role of the ECM in the control of growth, differentiation, and resorption of ovarian structures and the regulation of ovarian ECM remodeling by the MMP and PA will be discussed. Our results indicate that the MMP and PA are temporally and spatially regulated during specific stages of the ovarian cycle and control ECM remodeling fundamental to ovarian function. Supported by USDA 98-35203-6226 (GWS) & 98-35203-6282 (MFS).

Key Words: Ovarian Extracellular Matrix Remodeling, Matrix Metalloproteinases, Plasminogen Activators

ADSA Dairy Foods: Cheese

602 Quality attributes of cheddar cheese in the North Carolina marketplac. A. Hansen* and M. Keziah, *North Carolina State University Raleigh, N.C. USA.*

Approximately 250 samples of cheddar cheese were obtained from various retail markets in North Carolina. Cheddar cheese samples were evaluated over a two year period. The evaluation was conducted with 15 trained dairy judges. Attributes were appearance, body and texture and they were evaluated according ADSA protocol. The major defects in appearance were open and a few samples were gassy. The major body defects were, from most to least, short, crumbly, pasty and curdy. The flavor defects from most to least were high acid, bitter, whey, sulfide, unclean, heated, flat and yeasty. The national brands of cheeses had less appearance and body defects. The main flavor defects were high acid, bitter, sulfide and whey, whereas the store brands tended to be more open and gassy in appearance. The body and texture would be short, curdy, crumbly and pasty depending on the brand. The store brands tended to have more off flavors such as unclean, oxidized, yeasty, flat, whey, sulfide, fermented and fruity. The store brands of sharp cheese tended to be acid, bitter and sulfide as compared to the national brand cheese which were acid and sulfide. The national brands usually had a cleaner flavor and were better qualit

Key Words: Cheddar Cheese, Marketplace, Quality

603 Salt and calcium distribution in injected cheese. A.J. Pastorino*[1], N.P. Ricks[2], C.L. Hansen[1], and D.J. McMahon[1], [1]*Utah State University,* [2]*Ohio State University.*

Modifying cheese attributes by injecting ionic solutions requires knowledge of the time needed to obtain uniform concentration of ions in the cheese. Therefore, our objective was to determine whether even distribution of sodium chloride (salt) and calcium chloride in cheese, over 1.0 cm distance from injection site could be obtained after 30 to 45 d. Full-fat salted cheese (25% fat, 45% moisture) and reduced-fat unsalted cheeses (22% fat, 42% moisture) were made according to direct-acid, stirred-pressed curd procedures. Cheeses were cut into 0.4 to 0.6-kg blocks, vacuum-packaged, and stored at 4°C. After 3 wk of storage, full-fat cheese blocks were high-pressure injected with a 40% calcium chloride solution, while reduced-fat blocks were injected with a 23% salt solution. Injection was performed in a single, centered row, in the top of the cheese block, with injection sites 1 cm apart. Pressure of injection was set at 1500 psi, and burst duration at 1.5 s. Cheese blocks were then vacuum-packaged and stored at 4°C. After storage, cheeses were sectioned into bands, 0.5 cm thick, parallel to the injection line. Three bands to each side of the injection line were considered for analysis, and the chloride and calcium content determined. Salt-injected cheese was analyzed 6 wk after injection and had increased salt content compared to uninjected cheese, 0.25% versus 0.16% ($P < 0.01$). Also, the injected cheese had an even distribution of salt over 1.5 cm from the injection line. Calcium-injected cheese, analyzed 4 wk after injection, had increased calcium content when compared to uninjected cheese, 0.43% versus 0.33% ($P < 0.01$), and had even distribution of calcium over 1.0 cm from the injection line. Upon injection, increased localized ion concentration generated a concentration gradient in the cheese that operated as a driving force for ions to diffuse. Also, deflection of the injectant as it enters the cheese would provide some initial dispersion of the solution. We concluded that injecting concentrated solutions of sodium and calcium chloride allows for increasing their content in the cheese, and that injecting these solutions using a 1 x 1-cm injection pattern allows for even distribution of ions in 30 d.

