to unselected controls (CO). The selection line had an increase of 3.0 corpora lutea (CL) and an increase of 0.3 pigs in total litter size as compared to controls. DNA was collected from 262 CO and 258 OR gilts and boars at generations 12 and 13. Six microsatellite markers, including two utilized in validation of the QTL, that spanned from 69cM to 96cM were genotyped. Utilizing SAS/Genetics, the marker which had showed the most significant (P<0.001) divergence between OR and CO lines was SW1041 (69cM). Significant differences (P<0.001) of SW1041 alleles on CL were identified with a model including allele, line, year born, season born, and sire as a random effect. The most frequent SW1041 allele in the OR line was associated with the second largest CL mean. Two markers (SWR1829, SW951) had the most frequent OR allele associated with greatest CL mean. An additional two markers (MRC1MS, GAD2) had an increase in the frequency of the OR line allele, compared to CO, which was associated with greatest CL mean for the marker. These data indicate that the divergence in allele frequencies on SSC10 between the OR and CO lines is likely due to a CL QTL and they refine the region in which a CL QTL is located. The selection line will be useful to identify genetic markers and causative genes for use in the industry.

Key Words: Swine, Fine Mapping, Ovulation Rate

362 Genetics of immune response in Canadian dairy cows and potential use in selection. R. Rupp[1], A. Hernandez[1], F. Miglior*[2,3], and B. Mallard[1], [1]*Ontario Veterinary College*, *Guelph, ON, Canada*, [2]*Agriculture and Agri-Food Canada - Dairy and Swine Research and Development Centre*, *Lennoxville, QC, Canada*, [3]*Canadian Dairy Network*, *Guelph, ON, Canada*.

In the last years selection goals for dairy cattle have evolved worldwide, with increasing interest for functional traits and special attention given to resistance to disease. As an alternative or complement to various indirect traits, improving immune response of animals is a promising mean to increase broad based resistance to disease. Recent progress has enabled characterization of both antibody (AMIR) and cell mediated (CMIR) immune responses, two complementary traits that indicate the general immune ability of the host. AMIR can be measured as serum concentration of specific antibody after immunization with an inert antigen. In addition, a delayed type hypersensitivity test based on the increase in skin-fold thickness following injection with test antigens has been developed to characterise CMIR. Accordingly, AMIR and CMIR were measured in 127 cows in an experimental farm. Heritability of CMIR varied from 0.27 to 0.50, showing a large genetic determinism of this trait although standard errors were high. Heritability of AMIR, relationships between both immune response traits and relationships with production traits are in progress. The indirect response of the selection based on the Canadian Lifetime Profitability Index (LPI) on both immune traits has been evaluated and showed that AMIR and CMIR may be deteriorating under current selection if their genetic correlations with protein and fat are antagonistic. A simulation study is in progress in order to assess the desirability, feasibility and modality of including AMIR and CMIR in an health index (as an alternative or together with other indirect traits such as somatic cell counts) to improve resistance to mastitis and other diseases.

Key Words: Disease Resistance, Immune Response, Genetic Parameters

363 Electrical conductivity of milk are genetically correlated to mastitis. E. Norberg*[1], G. W. Rogers[2], J. B. Cooper[2], and P. Madsen[1], [1]*Department of Genetics and Biotechnology, Danish Institute of Agricultural Sciences*, *Tjele, Denmark*, [2]*University of Tennessee*, *Knoxville*.

