). Three replicates of natural cheese with a range in composition (37.73 - 43.49% moisture, 28.87 - 34.11% fat, 21.16 - 26.06% protein, and 1.60 - 2.24% salt) were manufactured with different protocols (cook temperature, curd washing, and salting rate) for each replicate. In each replicate a cheese was produced with Chy-Max M and Chy-Max Extra using the same protocol. The level of proteolysis in each cheese was determined at 2 weeks, 1, 2, and 3 mo of ripening. Additionally at 1 mo of ripening each natural cheese was utilized to produce process cheese that was standardized to 30% fat, 18% protein, 2.2% salt and 42.5% moisture using a formulation that contained water, sodium citrate, butter, salt, and deproteinized whey. In the natural cheese there was not a significant ($P > 0.05$) difference in fat, protein, moisture or pH between the Chy-Max M and Chy-Max Extra treatments. However, the level of primary proteolysis was significantly ($P < 0.05$) lower in the Chy-Max M treatment at all ripening times. In the process cheese the viscosity after manufacture and the TPA hardness of the Chy-Max M formulation was significantly ($P < 0.05$) higher than the Chy-Max Extra. These results demonstrate that Chy-Max M results in a reduced level of primary proteolysis in natural cheese and when utilized in process cheese results in an increase in viscosity and firmness.

Key Words: chymosin, proteolysis, process cheese

W214 High pressure processing of Queso Fresco: Effects on textural and rheological properties over 12 wk of storage. D. L. Van Hekken¹, M. H. Tunick¹, N. Farkye², and P. M. Tomasula¹, ¹USDA, Agricultural Research Service, Wyndmoor, PA, ²California Polytechnic State University, San Luis Obispo.

High pressure processing (HPP) is a non-thermal post-packaging process with the potential to improve cheese safety and shelf life because of its lethality to bacteria (spoilage and pathogens) and ability to inactivate many enzymes. Queso Fresco (QF), a high moisture Hispanic-style cheese popular in the US, could benefit from improved safety and shelf life but more information is needed to understand the effect that HPP has on the textural and rheological qualities of the cheese once it is placed in storage. A starter-free QF, made from pasteurized and homogenized milk, was vacuum packaged and then processed at 600 MPa for 3 or 10 min and stored at 4 or 10°C; controls were not HPP. After 1, 4, 8, and 12 wk of storage, QF were assayed for compositional, textural (texture profile analysis), and rheological (torsion and small amplitude oscillatory shear analyses) properties. After 1 wk of storage at 4°C, the control QF consisted of 56.4 ± 0.3% moisture, 15.4 ± 1.5% protein, 22.3 ± 0.3%

fat, 2.9 ± 0.1% lactose, and 2.0 ± 0.3% salt; pH 6.31 ± 0.03. Free whey accumulated in packaging following HPP and over time resulting in decreased moisture contents ($P < 0.05$). Controls decreased 2.0% in moisture over 12 wk while samples lost about 2.5% moisture after HPP treatment and another 2% by the end of the study; HPP QF stored at 10°C tended to have the lowest moisture contents. HPP QF were harder, more rigid, and fractured at higher stress than controls ($P < 0.05$); QF processed for 10 min tended to be firmer than samples processed at 3 min and QF stored at 10°C were firmer than QF stored at 4°C. Within a treatment, the textural and rheological properties were stable over 12 wk of storage. Loss of free whey, considered a defect by American consumers, was enhanced after HPP treatment and affected the moisture content, texture, and rheology of the cheese. As new post-processing steps are explored, it is essential to monitor texture and rheology to maintain the quality traits of the cheese that are expected by the consumer.

Key Words: cheese, high pressure processing, rheology

W215 Reducing fat levels in Cheddar-like goat cheese: Effect on proteolysis and rheological properties over 6 months of refrigerated storage. D. L. Van Hekken¹, Y. W. Park², and M. H. Tunick¹, ¹USDA, Agricultural Research Service, Wyndmoor, PA, ²Fort Valley State University, Fort Valley, GA.

Development of low-fat goat cheeses that appeal to health conscious consumers requires information on how the reduction of fat affects the quality traits of the cheese, such as its proteolysis and rheology. Goat milk samples containing 3.6, 2.0, 1.0, and < 0.5% fat were processed into full-fat (FF), reduced-fat (RF), low-fat (LF), and non-fat (NF) high-moisture Cheddar-like cheeses, respectively, vacuum sealed in pouches, and stored at 4°C. Compositions of the cheeses were determined after 1 mo of storage, protein profiles were compared between 1 and 6 mo of storage, and rheological properties were measured after 1, 3, and 6 mo of storage. The FF, RF, LF, and NF cheeses contained 26.3, 19.0, 9.65, and 1.50% fat; 48.7, 50.0, 51.5, and 55.2% moisture; and 21.0, 24.9, 35.9, 38.5% protein, respectively. The FF, RF, and LF cheeses had similar proteolysis with a 40% decrease of intact caseins (α_s - and β -CN) while the intact caseins in the NF cheese decreased by 14%. The NF cheese, with its dense protein matrix had the highest values for hardness, chewiness, cohesiveness, fracture stress, elastic modulus, and viscous modulus. Although the LF cheese was harder, chewier, more cohesive, and fractured at higher stress than the FF and RF cheeses, it softened somewhat with age while the NF cheese remained a hard mass. The FF and RF cheeses had similar rheological properties and had the softest and most flexible textures. It was concluded that fat can be reduced to 19% in a Cheddar-like goat cheese with minimal effect on rheology which will help in developing reduced-fat goat cheese products.