Key Words: Cheese, Salt, Calcium

604 Characterization of the melt properties of Cheddar cheese during ageing using dynamic low amplitude oscillatory rheology and melt profile analysis. Achyuth Hassan* and John Lucey, *University of Wisconsin-Madison.*

Melt characteristics are an important functionality of cheese on pizza. The melting properties of Cheddar cheese during ageing were determined by melt profile analysis and two dynamic low amplitude oscillation (DLAO) tests on a Physica UDS 200 rheometer. The newly developed melt profile method measures changes in cheese height during heating from 12 to 60°C and provides information on extent of flow and softening temperature. Extent of flow values (i.e., decrease in original cheese height) for 1, 7, 14, 21, 30, and 90 d samples were 54, 61, 64, 71, 71.5, and 71.5%, respectively. Rheological properties of cheese were evaluated at a strain of 0.2% and frequency of 0.1 Hz. Storage modulus (stiffness) and loss tangent parameters were determined from DLAO tests during heating. Cheeses were given two different types of heating profiles; one profile was the same as that used in the melt profile analysis technique (a non-linear but short heating profile or SHP). In the second heating profile, cheeses were heated from 5 to 80°C at constant rate of 1°C/min (long heating profile or LHP). In both heating profiles the loss tangent remained constant up to 40°C (0.5) and thereafter increased. The temperature when the loss tangent initially increased was similar to the softening temperature determined by melt profile analysis. Loss tangent values (at temperatures >40°C) increased with the age of cheese. In SHP tests, the values of the loss tangent at 55°C were 0.7, 1.3, 1.5, 1.7, 2.0, and 2.3 for 1, 7, 14, 21, 30, and 90 d cheese, respectively. In samples subjected to LHP, a well defined peak was observed in loss tangent and maximum values were 1.2, 2.0, 2.3, 2.5, and 2.1 which occurred at temperatures of 69, 67, 65, 64, 62, and 57°C for 1, 7, 14, 21, 30, and 90 d cheese, respectively. The decrease in height of cheese samples during heating paralleled trends in the increase in loss tangent value from rheological tests. An increased loss tangent indicates a change in character of cheese from solid-like material to viscous or liquid-like and it appears that this increase is involved in melting and flow of cheese at high temperatures. With increasing age and proteolysis the extent of flow increased and this coincided with higher loss tangent values in rheological tests.

Key Words: Rheology, Cheese, Melt profile

605 Reduced fat Cheddar cheese from a mixture of cream and liquid milk protein concentrate. Shakeel Rehman* and Nana Farkye, *Dairy Products Technology Center, Calpoly State University.*

Liquid milk protein concentrate (LMPC) is a high protein and low lactose dairy ingredient manufactured by ultrafiltration of skim milk. The study was undertaken to use LMPC and cream mixture in reduced fat Cheddar cheese (RFC) manufacture in order to increase yields. Control RFC was manufactured from standardized milk casein/fat, C/F 1.7, obtained from mixing whole milk (WM) and skim milk (SM) while experimental RFC was manufactured from standardized milk, C/F 2.0, obtained from mixing LMPC and 35 % fat cream. The % yield, % total solid (TS) and fat recoveries in the experimental RFC were 21.2, 61.4 and 85.4 as compared to 8.0, 45.1 and 77.3 in the control RFC, respectively. The average % moisture, fat, protein, salt and lactose were 40.7, 15.3, 32.8, 1.4 and 0.07, respectively, in the experimental cheese and 39.3, 15.4, 33.0, 1.3 and 0.10, respectively, in the control cheese. No growth of non-starter lactic acid bacteria (NSLAB) was detected in control or the experimental cheeses up to 3 mo ripening but at the end of 6 mo ripening the experimental cheese had 10^7 cfu NSLAB / g as compared to 10^6 cfu / g in the control. The experimental cheese had lower levels of water soluble N (as % of total N) than the control cheese after 6 mo ripening, suggesting lower levels of primary proteolysis in the experimental cheese. The total free amino acids, determined by Cd-ninhydrin method, were significantly lower in the experimental cheese than the control cheese during 6 mo ripening, suggesting lower

secondary proteolysis in the cheese containing LMPC. It can be concluded from the results of this study that LMPC can be used in the manufacture of RFC to improve yield, and fat and TS recovery. However, proteolysis in cheese made with LMPC and cream is slower than that made with WM and SM.