Electrical conductivity (EC) of milk was introduced as an indicator of mastitis several decades ago. Until now EC has solely been used for detection of bovine mastitis on the phenotypic level. However, EC may, if it shows genetic variation and is genetically correlated to mastitis, be used as an indicator trait in a breeding program. In this study, daily measurements of EC and mastitis on ~ 1500 first lactation Holstein cows, sired by 125 bulls, from 4 herds in Florida were used to estimate genetic parameters for EC and its relationship to mastitis. Electrical conductivity was measured in millimho (mmho) in composite milk from every milking with the Afikim computerized milking and management system (SAE Afikim, Kibbutz Afikim, Israel). Udder health status (mastitis or no mastitis) was recorded every day from DIM 6 to the last day of lactation. A bivariate analysis was carried out using a linear animal model with repeated measurements. Age at first calving, herd-test-day and DIM were included as fixed effects. Electrical conductivity was modeled with a constant additive genetic effect and a permanent environmental effect as a forth-order Legendre polynomial along the lactation trajectory. For mastitis, a simple repeatability model without random regressions was used. The permanent environmental variance of EC and mastitis was assumed to be uncorrelated. For EC, the estimated heritability ranged between 0.22 and 0.39 during the lactation. For mastitis, the heritability was as expected low (0.013). The genetic correlation between EC and mastitis was estimated to be 0.75, with a standard error of 0.13. These results show that electrical conductivity of milk has a high genetic correlation to clinical mastitis, and therefore has potential as an indicator trait in breeding programs were selection against mastitis is included.

Key Words: Dairy Cow, Electrical Conductivity, Mastitis

Dairy Foods: Cheese I—Cheddar, Mozzarella, and Kashar Cheeses

364 Effects of incorporation of probiotic *Lactobacillus acidophilus*, *Lb. casei*, *Lb. paracasei* and *Bifidobacterium* spp. on proteolytic patterns and production of organic acid in Cheddar cheese. L. Ong[1], A. Henriksson[2], and N. P. Shah*[1], [1]*Victoria University*, *Werribee Campus, School of Molecualr Sciences, PO Box 14428 melbourne City MC, Vic 8001 Australia*, [2]*DSM Food Specialties*, *Moorebank, NSW, Australia*.

Our objectives were to study i) the survivability of probiotic organisms in Cheddar cheeses and ii) the influence of these organisms on proteolytic patterns and production of organic acid.

Three types of Cheddar cheeses were made with lactococci starter (control) and a combination of probiotic bacteria. Probiotic, starter and non-starter lactic acid bacteria were enumerated using selective media. The compositional analysis was carried out as per AOAC. Concentration of organic acid was analysed using HPLC. Proteolytic patterns were examined using SDS-PAGE and soluble nitrogen method.

All probiotic adjuncts survived manufacturing process and maintained viability of >7.5 log10 CFU/g at the end of ripening for 6 months at 4°C. Lactococci counts decreased by one to two log cycles. No significant differences (P>0.05) were observed in fat, protein, moisture and salt contents, but acetic acid concentration was higher in probiotic cheeses. Primary proteolysis was not significantly different (P>0.05) between cheeses, but secondary proteolysis as indicated by concentration of free amino acids was significantly higher (P<0.05) in probiotic cheeses. Hydrolysis of casein after 6 months of storage was higher in probiotic cheeses with preference over α_s-CN than β-CN. As the concentrations of casein decreased, levels of lower molecular weight breakdown products of the caseins increased. Proteolytic activity, however, remained low for all cheeses.

Our results indicated that the addition of probiotic microorganisms in Cheddar cheeses increased proteolytic activity and changed flavour profile. Results also demonstrated that Cheddar cheese can be an effective vehicle for delivery of some health-promoting bacteria to the consumer.

Key Words: Probiotics, Proteolytic Patterns, Cheddar Cheese

365 Influence of calcium, phosphorus, residual lactose, and salt-to-moisture ratio (S/M) of Cheddar cheese on proteolysis during ripening. P. Upreti, P. S. Lehtola, and L. E. Metzger*, *University of Minnesota*, *St. Paul*.