Key Words: goat milk cheese, low fat cheese, rheology

W216 Influence of temperature and milk on W₁/O/W₂ double emulsions made with anhydrous milk fat. D. B. Clayton and D. J. McMahon*, *Western Dairy Center, Utah State University, Logan.*

Water (W₁) in oil (O) in water (W₂) double emulsions (W₁/O/W₂) have been added to milk to improve texture and to add fiber to low-fat cheese. Our objective was to determine stability, and suitability for cheesemaking, of a W₁/O/W₂ emulsion made using anhydrous milkfat (AMF) as the oil phase. Because the melting range of AMF covers typical cheese

manufacturing temperatures, we were concerned that an AMF $W_1/O/W_2$ emulsion would be unstable in cheese milk. The primary (W_1/O) emulsion was prepared by adding water (50°C) dropwise, under low shear into AMF (50°C) containing 8% polyglycerol polyricinoleate in a 40:60 ($W_1:O$) ratio. The W_1/O emulsion was then added to water containing 2% whey protein concentrate (50°C) in a 20:80 ($W_1/O:W_2$) ratio using low shear. The mixture was then subjected to high shear using an Omni GLH mixer at 5,000 rpm for 1 min to create a $W_1/O/W_2$ emulsion. Presence of double emulsions was verified through optical microscopy. Temperature stability of $W_1/O/W_2$ emulsions was measured by placing 5 to 7 mL of emulsion in test tubes that were held at 30, 35, 40, or 50°C for 3 h. In comparison, a canola oil $W_1/O/W_2$ emulsion was used as control. Light backscattering from the test tubes was measured every 15 min in a Turbiscan for 3 h to determine instability of the emulsions due to creaming. The $W_1/O/W_2$ emulsion was also added to skim milk at 1:20 ratio and held at 32°C for 3 h then viewed using optical microscopy to see if the $W_1/O/W_2$ remained or reverted to an O/W_2 emulsion. The AMF $W_1/O/W_2$ emulsion was most stable at 30°C, with only a 4.11 mm change in backscattering after 3 h as shown by Turbiscan measurements, compared with 4.49, 4.57, and 5.71 mm for emulsions stored at 35, 40, and 50°C, respectively. After 3 h in milk, the initial $W_1/O/W_2$ emulsions were not stable, with the inner primary phase being lost resulting in an O/W_2 emulsion. This problem was solved by adding 0.4% NaCl to the W_1 before making the emulsion to balance osmotic pressure with milk, and $W_1/O/W_2$ emulsion droplets in milk were still visible after 3 h. We concluded that a double emulsion made using this process is sufficiently stable to be used in the manufacture of cheese.

Key Words: emulsion, cheese

W217 Cheese milk fortification with denatured whey/buttermilk blend—Effect on rennet gel characteristics. M.-P. Gauvin^{*1}, M. Britten², and Y. Pouliot¹, ¹STELA Dairy Research Center, Institute on Nutrition and Functional Foods (INAF), Université Laval, Québec, Québec, Canada, ²Food Research and Development Center (FRDC), Agriculture and Agri-Food Canada, St-Hyacinthe (Québec), Canada.

Thermal aggregation of whey protein concentrate with buttermilk has been studied as a way to produce a new enrichment ingredient for cheese making. The purpose of this work is to describe the effect of adding whey protein/buttermilk denatured blend to cheese milk in terms of gelation and rennet gel properties in comparison with the use of 100% whey protein or buttermilk aggregates. Whey protein, buttermilk and a 1:1 combination of whey protein and buttermilk were reconstituted from powders to 3.15% protein (wt/wt) and heat denatured (80°C, 30 min, pH 4.6) under stirring. After cooling, the mixtures were adjusted to pH 6.5 and homogenized. The ingredients were added to reconstituted skim milk and milk protein concentrate to constitute 17.7% (wt/wt) of the total protein of a 5.1% protein dispersion (wt/wt). To discriminate the contributions from the colloidal and soluble phases of the ingredients, cheese milks were also formulated after removing colloidal material by centrifugation (30,000 × g, 1 h). Cheese milks were renneted and coagulation kinetics, gel rupture properties and syneresis were measured. All experiments were performed in triplicate. Milk gelation was accelerated with increasing amount of buttermilk in the ingredient. For the milks containing buttermilk (B) or whey protein only (WP), lag phase (Tlag) and maximum gelation rate (Vmax) ranged from 23 to 28 min and from 0.027 to 0.034 min⁻¹ respectively. Tlag and Vmax values obtained with the milk enriched with whey protein/buttermilk blend (WP/B) were 26 min and 0.032 min⁻¹. The WP/B and B gels showed very similar rupture stress (284 and 291 Pa respectively), greater than the value obtained for gels containing whey protein only (WP) (236 Pa). Along with WP gels,

WP/B gels showed lower syneresis (64.8 and 63.9%) compared with B gels (66.3%). WP/B gels were therefore more humid. Milk fortification with WP/B blend tends to give rennet gels with intermediate characteristics when compared with WP and B. However, discriminating the contributions from the colloidal and soluble phases provides a better understanding of the ingredient behavior in cheese milk.

Key Words: whey protein, buttermilk, cheese

W218 Physicochemical and sensory properties of Prato cheese made with different coagulants. L. S. Alves¹, C. Merheb-Dini^{*1}, E. Gomes², R. da Silva², and M. L. Gigante¹, ¹Faculty of Food Engineering, University of Campinas - UNICAMP, Campinas, SP, Brazil, ²Instituto de Biociências, Letras e Ciências Exatas, UNESP - Univ Estadual Paulista, São José do Rio Preto, SP, Brazil.

