155 Development of a selection index for the Reggiana dairy cattle breed. M. Fioretti[1], V. Palucci*[1], and F. Miglior[2], [1]*Associazione Italiana Allevatori, Rome, Italy,* [2]*Agriculture and Agri-Food Canada, CDN, Guelph, ON, Canada.*

The Reggiana population is a dairy cattle breed reared in the province of Reggio Emilia, located in the Italian Po Valley. Milk from this breed has been mainly used for the production of Parmigiano Reggiano cheese. The Reggiana breed has shrunk from 84,000 cows in 1940 to 200 animals in 1984, having being replaced by much more productive Holstein-Friesian cows. Thanks to government support the breed was recovered in the last two decades, and currently close to 1000 cows are milk recorded. Selection has been based mainly on milk yield and produced moderate genetic progress for production (60 kg milk/yr, 2.5 kg fat/yr and 1.5 kg protein/yr) and phenotypic and genetic decrease for protein percent. In order to invert the negative genetic trend for protein percentage, unsuitable for Parmigiano Reggiano production, a selection index was developed that accounted for milk price for cheese production. The new index with economic weights of -26%, +7% and +67% emphasis for milk, fat and protein yield respectively, was found to increase protein percentage 10-yr genetic progress, and to greatly increase protein yield genetic progress (3.3 kg/yr), leaving milk and fat yields at current levels (61 kg milk/yr and 2.5 kg fat/yr).

Key Words: Dairy cattle, Selection index

156 Analyses of heat tolerance for milk in Holsteins using different sources of heat-stress information. I. Misztal*, S. Oseni, and S. Tsuruta, *University of Georgia, Athens, GA, USA.*

The purpose of this study was to evaluate parameters of alternative models for analysis of test day milk under various levels of heat stress. Data included 81,674 first parity milk test days on 10,162 cows in FL. Also available were daily temperature-humidity indices (THI) from public weather stations in FL. Models included the effects of herd-test day, age class, days in milk class, frequency of calving, and additive and permanent environment implemented as linear random regressions. Models differed by the choice of covariables used in random regressions. The choices were: a) THI during the test day measured at the nearest public weather station, b) average THI across all weather stations for the month of test day, and c) solutions of month of test-day computed in a fixed model. The last model would correspond to a norm reaction model. Lowest production in models a) and b) corresponded to July, and lowest production in model c) corresponded to August-September. Constant terms in the random regression could be interpreted as regular effects, and linear terms as heat-tolerance effects. Genetic correlations between the constant and linear additive effects were -0.42 for a), -0.46 for b), and -0.76 for c). Correlations between additive effects in a) and b) were 0.96 (regular) and 0.94 (heat-tolerance). The same correlations in a) and c) were 0.95 and 0.56. Genetic variance for the heat-tolerance effect corresponding to the peak of heat stress was 20% higher for c) than for b). For genetic analyses of heat tolerance, average monthly THI per state provided comparable information to daily THI from nearby weather stations. The heat tolerance effect in the norm reaction model accounts not only for the effect of heat stress due to current THI, but also for additional factors such as accumulated effects of heat stress or varying forage quality over time.

Key Words: Dairy cattle, Heat stress, Random regression

157 Comparison of Holstein, Holstein-Jersey crossbred, and Holstein-Normande crossbred first-parity cows for milk, fat, and protein production and SCS during the first 150 days of lactation. B. J. Heins[1], L. B. Hansen*[1], and A. J. Seykora, [1]*University of Minnesota, St. Paul.*