Proteolysis in cheese is influenced by the state of proteins (protein-calcium-phosphate interactions), level of indigenous milk enzymes (plasmin), externally added milk-clotting enzymes (chymosin), and endogenous and exogenous enzymes from starter and non-starter lactic acid bacteria (NSLAB). The objective of this study was to determine how different levels of Ca and P, residual lactose, and S/M in cheese influences proteolysis during ripening. Eight cheeses with two levels of Ca and P (0.67 and 0.47% vs 0.53 and 0.39%), lactose at pressing (2.4 vs 0.78%) and S/M (6.4 vs 4.8%) were manufactured. The cheeses were analyzed for changes in pH-4.6 soluble-N, starter and NSLAB counts during 48-wk of ripening. Starter bacteria and NSLAB counts were measured by plating appropriate dilutions of cheeses on Bacto-Elliker and LBS agars respectively, and incubating at 30°C for 48h under aerobic and anaerobic conditions respectively. Cheeses at d1 were also analyzed for residual chymosin activity. A significant increase ($p<0.05$) in soluble-N was observed during ripening for all the treatments. Cheeses with low Ca and P, low lactose, and low S/M treatments exhibited higher levels of proteolysis ($p<0.05$) as compared to their corresponding treatments. Differences in the rate of proteolysis for cheeses with different levels of Ca and P were partly attributed to differences in residual chymosin in the cheeses. Cheeses with low Ca and P were manufactured by lowering the pH at set and drain, which led to a higher chymosin retention in cheeses with low Ca and P as compared to high Ca and P ($p<0.05$). All cheeses had a similar number of starter bacteria (~10^{10} cfu/g) in cheese curds before salting; which decreased significantly during ripening ($p<0.05$). However, the decrease was larger in the case of high S/M treatments as compared to low S/M treatments ($p<0.05$). In contrast, the number of NSLAB increased during ripening, and cheeses with low S/M had higher counts as compared to high S/M ($p<0.05$). Hence, differences in proteolysis due to S/M may be partially due to differences in the starter/NSLAB counts.

Key Words: Proteolysis, Cheese Ripening

366 Moisture retention and salt uptake in Cheddar curds made from milk preacidificed with carbon dioxide: a possible solution to the salt whey problem. B. Nelson* and D. Barbano, *Cornell University*, *Ithaca, NY*.

The high salt (NaCl) content of salt and press whey limits utilization of these cheese by-products. Consequently, these by-products become part of the plant effluent routed to a waste treatment facility. The salinity, fat content, and biological oxygen demand make these costly by-products. Decreasing or eliminating salt and press whey would be beneficial to the industry and the environment. Preacidifying milk with CO_2 before making cheese effectively decreased the loss of moisture during salting and pressing and increased the salt uptake. Salt uptake was enhanced so much that 29% less salt was added to the curds of the CO_2 treatment than the control while a similar salt content in the cheese was achieved. The salting rate of the CO_2 treatment was only 2.0% of the curd weight while our control salting rate was 2.8% of the curd weight. The salt contents of the CO_2 and control cheeses after 17 h of pressing was 1.71 and 1.68%, respectively. The total salt for the control and treatment was added in three equal portions. Not only was the moisture content of the control unsalted milled curd higher, but the curd lost more moisture after each salting than the CO_2 treatment curd. During the first 5 h of pressing, the control cheese lost more moisture than the CO_2 cheese. Because of the greater moisture loss of the control cheese the cheese had lower moisture (35.04%) than the CO_2 cheese (37.29%) and a higher salt in the moisture. The ability of the CO_2 cheese to retain moisture was also observed with less expressible serum being obtained from the curds and cheeses of the CO_2 treatment. Casein in the water phase appears to be the reason why the CO_2 treatment curd and cheese better retain moisture and have enhanced salt uptake. Salt and press whey will be reduced if cheese is manufactured from milk preacidified with CO_2.

Key Words: Cheese, Salt, Whey

367 Mathematical modeling of buffering properties of Cheddar cheese. P. Upreti*[1], P. Buhlmann[2], and L. E. Metzger[1], [1]*University of Minnesota*, *St. Paul,*, [2]*University of Minnesota*, *Minneapolis*.