Key Words: Milk protein concentrate, reduced fat Cheddar

606 Effects of standardization of whole milk with milk protein concentrate on the yield and ripening of reduced fat Cheddar cheese. Shakeel Rehman[1], Nana Farkye[1], and Andrew Schaffner[2], [1]*Dairy Products technology Center, Calpoly State University,San Luis Obispo, CA,* [2]*Department of Statistics*.

Milk Protein concentrate (MPC), manufactured by spray drying of skim milk retentate, is becoming a popular dairy ingredient. Because of its high protein and low lactose contents, MPC can be used to standardize whole milk to give high yields of reduced fat Cheddar cheese. Four cheesemaking trials were conducted, each involving three cheeses, one control (CC) made from standardized milk (casein to fat ratio, C/F 1.7) obtained by mixing skim milk and whole milk (WM); the other two (MP1 and MP2) made from standardized milk (C/F 1.8) obtained from mixing WM and MPC. Commercial mesophilic starter was added at the rate of 1% to the CC and MP1, and 2 % to MP2. The addition of MPC doubled the yield and resulted in significant increases in the recovery of fat (94 % in MP1 and MP2 vs 92 % in CC) and total solids (43 % in CC vs 63 % in MP1 and MP2). Although minor differences were noted in the gross composition of the cheeses, both MP1 and MP2 cheeses had lower lactose, 0.25 or 0.32, respectively in MP1 or MP2 than in CC (0.60 %). All the three cheeses had 10^9 cfu/g starter bacteria. The non-starter lactic acid bacteria (NSLAB) grew slowly in MP1 and MP2 cheeses during ripening compared to CC, and at the end of 6 mo, the CC had 1-2 log cycle NSLAB higher than MP1 and MP2. Primary proteolysis, as noted by urea-PAGE or water soluble N contents, was markedly slower in MP1 and MP2 compared to CC. The concentration of total free amino acids, as determined by Cd-ninhydin method, was highest in the CC cheese followed MP2 and MP1, respectively, suggesting slower secondary proteolysis in the MPC than in CC cheese. Increasing the amount of starter bacteria improved secondary proteolysis in MPC cheese.

Key Words: Milk protein concentrate, reduced fat Cheddar

607 Controlling the coagulation properties of high solids cheesemilks that are standardized with cold ultrafiltration retentates. S. Govindasamy-Lucey*[1], J.J. Jaeggi[1], M.E. Johnson[1], and J.A. Lucey[2], [1]*Wisconsin Center for Dairy Research, University of Wisconsin, Madison, Wisconsin/USA,* [2]*Department of Food Science, University of Wisconsin, Madison, Wisconsin/USA*.

The cheese industry is currently using higher solids milks with the objective of increasing yields and processing efficiency. Increasing the solid contents of milk in-vat from 11 to 14.5% results in faster coagulation and firmer setting of the curd but possibly increased fat losses in whey if the cutting process is not carefully controlled. In this study, the coagulation properties of cheesemilks were determined using dynamic low amplitude oscillation in a Physica UDS 200 Rheometer. Milks with elevated solids (14.5%) were made by blending retentates obtained by cold (<7C) UF. Control milks with similar casein:fat ratios and total solids of 11.3% were also analyzed. The effects of cutting on the textural properties of rennet-induced gels were simulated using a low constant shear ($0.01\ s^{-1}$) test of the pre-formed gel made in the rheometer. The shear test was performed at the cutting times that our licensed cheesemakers used in cheese trials with these types of milk. Several trials were performed with gels made in the rheometer under identical conditions (pH, temperature, enzyme concentration) as used in Parmesan and Swiss cheese manufacture. Gels made from higher solids cheesemilks coagulated faster (although the rennet to casein ratio was identical for all samples), with a reduction in clotting time by 25-30%. The shear stress of the gels, that is, the force required to break the gels, during shearing was considerably higher (120-130%) in the high solids cheesemilks compared to control samples, which indicates that the cutting operation may need to be modified to prevent excessive fat losses. The storage modulus (or stiffness) of all gels at cutting were generally similar as our cheesemakers started cutting the coagulum earlier in the higher solids milks. The rate of firming was considerably faster in the higher solids milks. In commercial cheese vats, it is more difficult to monitor coagulation and the cutting cycle is considerably longer than in our pilot-scale cheesemaking; both problems need to be addressed so as to successfully use higher solids cheesemilk with conventional cheesemaking equipment.