Prato cheese is a typical Brazilian variety, obtained by enzymatic curdling. It is made from a semi-cooked, washed and pressed mass, which is ripened for at least 25 d. The aim of this work was to compare the effect of coagulant type on Prato cheese yield and sensory acceptance. Cheeses were manufactured from 50 L of milk in vats with a heating-cooling jacket, stirrers and speed control, according to traditional methodology using the following coagulants: laboratory obtained protease, from the fungus *Thermomucor indicae-seudaticae* N31, recently isolated in Brazil (*Thermomucor* cheese) and commercial coagulant from *Rhizomucor* sp. (Alternative, Bela Vista) (Control cheese). For both cheeses the amount of enzyme added was calculated to achieve milk clotting in ≈35 min. The experiment was repeated 3 times and the results were evaluated by ANOVA and mean values were compared by Tukey's test ($P < 0.05$). Milk, whey and cheese composition were evaluated and cheese yield was calculated. After 25 d of ripening, sensory acceptance was evaluated by 100 consumers who were asked to score each sample with respect to their degree of liking or disliking the appearance, aroma, taste, texture and overall liking using a 9-point hedonic scale. The different coagulants did not affect cheese composition, which exhibited average content of 42.68% ± 1.87 for moisture, 41.52% ± 0.69 for protein (dry base) and 49.83% ± 0.22 for fat (dry base). Protein and fat recovery and, consequently cheese yield, were not affected by the coagulants as well. No significant differences were observed in respect to sensory properties among the cheeses, which had good acceptability with overall liking scores of 7.06 ± 1.33 and 7.13 ± 1.30 for *Thermomucor* cheese and Control cheese, respectively, both representing the 'like moderately' category. The gathered data suggest that the new protease from *Thermomucor indicae-seudaticae* N31 has technological potential to be used in cheese making and, therefore, has potential to be produced in large scale. Acknowledgments: FAPESP, CNPq

Key Words: cheese yield, composition

W219 The effect of cation substitution on the flavor of reduced-fat, reduced-sodium Cheddar cheese. H. H. Chang^{*1}, E. J. Kang¹, R. E. Miracle¹, D. J. McMahon², and M. A. Drake¹, ¹North Carolina State University, Raleigh, ²Utah State University, Logan.

Sodium and fat reduction in dairy products are critical as diets high in sodium and fat are associated with many chronic diseases. However, sodium and fat play important roles in Cheddar cheese flavor development, and consumers are willing to purchase foods with reduced sodium and fat only when flavor profiles are similar to full fat and sodium counterparts. A previous study demonstrated that cation salts other than sodium could be used in place of sodium with minimal sensory effects up to 50% sodium replacement. The objectives of this

study were to determine the effect of cation substitution on the flavor of reduced sodium and fat (50% reduction) Cheddar cheese. Eight 50% reduced-fat Cheddar cheeses with different ratios of sodium, potassium, calcium and magnesium cations were manufactured. Traditional sodium chloride (NaCl) (1.7% wt/wt) and low sodium chloride (0.7% wt/wt; LC) cheeses served as controls. Cheeses were manufactured in triplicate, and analyzed for organic acids (HPLC), volatile compounds (SPME GCMS), and descriptive analysis (8 trained panelists with an established lexicon) across 9 mo ripening. Consumer acceptance testing was conducted with regular and sodium-restricted diet consumers (n = 100 each group) after 3 and 6 mo. No differences ($P > 0.05$) due to cation substitution were observed in organic acids, but higher concentrations of citric, pyruvic and lactic acids were present in LC compared with other reduced fat cheeses. Volatile compound differences were observed when more than 50% sodium was replaced. Trained panelists documented differences ($P < 0.05$) in flavor and basic tastes with more than 25% sodium substitution. The largest sensory impact was increasing intensities of bitter taste with sodium substitution. Sulfur and brothy flavors increased with decreased NaCl. Consumer acceptance scores, on regular or salt-restricted diets, were not different in overall liking up to 50% replacement of KCl with NaCl. Differences due to cation substitution are not likely to affect consumer liking and flavor chemistry up to 50% sodium replacement in reduced fat Cheddar cheeses.

Key Words: cheese, reduced sodium, reduced fat

W220 Comparison of physicochemical properties of Asiago cheese added with nanopowdered red ginseng and powdered red ginseng during ripening (II). K. H. Choi*, P. Ganesan, and H. S. Kwak, *Sejong University, Seoul, South Korea.*

Red ginseng which contains various ginsenosides is known to have various health benefits, such as antiinflammatory, anticancer, antitumor, antidiabetic. However, the low oral bioavailability of red ginseng is a major obstacle to its applicability as a functional food material. To overcome the obstacle, red ginseng was milled to nano scale (200 nm) and it was added into Asiago cheese. Therefore, this study was carried out to investigate physicochemical properties of different concentrations (0.1, 0.3, and 0.5%) of nanopowdered red ginseng (NRG) and powdered red ginseng (PRG)-added Asiago cheeses (AC). The proximate composition, lactic acid bacteria (LAB) counts, color, texture, and sensory analysis were measured to compare NRGAC and PRGAC during ripening at 14°C for 4 mo. The proximate composition such as moisture, protein, and fat contents were similar in NRGAC and PRGAC during ripening. LAB counts were not found significantly different between NRGAC and PRGAC during ripening ($P > 0.05$). However, L* value of 0.1% NRGAC showed significantly lower than that of PRGAC during the ripening. In texture, hardness was significantly increased during ripening in both NRGAC and PRGAC. In sensory analysis, the overall acceptability of 0.1% NRGAC was similar to control during ripening. In conclusion, the addition of NRG into cheese was slightly influenced to the properties of Asiago cheese, and 0.1% NRGAC was quite similar to control that may be worth developing functional cheese.