The buffering capacity of cheese is an important determinant of cheese pH. It depends on several compositional factors including proteins, colloidal calcium phosphate (CCP), inorganic phosphate, and weak organic acids. The objective of this study was to quantitatively characterize the chemical species responsible for buffering properties of cheese. Eight cheeses with two levels of Ca and P (0.67 and 0.47% vs 0.53 and 0.39%), lactose at pressing (2.4 vs 0.78%) and salt-to-moisture ratio (6.4 vs 4.8%) were manufactured. The cheeses were analyzed for total Ca and P, proteins, water-soluble P, organic P, citric acid, and lactic acid. Titration curves were made by titrating cheese:water mixtures with HCl to reach pH 4.0 and subsequently adding NaOH to reach pH 8.5. To model buffering curves, 40 species were identified. These species can be classified into the following categories: free and protein-bound amino acids that have a pKa in the range of 4 to 8.5, acids (phosphoric, lactic, citric), complexes (phosphate, citrate, and lactate complexes of Na, Ca and Mg), and precipitates of Ca and Mg. The 40 corresponding equilibrium equations with known constants and measured parameters were solved to calculate the effect of pH on the concentration of the 40 species. The experimental and predicted buffering curves were divided into 3 regions (pH 4 to 5, 5 to 6, and 6 to 8) and compared. The mathematical model suggests that buffering in the pH range of 4 to 5 is predominantly due to protein-bound glutamate and aspartate, and lactic acid in the cheese. Buffering in the region from pH 5 to 6 is due to a precipitate of $Ca_3(PO_4)_2$. This is consistent with the observation that cheeses with high Ca and P had higher buffering capacity in this region as compared to cheeses with low Ca and P. Bufffering in the pH range from 6 to 8 was observed when cheeses were made alkaline with NaOH after the initial acidification to pH 4. Model suggests that the buffering peak in this region is partially due to protein-bound histidine and serinephosphate. In addition, there appears to be an additional component from kinetically delayed $Ca_3(PO_4)_2$ precipitation.

Key Words: Cheese, Buffering

368 Effect of emulsifying salts on the state of calcium in pasteurized process Cheddar cheese. N. Shirashoji*[1,2], J. J. Jaeggi[2], and J. A. Lucey[2], [1]*Food Research & Development Laboratory, Morinaga Milk Industry Co.*, *Kanagawa, Japan*, [2]*University of Wisconsin*, *Madison*.

The amount of calcium associated with casein plays an important role in modifying the physical properties of cheese. However, there has been little research on the impact of different types of emulsifying salts (ES) on the state of calcium in process cheese. Pasteurized process cheeses were made from 4 mo old Cheddar cheese and trisodium citrate (TSC) and sodium hexametaphosphate (SHMP) (concentrations of ES ranged from 0.25-2.75%) were used as ES. Cheese was heated at 80°C for various holding times (0-20 min) using a Blentech twin-screw cooker. Hot melted cheese was poured into pouches and stored at 5°C for 7 d. The pH value of all cheeses was maintained at pH ~5.6. Serum phase of process cheese was extracted from cheese dispersions by ultrafiltration (5kDa cut-off) and concentration of calcium in this was called soluble calcium. Small amplitude oscillatory shear were used to determine the rheological properties of process cheese. Melting properties were analyzed using UW Melt profiler (degree of flow, DOF) and Schreiber test. Acid-base titrations were used to determine the state of calcium phosphate. Storage modulus increased as concentrations of ES increased in process cheese made with TSC or SHMP. Bound calcium increased as the concentrations of ES increased for both ES. Loss tangent values at 40 °C were positively correlated with DOF and Schreiber melt area ($r > 0.83$). Bound calcium was negatively correlated with loss tangent value at 40 °C and Schreiber melt area ($r > 0.63$). Titration curves of cheese made with TSC had a smaller buffering peak at pH ~$4.8 (which was caused by residual CCP) and an increase in buffering peak at pH ~3.8. The buffering peak at pH ~$4.8 shifted to a lower pH value with increasing concentration of added SHMP. This study indicated ES may not only chelate calcium but may form different types of calcium bridges in cheese systems that may influence the physical properties of process cheese.