Key Words: Coagulation, Rheology, Ultrafiltration

608 Study of the effects of pH, temperature and NaCl on amino acid catabolic enzyme activities using quadratic response surface methodology. A.C. Curtin[1], M. De Angelis[2], M. Cipriani[2], M.R. Corbo[3], P.L.H. McSweeney*[1], and M. Gobbetti[4], [1]*University College, Cork, Ireland,* [2]*University of Perugia, Italy,* [3]*University of Foggia, Italy,* [4]*University of Bari, Italy*.

The objectives of this study were to screen cystathionine-β-lyase, cyctathionine-γ-lyase and L-methionine aminotransferase activities of lactococci, lactobacilli and coryneform bacteria and to determine the individual and interactive effects of temperature, pH and NaCl concentration on these enzyme activities which may have a role in flavour development during cheese ripening. A subcellular fractionation protocol and specific enzyme assays were used, and a quadratic response surface methodology was applied. The majority of the strains (21 of 33) had detectable cystathionine lyase activity the level of which varied between strains. L-Methionine aminotransferase activity was observed in only 3 strains. The cystathionine lyase activities of Lactobacillus reuteri DSM20016, Lactococcus lactis subsp. cremoris MG1363, Brevibacterium linens 10 and Corynebacterium ammoniagenes 8 and the L-methionine aminotransferase activity of Lb. reuteri DSM20016 had temperature and pH optima of 30-45C, and 7.5-8.0, respectively. As shown by quadratic response surface methodology, these enzymes retained activities in the range of temperature, pH and NaCl concentration characteristic of the cheeses from which the bacteria originated. The results of this study contribute to knowledge about the role of amino acid catabolic enzymes in flavour development in cheese during ripening.

Key Words: Amino Acid Catabolism, Cheese Flavour

609 Headspace analysis of volatile compounds in Monterey Jack goat milk cheese. R Attaie *[1], *Prairie View A&M University, Prairie View, TX*.

Samples of goat Monterey Jack cheese were used for analyses of volatile compounds on day 1 and at 6 week intervals for 30 weeks during aging. These cheeses were vacuum-packed and stored at 4 to 5C for sampling and aging. Triplicate 0.5 g samples of cheese were placed in 20 ml vials of headspace analyzer (HS 40XL, Perkin Elmer, Norwalk, CT) and heated at 120 C for 60 min while rotating. The needle temperature was kept at 120 C and the transfer line was set at 150 C. Samples were pressurized for 0.5 min prior to injection and the injection time was 0.1 min. Analyses were performed using a bonded polyethylene glycol fused silica capillary column (Supelcowax-10, 60 m x 0.32 mm i.d., 0.25-m coating thickness; Supelco Inc., Bellefonte, PA). Gas chromatography was performed with a model HP 5890 Series II (Hewlett-Packard, Avondale, PA) equipped with a flame ionization detector. Ultra-high purity helium at 1.5 ml/min and 30 ml/min was used as carrier and makeup gas, respectively. Ultra-high purity hydrogen (30 ml/min) and high purity air (400 ml/min) were used for flame ionization detector. Detector temperature was at 250 C, whereas the column oven temperature was increased from 40 to 220 C at 3 C/min after an initial hold at 40 C for 2 min. The peak areas of compounds from gas chromatographic responses were measured quantitatively by a model HP 3396 Series II integrator (Hewlett-Packard). Both the integrator attenuation and threshold were set at 2. The following volatile compounds that contribute to flavor of goat Monterey Jack cheese were identified: propionaldehyde, butanal, methanol, ethanol, pentanal, 2,3-butanedione, propanol, 2-hexanone, 3-ethyl-2-pentanone, butanol, 2-heptanone, pentanol, 3-methyl-2-pentanol, 3-hydroxy-2-butanone, hydroxy acetone, 2-nonanone, acetic acid, 2-decanone, 2,3-butanediol, butanoic acid, 2-methyl butanoic acid, pentanoic acid, hexanoic acid, heptanoic acid, octanoic acid, and nonanoic acid.