Key Words: Asiago cheese, nanopowdered red ginseng, physicochemical property

W221 Monitoring water-soluble compounds of Swiss cheese before cold room by attenuated total reflectance-Fourier transform infrared spectroscopy (ATR-FTIR). N. Cheng*, W. J. Harper, and C. Wick, *Ohio State University, Columbus.*

Eye formation plays an important role in Swiss cheese quality and consumer acceptance. Critical amount production of gas and rheological properties were reported to cause eye formation in Swiss cheese. This study focused on monitoring the water-soluble chemical compounds profile of Swiss cheese before cold room by Fourier transform infrared spectroscopy (Varian 3100, Varian Inc., Hercules, CA). Ten vat makes of Swiss cheese were sampled out of press, out of pre-cool and out of warm room stages. Water extract of each sample was made by using chloroform and ethanol and then vacuum dried on a triple-reflection ZnSe crystal mounted on an attenuated total reflectance (Pike Technologies, WI) accessory. Four spectra were collected for each sample from 4000 to 700 cm^{-1} with a resolution of 8 cm^{-1} and 64 scans were co-added per spectrum to enhance signal-to-noise ratio. All spectra were analyzed using soft independent modeling by class analogy (SIMCA, Pirouette 4.0, Infometrix Inc., WA). The discriminating wave number included fatty acids, amino acids and amide I and amide II compounds. The amino acid and amide bands indicate protein degradation that favors formation of eyes. The fatty acids probably arise from the formation of acids related to lactose degradation (probably acetic, propionic and butyric) and their formation can be associated with gas formation. Amino acid is also known to stimulate the growth of propionic acid bacteria in secondary fermentation of Swiss cheese and lead to the production of carbon dioxide. Our study showed that there were differences of water soluble compounds among out of press, pre-cool and out of warm room stage, which were associated with amino acid and aliphatic chains of fatty acids.

Key Words: Swiss cheese, eye formation, FTIR

W222 Survival of free and microencapsulated *Lactobacillus acidophilus* La5 in probiotic Prato cheese during simulated gastrointestinal conditions. C. Gebara, M. C. E. Ribeiro*, K. S. Chaves, F. N. Souza, C. R. F. Grosso, and M. L. Gigante, *Faculty of Food Engineering, University of Campinas, Campinas, SP/Brazil.*

The aim of this study was to evaluate the survival of free and microencapsulated *L. acidophilus* La5 added to Prato cheese during exposure to simulated gastrointestinal conditions. The probiotic was microencapsulated using citrus pectin by ionotropic gelation and coated with whey protein by complex coacervation. Three treatments were studied: Prato cheese with free La5, Prato cheese with La5 microencapsulated in pectin and Prato cheese with La5 microencapsulated in pectin coated with whey protein. After 30 d of storage at 12°C, the cheeses were exposed to conditions simulating the passage through the gastrointestinal tract: artificial gastric juice at pH 3.0 with addition of mucin and pepsin at 37°C for 120 min and followed by artificial intestinal juice at pH 7.0 with addition of pancreatin for 300 min. The cheeses were also exposed to bile solution (0.5%, pH 7.0) for 300 min. The effect of the treatments (free or microencapsulated probiotic) on the survival of the microorganism exposed to the gastrointestinal conditions was evaluated by ANOVA and Tukey's test for comparison between means ($P < 0.05$). The treatments did not significantly affect the probiotics survival during the exposure to simulated gastrointestinal conditions. For both free and encapsulated microorganism, a significant decrease of *L. acidophilus* La5 was not observed. The results suggest that regardless of microencapsulation, the fat-protein matrix of Prato cheese provides, by itself, protection to the microorganism during passage through gastrointestinal tract, allowing the probiotics to be delivered to its site of action, maintaining the initial population present in the product. Acknowledgments: FAPESP, CNPq.

Key Words: microencapsulation, probiotic, enteric resistance

W223 Evaluation of flavor variation in Swiss cheese from five factories using SIFT-MS, descriptive sensory analysis, and consumer sensory testing. K. Taylor¹, M. Leidheiser¹, M. A. Drake², S. Barringer¹, and W. J. Harper^{*1}, ¹The Ohio State University, Columbus, ²North Carolina State University, Raleigh.

Variation in Swiss cheese flavor has become a problem in the Swiss cheese industry. The objective of this study is to identify the compounds and flavor attributes causing variation in Swiss cheese flavor by using selected ion flow tube-mass spectrometry (SIFT-MS), descriptive sensory analysis, and consumer sensory testing. Three Swiss cheese samples were obtained from each of 5 different factories for a total of 15 samples. These cheeses varied in manufacturing dates, as well as the vat and block location. The trained panelists in the descriptive analysis found significant differences between the cheeses from different factories. Although there are some similarities between factories, there are also attributes that distinguish samples and are unique to each factory. To determine consumer preferred flavors this study utilized an untrained consumer panel of 100 people who consume Swiss cheese, to determine which cheeses were liked the most, met expectations, and had the highest liking rating. Overall, one factory was liked the most and was the best balanced in all attributes. SIFT-MS showed that the cheeses contained varying concentrations and odor activity values (OAV) of high impact volatile organic compounds (VOCs). OAVs (concentration/threshold) were utilized to discriminate all factories using soft independent modeling of class analogy (SIMCA) indicating unique flavor profiles. A variety of variables inherent to Swiss cheese manufacture may contribute to the variation in flavors associated with each factory. This study provided end-point flavor characteristics and compounds to be traced back through fermentation pathways to help determine the source of flavor variation.

Key Words: flavor, cheese, SIFT-MS

W224 Gas formation and growth characteristics of an oligotrophic *Lactobacillus* species isolated from Cheddar cheese. F. Ortakci^{*1}, C. Oberg^{2,1}, J. Broadbent¹, T. Oberg¹, and D. McMahon¹, ¹Western Dairy Center, Utah State University, Logan, ²Weber State University, Ogden, UT.