Acknowledgements: Morinaga Milk Industry Co.

369 Use of cold microfiltration retentates for standardization of milks for pizza cheese: Impact on yield and functionality. S. Govindasamy-Lucey*, J. Jaeggi, M. Johnson, T. Wang, and J. Lucey, *University of Wisconsin*, *Madison*.

Non pasta-filata mozzarella (pizza) cheese was manufactured with milk (12.1% TS, 3.1% casein, 3.1% fat) standardized with cold microfiltered (MF) retentates. Non-ceramic MF membranes were used to process cold (<7°C) skim milk. MF and diafiltration resulted in at least ~35% of serum protein removal from the MF retentate. Cheesemilks were obtained by blending MF retentate (16.4% TS, 11.0% casein, 0.4% fat) with whole milk (12.1% TS, 2.4% casein, 3.4% fat). Control cheese was made with partially-skimmed milk (10.9% TS, 2.4% casein, 2.4% fat). Initial trials with MF fortified cheeses resulted in ~ 2-3% lower moisture (45%) than control cheese (~47-48%). Procedures were then altered to obtain similar moisture content in all cheeses. Two types of MF cheeses were produced; one with pre-acidification of milk to pH 6.4 (pH6.4MF) and another made from milk pre-acidified to pH 6.3 (pH6.3MF). Moisture content of MF cheeses was increased by using lower setting temperature, increasing curd size and lower wash water temperature. Cheese functionality was assessed using dynamic low-amplitude oscillatory rheology (DLAOR) and performance on pizza. The coagula were cut at the same firmness. Use of lower pre-acidification pH resulted in shorter coagulation time. Nitrogen recoveries were significantly higher in MF fortified cheeses. Fat recoveries were highest in the pH6.3MF cheese than the control or the pH6.4MF cheese. Moisture-adjusted cheese yield was significantly higher in the two MF-fortified cheeses. Maximum loss tangent (LTmax) values (from the DLAOR test) were not significantly different in the three cheeses and the LTmax value increased during ripening. Temperature for LTmax was highest in control and was lower in pH6.3MF cheese than pH6.4MF cheese. Temperature for LTmax decreased with age for all three cheeses. TCA-soluble nitrogen levels were similar in all three cheeses. Performance on pizza was similar for all cheeses.

Key Words: Cheese Yield, Texture, Functionality

370 The effect of cheese temperature on the texture and shredding of mozzarella. K. Lim*, A. Bostley, and C. Chen, *Wisconsin Center for Dairy Research*, *Madison, WI.*

For mozzarella the primary texture attributes related to acceptable shredding are firmness and adhesiveness. The firmer and less adhesive the mozzarella, the higher the Shred Grade (an indicator of shredded cheese quality). The objective of this study was to investigate if decreasing the cheese temperature at shredding would lead to higher shred quality. Mozzarella was manufactured at the WI Center for Dairy Research using a typical manufacturing methods, stored at 7.2°C and then tempered to -1.1, 1.7, 4.4 and 7.2°C prior to shredding and texture evaluations. Cheeses were shredded using an Urschell CC-D shredder and texture evaluated at 2 and 6 weeks of age. Shredded cheese quality was determined by Shred Grade which is derived from shredded cheese size distribution, size measurements and characteristics. The texture attributes of firmness and adhesiveness were determined using the Sensory Spectrum method (15-point product-specific reference scale, 11 trained panelists). Data were statistically analyzed using ANOVA. We observed a significant difference in firmness as cheese temperature decreased for 2 and 6-week old mozzarella. No differences were noted in the adhesiveness of cheeses at the temperatures evaluated. Although lowering cheese temperatures resulted in a firmer cheese, this did not guarantee greater shredded cheese quality. For 2-week old mozzarella, the cheeses shredded at lower temperatures (which were firmer) had significantly higher Shred Grade scores. At 6 weeks, cheese shredding quality did not differ with shredding temperature (even though cheese firmness did). Shredded cheese quality decreases at sensory adhesive scores above 5. The mean adhesive scores were 5.4 and 6.8 for 2 and 6 week old cheeses respectively. Authors speculate that at 2 weeks, shredded cheese quality increased with decreasing temperature due to the firmer texture and adhesive scores that did not surpass 5. At 6 weeks, adhesiveness values surpassed the critical value 5, thus overriding any benefits of a firmer texture.