Key Words: Goat cheese, Flavoring compounds , Ripening

610 Effect of microbial exopolysaccharide on functionality in high moisture cheese. T. J. Singleton*[1], D. J. McMahon[1], J. R. Broadbent[1], and C. J. Oberg[2], [1]*Western Dairy Center, Utah State University,* [2]*Weber State University*.

Functional attributes of cheese such as shreddability and melt are dramatically affected by cheese moisture level. Previous work by our group has demonstrated that the addition of *Streptococcus thermophilus* MR1C, a strain that produces a large capsular exopolysaccharide (EPS^+), to cheese results in a significant increase in the cheese moisture level. The objectives of this study were to determine if the addition of MR1C could be used to improve shreddability in high moisture American style cheese. Stirred curd cheeses were manufactured to contain equivalent moisture levels using either MR1C (41.4 - 43.7% moisture) or a non EPS-producing (EPS^-) derivative of MR1C (40.5 - 44.4% moisture). The suitability of individual cheeses for shredding was determined by rheometry and texture profile analysis. Cheese firmness was determined after 1, 3, and 6 weeks of aging, then the cheese was shredded, and 3% (wt/wt) powdered cellulose was added to prevent caking. The cheese was packaged with a nitrogen gas flush, and melt properties were measured periodically. When cheeses with the same moisture content (i.e., 41.6 $\pm$ 0.2%) were compared over the 6 wks of storage, there was no overall significant affect on hardness although there was a significant week * culture interaction ($P = 0.026$) . The (EPS^+) cheese was softer at wk 1, then became harder at wk 3, but softened by wk 6. There was also a tendency ($P = 0.095$) for the (EPS^+) cheese to be less adhesive than the (EPS^-) cheese. There were no overall differences in elasticity or viscosity, and the cheeses melted to the same extent after 6 wks storage from when the cheese was shredded.

Key Words: Exopolysaccharide, Functionality, American style

611 Relationship between chemical, physical and sensory properties for pasta filata and stirred curd LMPS Mozzarella cheeses. C. M. Chen*, A. L. Dikkeboom, M. E. Johnson, and M. G. Zimbric, *Wisconsin Center for Dairy Research*.

Chemical (pH, TCA sol N) and physical properties (free oil release, melt profile) of LMPS Mozzarella (46.4.9% moisture, 42.8.9% FDM) were correlated to sensory characteristics. Descriptive taste panelists scored the degree of skinning (none to pronounced), chewiness (tough/chewy to tender/fluid), and preference (dislike to like) of cheese on pizza pies cooked in traditional and forced air ovens. Stirred curd Mozzarella tended to exhibit more skinning than pasta filata Mozzarella. In a traditional oven the degree of skinning remained constant (very slight, all ages). In a forced air oven, cheeses had an increased skinning after 10 d (slight to definite). For the stirred curd Mozzarella in a forced air oven there was a high correlation between the skinning and softening temperature (negative, $R^2 = .95$) and proteolysis (positive, $R^2 = .89$). Cheese chewiness was influenced by the age, manufacturing protocol, and to a lesser extent, oven type. Stirred curd Mozzarella was more fluid/tender than the pasta filata Mozzarella, and cheeses baked in a forced air oven tended to be more chewy. For stirred curd Mozzarella, softening temperature in the melt profile most highly correlated with the chewiness scores ($R^2 = .88$). For pasta filata Mozzarella, chewiness was most highly correlated to free oil release ($R^2 = .85$). Preference was influenced by the cheese age, but not manufacturing style or oven type. Cheeses were most preferred at 10 d, with stirred curd Mozzarella being slightly more liked than the pasta filata Mozzarella. The high preference scores can be attributed to lack of skinning, slightly tender/fluid chew characteristics and more acceptable strand formation. Using the linear relationship between chewiness scores and softening temperature, one can predict that if a stirred curd LMPS Mozzarella cheeses softens between 40.5 and 43.3C it will have acceptable performance on pizza pies. Similarly, pasta filata LMPS Mozzarella with free oil release between 43 and 48% (wt free oil release/wt cheese fat) will have acceptable performance on pizza pies.