A heterofermentative *Lactobacillus* (WDC04), isolated from gassy Cheddar cheese, was studied for growth and gas formation. Previously, WDC04 was shown to only use ribose (Rib) as a sugar source. Our aim was to determine rate and extent of growth, and gas production when grown anaerobically in various combinations of Rib and galactose (Gal) at 12, 25, and 37°C. Using MRS broth without glucose at pH 5.2, we added Rib and Gal individually or combined at 0.05%, 0.1%, 0.5%, 1.0% and 2.0%. The WDC04 isolate was grown to 7×10^8 cfu/mL in MRS (without glucose) + 0.5% Rib+1% Gal then inoculated into the various broths to an initial turbidity at 640 nm of 0.05 to 0.15 ($\sim 10^7$ cfu/mL). Cell growth was monitored through turbidity change every 12 h. At all 3 temperatures, the most growth of WDC04 occurred in 1% Rib, 0.5% Rib + 0.5% Gal, or 1% Rib + 1% Gal. Stationary phase was reached in 180, 48 and 48 h at 12, 25 and 37°C, respectively. Cell numbers at stationary phase were similar ($\sim 10^9$ cfu/mL) when WDC04 was grown at 12 and 25°C, but lower ($\sim 10^8$ cfu/mL) when grown at 37°C. Growth rates were similar when lower levels of Rib or Rib/Gal were used but extent of growth was less. When Gal was the only sugar source, growth of WDC04 was slower, with stationary phase at 25°C reached after 156 h in 0.5% Gal compared with 24 h in 0.5% Rib. When WDC04 was grown in Gal only at 37°C there was no further growth after the initial 12 h ($P > 0.05$). Gas formation was observed only when Gal were present and at 25°C either in the presence or absence of citrate. The

similar growth patterns in 1% Rib and 0.5% Rib + 0.5% Gal indicates that WDC04 can utilize Gal for energy but transport of Gal into the cell is dependent on Rib metabolism. Furthermore, the metabolic pathways associated with Gal utilization appear to be required for gas production. To confirm the ability of WDC04 to cause late blowing in cheese, we made Cheddar cheese from milk inoculated (10^2 cfu/g) with WDC04 and stored the cheese at 6 and 12°C. After 3 mo at 12°C, gas formation was observed in the cheeses containing WDC04 while slower gas production occurred at 6°C.

Key Words: *Lactobacillus*, gas former, cheese late blowing

W225 Effect of oil-based and microencapsulated n-3 fatty acids on physical and chemical properties of processed cheese. M. Rouse, C. A. Boeneke, K. V. O'Brien*, and K. Aryana, Louisiana State University, Baton Rouge.

In recent years the benefits of n-3 fatty acids has been elucidated in numerous studies related to cardiovascular health, immune functioning, renal disorders, diabetes and cancer. Fish and fish oils are a good source of n-3 fatty acids; however, the recommended dietary amounts are not often achieved in the Western diet. The addition of fish oils to commonly consumed dairy products, such as yogurt or processed cheese, could serve as effective method to incorporate more n-3 fatty acids into the diet. The objective of this study was to evaluate several sensory qualities of a processed cheese containing varying levels of docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). Fortification of this dairy product with DHA and EPA was achieved by the addition of microencapsulated fish oil during the melting stage of the processed cheese manufacture. The addition of 25 mg 2:1 DHA:EPA received the highest scores for both flavor and overall liking by testers; however, few significant differences were found between the samples. The flavor and aroma are the most deterrent factors in consumer acceptance of products fortified with fish oils due to relatively high rates of lipid oxidation and the resulting off flavors that can occur in the finished product. Microencapsulation of fish oils before addition may reduce the rate of oxidation and therefore improve marketability of dairy products fortified with fish oil.

Key Words: processed cheese, fish oil, microencapsulation

W226 Variability of volatile organic compounds profile during the manufacture of Swiss-type cheeses using selected ion flow tube mass spectrometry. H. Z. Castada* and W. J. Harper, Department of Food Science and Technology, The Ohio State University, Columbus.

The determination of the volatile organic compounds (VOCs) profile variability during the manufacture of Swiss cheese was achieved using static headspace sampling and quantitative analysis of the volatiles with selected ion flow tube-mass spectrometry (SIFT-MS). Cheese samples from 5 different vats at each of the 4 different stages of manufacture from a single factory were obtained. These stages include: out-of-press, end of pre-cool, end of warm room and at time of cutting. Two batches of samples and their subsequent stages from 2 different starting make dates were investigated in this study. Statistical analyses and comparison of VOC profile between vats and between stages of manufacture were applied using soft independent modeling of class analogy (SIMCA) and statistical analysis system (SAS). Significant VOC profile differences have been identified between the 4 stages of cheese manufacture. Multivariate stage-level (VOC concentrations were pooled from the 5 vats at each stage) classification using SIMCA showed significant discrimination between the 4 manufacturing stages. The key VOCs

that predominantly discriminated each stage after SIMCA analysis and subsequent least squared means analysis using SAS revealed that 2-methylpropanal, 3-methylbutanal, butanal and propionic acid were significantly highest at the time of cutting; acetic acid and methional at the end of warm room; butanoic acid, ethyl methyl sulfide and 3-methylbutanoic acid at the end of pre-cool; and ethanol and 2,3-butanedione in out-of-press samples. Another significant finding of this study was the apparent variability of the VOC profile in cheeses at each stage made in different vats and manufactured on the same day. Variability is most probably related to the changes in microflora and environmental conditions at each stage. Such findings could be used to explain and control the flavor and aroma heterogeneity of the cheese samples, especially for the cheeses at the time of cutting and packaging.

Key Words: Swiss cheese, volatile organic compounds (VOC), selected ion flow tube mass spectrometry (SIFT-MS)

W227 Tracking the progression of thermophilic bacteria during the manufacture of Cheddar cheese—A case study. K. Bhanduriya*, S. Anand, and L. Metzger, *Midwest Dairy Foods Research Center, Dairy Science Department, South Dakota State University, Brookings.*