First-parity Holsteins (n = 247), Holstein-Jersey crossbreds (n = 97), and Holstein-Normande crossbreds (n = 68) were compared for milk, fat, and protein production and SCS during the first 150 days of lactation. Cows were housed in six commercial dairies in California and calved from June 2001 to December 2002. Dependent variables for analysis were test-day observations from DHI. Independent variables were breed composition (H, HxJ, HxN), random effect of cow within breed composition, stage of lactation (4-30 d, 31-60 d, 61-90 d, 91-120 d, or 121-150 d), herd (1 to 6), milking frequency (2X or 3X), and interaction of breed composition and milking frequency. Breed composition was significantly different for milk and fat production and approached significance for protein production; however, there was not a significant difference of breed composition for SCS. Least-squares means for test-day milk production were 32.7 kg (H), 30.3 kg (HxJ), and 29.1 kg (HxN). For test-day fat production, least-squares means were 1.13 kg (H), 1.20 kg (HxJ), and 1.09 kg (HxN). Least squares means for protein production were 0.96 kg (H), 0.95 kg (HxJ), and 0.93 kg (HxN). Although not significantly different, least squares means for SCS were 2.3 (H), 2.8 (HxJ), and 2.5 (HxN).

Key Words: Crossbreeding, Production, SCS

Dairy Foods: Processed cheese, milk powder, and microbiology

158 Comparison of pilot-scale and RVA process cheese manufacture. L. E. Metzger*, P. Lehtola, and R. Kapoor, *MN-SD Dairy Foods Research Center, University of Minnesota, St. Paul, MN.*

Numerous formulation and processing parameters influence the functionality of process cheese. Consequently it is sometimes difficult to predict the functionality of process cheese based on the formulation used. However, a small-scale manufacturing and analysis method could be used to evaluate the influence of formulation parameters on the functionality of process cheese. The objective of this study was to compare process cheese produced on a small scale (20 g) in a Rapid Visco Analyzer (RVA) to process cheese produced on a pilot-scale (4.5 kg) Blentech twin screw (BTS) cooker. Three different formulation of process cheese (PC) and process cheese food (PCF) were produced in a RVA and in a BTS cooker. Each formulation was produced in triplicate in the RVA and in duplicate in the BTS cooker. In the RVA the temperature of the heating block was maintained at 80°C and the stirring speed was sequentially increased from 0 rpm to 500 rpm in two minutes. The RVA was stopped 1 min or 2 min after an increase in viscosity was observed for the short and long manufacturing profiles respectively. In the BTS cooker each formulation was heated to 80°C in 3 min and held an additional 4 min. A screw speed of 120 rpm or 140 rpm was used for the PC and PCF respectively. Texture profile analysis (TPA) and the RVA melt test were performed on all PC and PCF produced. The formulation used had a significant ($P<.05$) effect on the TPA hardness, hot viscosity, and melt time of the PC and PCF produced in the RVA and in the BTS cooker. However, the PC and PCF produced in the RVA had a significantly ($P<.05$) higher TPA hardness and melt time as compared to PC and PCF produced in the BTS cooker. The RVA manufacturing time (short vs long) did not have a significant ($P>.05$) effect on any parameter for the PCF. However with the PC, the long manufacturing time significantly ($P<.05$) increased hot viscosity and melt time. Future research will focus on identifying RVA manufacturing profiles that produced PC and PCF that matches the functionality of process cheese produced on a pilot scale.

Key Words: Process Cheese

159 Salt whey ingredient. V. V. Mistry* and M. R. Acharya, *South Dakota State University.*

A method for manufacturing a salt whey ingredient (SWI) was developed (patent pending). Approximately 110 of kg salt whey was obtained for each of three replicates from salted curd that had been placed in barrels for draining and separated by centrifugal separation at 35°C. The skimmed salt whey was pasteurized at 63°C for 30 min, cooled to 20°C and condensed in a rising-film single-stage evaporator. The concentrate was spray dried in a single-stage spray drier to 3.3% moisture, 1.97% fat, 10.1% protein, 40.1% salt and 39.8% lactose and used in the manufacture of pasteurized process cheese and cheese spreads. The pasteurized process cheese formulations consisted of a blend of young (1- to 2-mo old) and aged (4- to 6-mo old) Cheddar cheese in equal proportions as follows: control pasteurized process cheese; control with no emulsifier; cheese with 2% SWI; cheese with 1.7% SWI but no emulsifier. For the cheese spread there were two formulations: control Provolone cheese