Key Words: Mozzarella, physical properties, sensory analysis

612 Reversibility of pH-induced changes in the melting characteristics and calcium distribution of Mozzarella cheese. Q. Ge, M. Almena-Aliste, and P.S. Kindstedt*, *University of Vermont, Burlington, VT/USA*.

Previously a model system was developed to increase or decrease the pH of Mozzarella cheese through exposure to volatile ammonia or acetic acid, respectively. Changing the cheese pH in this manner caused large changes in the apparent viscosity and calcium distribution. The objective of this study was to evaluate whether these pH-induced changes are reversible. In the first experiment, representative samples of shredded low moisture part-skim Mozzarella cheese were exposed to ammonia to increase the pH by ca. 1.0 pH unit in 3 increments. After equilibration at 4°C for 24 h, the samples were analyzed for apparent viscosity and water soluble calcium. Next, the sample with the highest pH value was divided into representative subsamples and then exposed to acetic acid vapor to decrease the pH by ca. 1.0 pH unit (i.e., to the original cheese pH) in 3 increments. After equilibration at 4°C for 24 h, the subsamples were analyzed for apparent viscosity and water soluble calcium. This experiment was replicated 3 times with different batches of cheese. The second experiment was similar to the first except that the cheese pH was first decreased in 3 increments to ca. pH 4.7 and then increased. In the first experiment, increasing the cheese pH from ca. 5.3 to 6.3 resulted in linear increases in apparent viscosity and linear decreases in water soluble calcium. Upon reversal of cheese pH back to ca. 5.3, apparent viscosity decreased and water soluble calcium increased in linear manners, displaying high degrees of reversibility. In the second experiment, decreasing the cheese pH from ca. 5.3 to 4.7 resulted in nonlinear increases in apparent viscosity and water soluble calcium. Upon reversal of cheese pH back to ca. 5.3, apparent viscosity and water soluble calcium decreased in nonlinear manners, displaying high degrees of reversibility. Results indicate that the melting characteristics of Mozzarella cheese can be altered substantially and then restored by manipulating cheese pH and shifting calcium between the water soluble and casein-associated states.

Key Words: Mozzarella, Functionality , Calcium

ASAS Nonruminant Nutrition: Weaning Pig Nutrient Requirements

613 Effect of threonine supply on the true ileal digestibility of amino acids and on performance in weaned piglets†. L. Babinszky*, J. Tossenberger, P. Horn, and R. Kovcs, *University of Kaposvar, Kaposvar, Hungary*.

Weaned piglets were used in a trial aimed at determining the effect of threonine supply on true ileal digestibility of amino acids and piglet performance. Digestibility studies used a total of 8 animals per treatment, growth studies a total of 96 piglets per treatment, respectively. Initial live weight was 12.4±1.8 kg in the digestibility studies, and 7.8±1.0 kg in the growth study. Nutrient content of the wheat-barley-soybean based diets of different threonine levels complied with the NRC (1998) recommendations. One kg of the basal diet contained 13.4 MJ ME, 188 g CP, 12.2 g Lys, 8.5 g M+C and 6.2 g Thr. Endogenous amino acid excretion was determined in a separate trial group (n=8) by feeding N-free diets. In the digestibility studies we used three treatments (0, 1.3 and 2.1 g crystalline Thr per 1 kg feed), and six treatments in the growth studies (0, 0.42, 0.84, 1.26, 1.67, 2.09 g crystalline Thr per 1 kg feed). The diet chemical composition was determined in accordance with AOAC. Trial data were subjected to variance and regression analyses. Our results show that 586 mg/kg DM intake threonine was excreted in the endogenous protein. From non-essential amino acids, excretion rate of proline was highest (2321 mg/kg DM intake). The varying threonine supply did not affect the true digestibility of amino acids ($P \geq 0.05$), the digestibility of threonine, however, was improved significantly ($P \leq 0.05$). Based the regression analysis and performance studies data the true ileal digestible threonine content for weaned piglets (8 to 30 kg) can be recommended at 6.6 g per kg of diet, which corresponds to a true ileal digestible threonine to lysine ratio of 62:100.

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Key Words: Threonine, Piglets, Digestibility