Many groups of thermophilic bacteria are known to cause slits, weak body or blowing defects in Cheddar cheese. These organisms are likely to increase during a typical Cheddar cheese making long run of 18 to 20 h, because of in-process multiplication and concentration. The present study was conducted to scan the thermophilic progression during Cheddar cheese manufacture in a commercial cheese plant. Three independent cheese manufacture runs were analyzed at monthly intervals. The entire process was divided into 3 sampling stages; raw milk, pasteurized milk, and cheese blocks. Samples were drawn in duplicates at 4 different time intervals; start of the cycle, pre mid-day wash, post mid-day wash, and end of the cycle. The microbiological analysis was conducted for thermophilic mesophiles and thermophilic thermophiles using standard techniques. Analysis of variance was used to compare mean counts. The average mesophilic counts in raw milk samples were log cfu 4.6/mL, of which, log 1.9 were thermophilics. Pasteurization process was able to bring down the total mesophilic count by 3–4 logs. The thermophilic mesophiles did not increase during the pasteurization duration. The average counts of thermophilic thermophiles in raw milk were log cfu 1.5/mL. These counts were shown to increase by about 1.0 log during pasteurization run of 9–10 h, which indicates a build-up of thermophilic thermophiles during the process of pasteurization. Mid-day wash was able to reduce this thermophilic increase by about 1.5 logs, as established by pre and post mid-day wash counts. However, the thermophilic build up during pasteurization was noticed again near the end of the 20-h run. Similarly, the cheese made early in the day or soon after the mid-day wash showed lower thermophilic thermophiles (average 2.15 log cfu/g) as compare with the cheese made before mid-day wash or at the end of the production run (average 2.7 log cfu/g). Further studies related to the effect of long production run hours on the population of thermophilics during ripening and its effect on cheese quality parameters are under progress.

Key Words: thermophilic, thermophile, Cheddar cheese

W228 Causative organisms for slit defects in Cheddar cheese samples—A case study. K. Bhanduriya*, S. Anand, and L. Metzger, *Midwest Dairy Food Research Center, Dairy Science Department, South Dakota State University, Brookings.*

Appearance of slits due to gas production, during ripening of Cheddar cheese, is a sporadic yet reoccurring problem faced by cheese manufacturers. A wide variety of facultative and obligate heterofermentative bacteria have been associated with these defects. The present study was conducted to identify the causative bacteria in Cheddar cheese samples with slits to help design a control strategy later on. The cheese samples drawn from 10 (18-kg) cheese blocks of 2 different lots, aged about 3 mo, were obtained from a commercial cheese manufacturing plant. The slits were spherical or oval in shape, and majority of them were concentrated toward the center of the sampled blocks. In the case of plug samples, the slits were observed to be unevenly distributed. Some of the plug samples were very fragile due to the gas holes. Two samples of 100 g each were drawn from the cheese blocks and 11 g samples were plated in duplicates for the species of *Lactobacillus* on de Man, Rogosa, and Sharpe (MRS) agar, *Lactococcus* on M17 agar with 10% added lactose, coliforms on violet red bile agar (VRBA), anaerobic spore-formers on reinforced clostridial medium agar (RCM), and yeast and molds on potato dextrose agar (PDA). Statistical comparison of counts within spoiled samples indicate RCM counts were significantly different between the lot ($P < 0.0001$) whereas M17 and MRS were not. Representative colonies of the isolates were Gram stained for purity, and were tested for gas production in skim milk with 1% glucose, and the organism specific media broths with the inverted Durham tubes. Biochemical identification of the isolates was performed using API CH50 strips. The gas producing isolates from MRS agar were identified to be *Lactobacillus fermentum*, and from the RCM belonged to genus *Clostridium*. *Lactobacillus* isolates were observed to be of both thermophilic and mesophilic types, while the *Clostridium* isolates were thermophilic mesophiles. The present study thus indicates the involvement of lactobacilli and clostridia in causing the slit defects in Cheddar cheese samples.

Key Words: Cheddar cheese slits, *Lactobacillus*, *Clostridium*

W229 Impact of cation substitution on composition and microbiology of reduced-fat Cheddar cheese. D. J. McMahon*¹, C. J. Oberg^{2,1}, L. V. Moyes^{2,1}, M. A. Drake³, and N. Farkye⁴, ¹*Western Dairy Center, Utah State University, Logan*, ²*Department of Microbiology, Weber State University, Ogden, UT*, ³*Department of Food, Bio-processing, and Nutrition Sciences, North Carolina State University, Raleigh*, ⁴*Dairy Products Technology Center, California State Polytechnic University, San Luis Obispo.*

Substituting potassium (K) for sodium (Na) in cheese can assist in reducing overall dietary Na intake. Our objective was to evaluate the effect of partial Na substitution on composition and microbiology of 50% reduced-fat (RF) Cheddar cheese. Seven RF Cheddar cheeses were made with molar salt contents equivalent to 2.1% (wt/wt) NaCl but with different ratios of Na, K, Ca and Mg cations, along with a cheese containing 0.7% NaCl. Cheese was made using pre-acidification to pH 6.35 and adding lactococcal starter and a lactococcal/lactobacilli adjunct culture. Control cheese was made using 100% NaCl and then 10%, 25%, 50% and 75% substitution with KCl. Additional cheeses were made with 50% NaCl, 40% KCl and 10% CaCl₂ or MgCl₂. During 6 mo storage at 6°C we measured pH, water activity, water-soluble N (WSN), organic acids, total lactic acid bacteria (LAB), lactococci, and nonstarter LAB (NSLAB). Control cheese had a mean composition of 48.4% moisture, 35% FDB, 27.0% protein, and 2.12% salt. Cheeses with K substitution had similar composition. When 10% Ca was added during salting, cheese moisture was lower at 43.7% ($P < 0.05$). There was no difference in water activity among full salt cheeses with mean value of 0.963 while the low salt cheese was 0.015 higher ($P < 0.05$). Changes in most of the organic acids followed similar trends for all 2.1% cheeses. Lactic acid

was initially lowest (and pH highest) in cheeses with higher Na levels, and increased during storage till by 3 mo all cheeses were similar. All cheeses had mean lactococci levels of 10^7 to 10^8 cfu/g and NSLAB of $\leq 10^2$ cfu/g. Lactococci stayed dominant throughout storage at $\sim 10^6$ cfu/g and for most cheeses the NSLAB were $\leq 10^4$ cfu/g. There was no apparent difference in bacterial numbers between cheeses containing 2.1% or 0.7% salt. In conclusion, differences in whey syneresis of RF compared with full-fat cheese was that calcium had been reduced from 0.8% to 0.6% and that dominance of lactococci throughout storage was a combined effect of a slightly lower salt-in-moisture content (4.3% versus 4.8%) and addition of the adjunct culture. Otherwise, substituting K for Na had little effect on cheese microbiology.