Key Words: Mozzarella, Shredding, Texture

371 The use of fat replacers in low-fat fresh kashar cheese: composition, proteolysis and yield. N. Koca*[1,2] and M. Metin[1], [1]*Ege University*, *Izmir, Turkey*, [2]*The Ohio State University*, *Columbus*.

Kashar cheese is a semi-hard cheese produced by heating and stretching its curd and is one of the most consumed cheeses in Turkey. It is classified as fresh and mature in terms of ripening level. The low-fat fresh kashar cheeses (about 70% fat reduction) were produced by using two protein-based fat replacers (1.0% w/w Simplesse®D-100 and 1.0% w/w Dairy-Lo™) and one carbohydrate-based fat replacer (5.0% w/w Raftiline®HP) in order to determine their effects on the composition, proteolysis and yield. Cheese samples were analyzed for yield on the 1st day, for composition on the 7th day and for proteolysis on the 1st, 7th, 30th, 60th and 90th days of storage. Full-fat and low-fat cheeses were also produced as control. The moisture contents of the cheeses made with fat replacers were significantly higher than those of the low fat control cheese whereas protein contents were significantly lower ($P<0.01$). Although all fat replacers significantly increased the value of moisture in non-fat substance (MNFS) and the yield of cheese ($P<0.01$), the MNFS value for low fat cheese with Simplesse®100 (63.43%) was higher than that of full fat cheese (63.28%) and the yield (8.08%) was similar to that of full fat cheese (8.09%). About a 70% fat reduction for the low-fat control cheese resulted in a 24% decrease in yield compared to the full fat cheese. The use of Simplesse®100 and Raftiline®HP increased the water-soluble nitrogen content ($P<0.05$) whereas Dairy-Lo™ had no significant effect ($P>0.05$). However, the 12% TCA soluble nitrogen content was not significantly affected by using fat replacers ($P>0.05$). One of the most important strategies for improving the functional properties of low fat cheese is to increase its moisture content sufficiently to provide a moisture to protein ratio or MNFS value that is equal to or higher than its full fat counterpart. As a result, the use of Simplesse®100 for the production of low-fat fresh kashar cheese was found technologically the most successful due to its ability to increase both the moisture content and yield of cheese.

Key Words: Low Fat Cheese, Kashar, Yield

Extension Education: Cow Comfort on Commercial Dairy Operations

372 Maximizing cow comfort on dry lot dairies. D. Armstrong*[1], J. Smith[2], and M. VanBaale[1], [1]*University of Arizona*, *Tucson*, [2]*Kansas State University*, *Manhattan*.

Dry lot dairy farms are frequently built in hot semi-arid climates where in the summer months they experience 30 to over 150 days of heat stress annually. Although most of these areas experience low annual rainfall (less than 38 cm.), moisture can restrict dry lying area for animals. Corrals need to have a 2 to 2.5% slope to provide adequate drainage and depending upon the annual evaporation rate, an area of 46 to 70 sq. m/cow. To provide adequate cow comfort, corrals need to be maintained by removing excessive dry manure from the corral. The excess dry manure needs to be removed several times a year depending on when rain or snow is expected. Walking distance of cows from the corral to the milking parlor should be minimized in the dairy design. Observations in hot weather indicate one-way lane walking distances from the corral to the milking parlor should be less than 365m for 2X milking, 274m for 3X milking, and 183m for 4X. Methods of reducing heat-stress in different parts of the dairy farm will depend upon the number of heat-stress days in the area where the