spread; and Provolone cheese spread with SWI. For cheeses with emulsifier 3% disodium phosphate duohydrate was used. The targeted salt (NaCl) content was 2%. All cheeses were manufactured using a single-auger lay-down cooker with direct steam injection and a batch size of up to 15 kg, packaged in 2-kg containers, sealed and stored upside down at 4°C. Pasteurization was at 74°C for 2 min. All pasteurized process cheeses contained approximately 42% moisture. Cheeses with the SWI were smoother than those without. Cheeses with the SWI but without emulsifier exhibited excellent stretch properties. The pH of cheeses without emulsifier was lower (5.8) than those with emulsifier (6.1) and the SWI had no impact on pH. Cheeses with the SWI and without emulsifier melted more (70 mm) than the corresponding control (64 mm) but the former released more free oil. There were no differences in hardness among cheeses with emulsifier but in the absence of emulsifier, the cheeses with added SWI were softer (10.5 kg) than the controls (15.5 kg). The spreads averaged 57% moisture and the composition of the control and SWI cheeses was similar. The flowing and melting characteristics of cheese with SWI were excellent.

Key Words: Salt whey, Drying, Cheese

160 Comparison of the melting properties of process cheese using a Rapid Visco Analyzer (RVA) and the Schreiber melt test. L. A. Rosenberg* and L. E. Metzger, *MN-SD Dairy Food Research Center, University of Minnesota, St. Paul, MN.*

The melt characteristics of process cheese are an important functional attribute. Currently, there remains a need for a fast, accurate and low cost test to evaluate cheese meltability. The objective of this study was to determine if the RVA melt test could distinguish differences between commercial process cheese samples and to compare this test to the Schreiber melt test. The melt properties of fifty-five commercial process cheese samples from four different manufacturers were analyzed with the RVA and Schreiber melt test. Three replicates using the RVA and five replicates using the Schreiber melt test were performed. In the RVA melt test 15 g of ground cheese and 1 g of propylene glycol were used. The sample was subjected to a heat, holding, cooling profile during continuous mixing, and an apparent viscosity vs. time graph was obtained. The melt time, hot viscosity and solidification time were determined from each apparent viscosity vs. time curve. In the Schreiber melt test, samples with a 34 mm dia. and 7 mm height were placed into a forced draft oven at 100°C for 7 minutes. After removal from the oven the diameter was measured. The RVA melt test had a lower coefficient of variation and of the 55 samples analyzed six had a CV greater than 5 whereas with the Schreiber melt test 50 of the 55 samples had a CV greater than 5. There was low correlation (<.50) between the Schreiber melt test and the individual RVA parameters. Additionally the correlation varied substantially depending on the manufacturer. The lack of correlation between the Schreiber melt test and individual RVA parameters maybe a result of the high CV observed with the Schreiber melt test. Also eight of the samples analyzed had a low Schreiber melt value (< 38 mm) and could not be distinguished, whereas these samples had significantly (P<.05) different RVA melt parameters. These results indicate that the RVA may be a more sensitive technique for measuring meltability as compared to the Schreiber melt test.

161 Effect of rice bran oil as a natural antioxidant on the storage stability of whole milk powder. L. F. Osorio*[1], J. U. McGregor[2], J. S. Godber[3], and N. Y. Farkye[4], [1]*Escuela Agrcola Panamericana, Zamorano, Tegucigalpa, Honduras,* [2]*Food Science and Human Nutrition Dept., Clemson University, Clemson, SC,* [3]*Food Science Dept., LSU Ag Center, Baton Rouge,* [4]*Dairy Products Technology Center, California Polytechnic State University, San Luis Obispo, CA.*