Key Words: cheese, sodium, potassium

W230 Production of reduced-fat Majorero cheese using supercritical CO₂. D. Sanchez-Macias^{*1,2}, A. Laubscher¹, N. Castro³, A. Arguello³, and R. Jimenez-Flores¹, ¹California Polytechnic State University, San Luis Obispo, ²Agroindustrial Engineering Department, Universidad Nacional del Chimborazo, Riobamba, Ecuador; ³Department of Animal Sciences, Universidad de Las Palmas de Gran Canaria, Arucas, Spain.

Consumer trends for healthier food choices and preferences for low-fat products have increased the interest in low-fat cheese and nutraceutical dairy products. However, consumers still value flavor over attributes in food. There are several strategies to produce low fat cheese. The method reported in this manuscript is another option to the conventional cheese-making strategy to produce reduced/low fat cheese. Using CO₂ as supercritical fluid (scCO₂) offers an alternative to reduce fat in cheese after ripening, maintaining the initial characteristics and flavor. The aim of this experiment was to evaluate the effect of pressure (100, 200, 300 and 400 bar) of the scCO₂ on the amount of fat extracted, microbial population, polar lipids profile, and microstructure of 2 varieties of goat cheese: Majorero (a PDO cheese from Spain), and goat Gouda-type cheese. The amount of fat was reduced 50–57% and 48–55%, for Majorero and goat Gouda-type cheeses, respectively. Higher content of sphingomyelin and phosphatidylcholine on fat basis were found in Majorero cheese compared with the control, and also compared with goat Gouda-type cheese. The microbial population was reduced after the supercritical fluid extraction in both cheeses, and the lethality was higher as pressure increased in Majorero cheese, most noticeably reductions on lactococcus and lactobacillus bacteria. Gouda-type cheese did not contain any lactobacillus. Micrographs obtained from confocal laser scanning microscopy showed a more open matrix and whey pockets in the Majorero control cheese. This could explain the effective fat extraction and significant reduction on the microbial counts in this cheese after the treatment with scCO₂. The results of this study demonstrated that the supercritical fluid extraction with scCO₂ process has potential in the dairy industry and commercial applications. Majorero cheese obtained after the SFE treatment is an excellent candidate to be considered as reduced fat goat cheese, with significant lower cholesterol, but still with all the flavor and health benefits inherent to the goat milk.

Key Words: reduced-fat cheese, supercritical CO₂, goat cheese

W231 Effect of post manufacture thermal dip treatment on proteolysis of commercial string cheese during refrigerated storage. M. K. Hsu^{*} and P. S. Tong, California Polytechnic State University, San Luis Obispo.

Due to its convenience, nutritive value, and fun appeal, string cheese is a popular snack for kids today. It can string in fibers when pulled apart and this quality has transformed how consumers eat cheese. Graders judge string cheese by its stringiness; samples with copious string are highly awarded. But just as the texture of natural cheeses softens with time, the stringy texture of string cheese can diminish with age too. Age related softening in cheese is due mainly to proteolysis. Previous research has examined the effects of changing curd-cooking and curd-stretching temperatures on the extent of proteolysis in Mozzarella. Increasing the temperatures for both cooking and stretching processes were successful in decreasing the amount of α_{S1} -CN breakdown, the action that causes softening. We reason that a post manufacture heat treatment of cheese could inactivate proteolytic enzymes. The main objective of this study was to determine the effects of a post manufacture thermal dip treatment on proteolysis in packaged, commercial string cheese. Proteolysis was observed by using urea-PAGE electrophoresis and by measuring % water-soluble nitrogen (%WSN). String cheese was sourced on 2 occasions and treated 6 d after manufacture. Treatment consisted of dipping cheese in water at 55°C, 75°C, and 95°C for 30 and 60 s at each temperature. String cheese that did not undergo treatment served as a control. Cheeses were stored at 4°C until sampling for urea-PAGE and WSN extraction on d 1, 11, 22, 29, 49, 91, and 172 after treatment. The degree of β -CN breakdown did not change between all treatments throughout storage. This was expected since Mozzarella should have higher plasmin activity due to inactivation of plasmin inhibitors and activation of plasminogen from any thermal process. There was a trend of slightly more intact α_{S1} -CN in the most severely treated cheese (95°C for 60s) compared with the control at the final time point. However, only ripening time had a significant effect on %WSN ($P < 0.0001$). Extending the storage time may show a clearer effect of the treatment on secondary proteolysis.

Key Words: string cheese, proteolysis, thermal treatment

W232 Effect of partial substitution of sodium chloride with potassium chloride on physicochemical composition and sensory acceptance of Minas frescal cheese. J. M. V. Pires, A. T. B. Vieira, J. B. Miazaki, A. M. T. Roque, P. C. B. Vianna, and C. M. V. B. De Rensis^{*}, Universidade Norte do Paraná, Londrina, Paraná, Brazil.

A high intake of sodium chloride causes negative effects on human health, because it is increasing the risk of heart attack and high blood pressure. Reducing the sodium content in cheese is expected to contribute to reducing the overall intake of sodium by world's consumers. Potassium chloride (KCl) has been studied as a salt (sodium chloride, NaCl) replacer in cheeses. The effect of partial substitution of NaCl with KCl on physicochemical composition and sensorial acceptance of Minas frescal cheese was investigated. Two batches of Minas frescal cheese were made and kept in 3 different brine solutions (20%, wt/wt), including A) NaCl only, B) and C) 1NaCl:1KCl and then stored at 4°C for 1 h. After 5 d of manufacture cheeses were analyzed for pH, titratable acidity, fat, moisture, protein, ash and salt contents. Sensory acceptance and purchase intention were performed on d 7 of manufacture cheese with 36 untrained panelists. Results were analyzed by ANOVA and Tukey's test ($P < 0.05$). No significant difference was found in physicochemical composition. The cheeses showed no significant differences ($P > 0.05$) regarding to attributes appearance, overall impression and texture. 1NaCl:1KCl cheese received lower scores for flavor and purchase intention showing that this cheese was not well accepted.

Key Words: acceptance, Minas frescal cheese, salt

W234 Effects of chelating agents on texture of low-fat Cheddar cheese. M. Poveda*, M. Arnold, and N. Farkye, *California Polytechnic University-San Luis Obispo, San Luis Obispo.*

Effects of 2 types of chelating agents on proteolysis and texture properties of low-fat Cheddar cheese (LFC) were analyzed and compared with full fat Cheddar (FFC) control during ripening for 120 d. We hypothesized that chelating agents would bind calcium ions from cheese matrix to give a softer curd due to decrease of protein-protein interactions and simultaneously increase in cheese moisture. Whole milk was skimmed to 0.57% fat for LFC manufacture. The LFC milk was divided into 3 lots (A, B, and C). Sodium citrate (SCLFC) and disodium EDTA (SELFC) were added to A and B at the rate of 0.02% and 0.2%, respectively. C served as control (CLFC). LFC milk (88°F) was preacidified to pH 6.2 before setting using 34 mL chymosin/454 kg and starter culture addition. After cutting, curd was cooked to 96°F in 30 min and held for 10 min. After cooking, the curd was washed, salted, hooped and pressed. FFC was made using the same batch of whole milk by the stirred curd method. Cheesemaking was replicated 5 times. Table 1 shows composition, water-soluble nitrogen (WSN) and TPA hardness of the cheeses. Results suggest that chelation of calcium in low-fat cheese reduces cheese hardness and improve texture of low-fat Cheddar cheese.

Table 1. Composition, WSN and TPA hardness of low-fat and full-fat Cheddar cheeses

Cheese	FDM (%)	Protein (%)	Ca (g/kg)	WSN (%)			TPA Hardness (g)		
				7 d	60 d	120 d	7 d	60 d	120 d
FFC	50.1	27.2	730	5.65	14.26	20.31	8657.7	6562.7	5527.7
CLFC	12.3	37.5	622.5	6.91	16.5	21.04	12747.6	9965.2	8111.5
SCLFC	13.0	37.3	477.5	6.86	14.87	20.57	10552.1	8664.7	7317.7
SELFC	13.3	35.6	502.5	6.76	16.62	22.17	10046.8	9121.4	7445.7

Key Words: proteolysis, texture, low-fat Cheddar cheese

W235 Heating curd grains during cheese-making could affect the appearance of fat and the phospholipids content in cheese.

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Analyzing the phospholipids content in different dairy products, it is affirmed that the ruptured membrane parts will preferentially migrate to the serum phases, resulting in an alteration of the phospholipid/lipid ratio in cheese. The literature reports that heating the curd grains induced the formation of fat globules aggregates, and pressing of the curd grains resulted in the greatest disruption of milk fat globules, their coalescence and the formation of nonglobular fat (free fat). Using CO₂ as supercritical

fluid (scCO₂) offers an alternative to reduce fat in cheese after ripening, maintaining the initial characteristics and flavor. The aim of this experiment was to evaluate the effect of pressure (100, 300 and 400 bar) of the scCO₂ on polar lipids profile and microstructure of 2 varieties of goat cheese: Majorero, (an artisan cheese from Spain), and commercial goat Gouda-type cheese. Sphingomyelin and phosphatidylcholine were detected in Majorero cheese. In Gouda cheese, a little sphingomyelin was detected in the treated cheeses. In majorero control cheese, the fat seems to have a coalesced or nonglobular appearance into the whey pockets. In Gouda-type control cheese, fat appears as nonglobular fat. Because heating the curd grains is part of the Gouda making-cheese, but not in Majorero, it could explain the large fat globules found in the images of control goat Gouda-type cheese, compared with control Majorero cheese. The shape of fat in control Gouda-type cheese images obtained with CLSM in this study and the lower phospholipids content found in the TLC analysis are results that concord with the heating curd grains during cheese-making.

W449 Evaluation of off-flavor development in Alpine cheese using selected ion flow tube mass spectrometry (SIFT-MS). E. Berusch, K. Taylor, and W. J. Harper*, *The Ohio State University, Columbus.*

A manufacturer of Alpine cheese has found that within three weeks of removing their product from vacuum packaging, off-flavors start to develop in the cheese. It was speculated that the development of these off-flavors was caused by lipid oxidation. The objective of this study was twofold: determine if the flavor change is, in fact, caused by lipid oxidation, and if it is not, find the agent causing the flavor profile to change. Both goals were met by using selected ion flow tube-mass spectrometry (SIFT-MS) to evaluate two different lots of Alpine cheese, #153 and #160. SIFT-MS is a direct mass spectrometric technique used to quantify volatile compounds in the headspace of a sample in real time. To prepare the samples, both cheeses were divided in half and grated – one part vacuum sealed and the other part exposed to oxygen. Over the course of 56 days, both the cheese exposed to oxygen and the vacuum-packed cheese were examined for development of off-flavors using SIFT-MS for cheese #153 and #160. Concentrations of 32 compounds in the cheeses, including alcohols, aldehydes, ketones, esters, sulfur compounds, and pyrazines, were analyzed. The results showed that 6 to 7 compounds, which changed in concentration over the testing period in samples exposed to oxygen, were derived from degradation of amino acids and lipids. This suggests that the off-flavor production in the Alpine cheeses are due to amino acid degradation as well as lipid oxidation. The compounds that underwent significant concentration changes, however, varied between cheese #153 and #160. In addition, the impact of time and oxygen on cheese #160 appears to be far greater than that on cheese #153. Further studies will be done to narrow down the causes of the changes in the Alpine cheese flavor profile and to determine ways to prevent the development of these off-flavors.

Key Words: oxidation, cheese, SIFT-MS