As the world economic conditions continue to improve, the demand for whole milk powder (WMP) will continue to increase. There is a need to increase production of WMP to satisfy the U.S. market and enhance potential for export. Autoxidation drastically reduces the shelf life of WMP due to the production of off flavors and odors. The objective of this study was to evaluate the use of rice bran oil (RBO) containing 5 percent oryzanol as an antioxidant in WMP produced using commercial and pilot scale spray drying systems. WMP was obtained by three different drying technologies; commercial spray, pilot spray and pilot pulse. RBO at 0.1 percent w/w of the original milk was added before and after drying in pilot pulse and pilot spray drying and after drying in commercial spray drying. Samples were stored at 45°C for 50 days in an incubator to accelerate oxidation. Samples were tested every 10 days for oxidation progress. RBO proved to be an effective antioxidant regardless of drying method and regardless if RBO was added before or after drying. RBO significantly slowed oxidation as shown by TBARS, peroxide value, and hexanal production. Significantly lower concentrations of malonaldehyde (mg/kg) were obtained when RBO was added before drying, compared to RBO added after drying. Trained sensory panelists were not able to detect the presence of RBO added before or after drying. Small levels of RBO addition have the potential to extend the shelf-life and functional properties of high fat containing milk powders by acting as an antioxidant.

Key Words: Whole milk powder, Oxidation, Rice bran oil

162 Flavor stability of skim and whole milk powder. M. E. Carunchia Whetstine*, M. A. Drake, Y. Karagul-Yuceer, and Y. K. Avsar, [1]*North Carolina State University.*

Skim and whole milk powder (SMP, WMP) are widely used as food ingredients and for direct consumption. Since milk powders may be stored, flavor stability and changes in flavor profiles during storage can impact quality and saleability. Hexanal concentrations have been used to follow quality degradation in milk powders. However, specific sensory changes and other volatile compound changes during storage are not well-characterized. The objectives of this study were to characterize flavor changes in SMP and WMP throughout 1 year storage at 21C using sensory and instrumental methods. Composite 25 kg commercially packaged samples of SMP or WMP (2 bags each) were collected from four different production locations. Powders were shipped overnight and received within 48 h of production. Flavor of rehydrated milk powders was characterized every three months by sensory and instrumental methods. Descriptive sensory analysis (n=7) was used to determine flavor profiles of the milk powders. Solid phase microextraction (SPME) and solvent extraction with high vacuum distillation in conjunction with gas chromatography-olfactometry and gas chromatography-mass spectrometry were used to characterize volatile compounds. Fresh SMP were characterized by cooked and sweet aromatic flavors while WMP exhibited cooked, caramelized, and milkfat flavors. These flavors were linked to specific volatile compounds. A wide variety of aroma-active volatiles were isolated from powders. WMP, in general, exhibited higher intensities of lactones and sugar degradation products (maltol, fureanol). WMP developed grassy, painty, and fatty flavors with storage time; SMP developed cardboard/fatty flavors. Aldehydes increased in SMP and WMP with storage time. Flavor of SMP was more stable than WMP, but flavor and flavor stability differed between the two SMP and the two WMP.

Key Words: Milk powder flavor, Aroma extract dilution analysis, Sensory analysis

163 The effects of composition and processing on milk foaming characteristics as measured by steam frothing. M. Levy[1], J. U. McGregor*[2], and W. Prinyawiwatkul[3], [1]*Chef John Folse and Company, Gonzales, LA,* [2]*Clemson University, Dept. of Food Science and Human Nutrition, Clemson, SC,* [3]*Food Science Dept., LSU Ag Center, Baton Rouge.*

Steam frothing of milk is required to produce an acceptable foam for many espresso coffee drinks (i.e. cappuccinos). Specific aspects of composition and processing may affect the foaming properties of milk. The aim of this study was to determine the effect of fat content, heat treatment, free fatty acid addition and storage time on the frothing properties of milk. The four treatments included: fat content (0.08 percent and 3.25 percent), HTST and Ultra pasteurization temperatures, pre and post-pasteurization addition of lauric acid solution (0.0 percent and 2.0 percent of 0.5 M concentration) and storage time (1 and 10 days). For each treatment, 250 ml of milk was frothed with a Feama Espresso machine (model c85/1) using a 7.5-cm diameter graduated beaker for 25 seconds. Froth characteristics were observed and the steam froth value (SFV), amount of dissipation and foam volume were determined after 5 minutes. The free fatty acid level for all treatments was also determined prior to frothing. There was no significant difference found between day 1 and day 10 for SFV, foam volume, or dissipation when comparing each treatment over time. There was also no significant difference over time based on fat level, pasteurization temperature, or pre pasteurization free fatty acid addition. When total interactions for all treatments over time were observed, there was a significant difference in SFV and FFA level.

There was also a significant difference for all testing procedures between all free fatty acid levels between treatments.

Key Words: Cappuccino, Coffee, Milk

164 Distribution of milk protein at air interfaces in ice cream examined by transmission electron microscopy and immunogold labeling.

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This study investigated the distribution of β-casein and β-lactoglobulin at air interfaces in ice cream by the combined use of freeze substitution transmission electron microscopy and immunogold labeling. When there was no added emulsifier, the fat globules appeared as discrete with clear dark protein edges and did not directly attach to air interfaces. Air interfaces mainly contained casein micelles, β-casein and a minor part of whey proteins, among which β-lactoglobulin was detected. Dissociation of casein micelles was evident by the presence of free β-casein and deformed casein micelles, especially for those adsorbed to fat and air interfaces. Addition of EDTA to ice cream led to thicker protein lines surrounding fat globules and air bubbles. The fact that less casein micelles but considerable free β-caseins were found adsorbed to either air or fat interfaces indicated more dissociation of casein micelles induced by EDTA. When mono and di-glycerides (MDG) were introduced to ice cream, the protein border between fat globules became discontinuous and partial coalescence of fat took place. Partially coalesced fat, individual fat globules, casein micelles, β-caseins and β-lactoglobulins were found attached directly to air interfaces.

Key Words: Ice cream, Protein, Foam

165 Effect of pH and ionic strength on competitive protein adsorption to air bubbles in aqueous foams made with mixed milk proteins.

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Quantitative analysis of competitive milk protein adsorption to aqueous foam was performed by capillary zone electrophoresis (CZE). Foams were made by whipping protein solutions, in which skim milk powder (SMP) and whey protein isolate (WPI) were dissolved in various proportions and with various pH and concentration of NaCl. Adsorption of β-casein into foam phases was most preferential under all solution conditions. Enrichment of caseins into the foam phase was more apparent than that of whey proteins and more so when samples contained less proportion of SMP and more WPI. The foamability of WPI increased when the concentration of NaCl rose from 0 to 0.1 M, and deceased when NaCl concentration increased further. The foamability of SMP demonstrated a continuous improvement when ionic strength increased from 0 to 0.8. NaCl at low concentration (< 0.4 M) did not show significant effect on competitive adsorption among milk proteins, indicating electrostatic interactions do not play a key role in competitive adsorption. NaCl at higher concentration, e.g. at 0.6 M, retarded whey proteins from adsorption to the foam made from 50:50 mixtures of SMP and WPI. The whippability of WPI was highest at pH 4.5 and lowest at pH 3, and that of SMP was exactly the opposite. More α-lactalbumin was adsorbed to foam when the protein solutions were acidified from pH 6.6 to pH 3. The proportions of β-lactoglobulin and α-lactalbumin in the foam phase were obviously higher at basic pH and lower at acidic pH, compared with that at natural pH of WPI. The whippability of SMP was slightly improved when pH of SMP increased to 7 and 8.

Key Words: Protein, Foam, Capillary electrophoresis

166 Elucidation of the mechanisms of casein micelle stabilization by carrageenans extracted from *Gigartina lanceata* red seaweed.

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The stabilization mechanisms of carrageenans on casein micelles were examined using diffusing wave spectroscopy (DWS). Carrageenans were extracted from the male, female, and tetrasphorophyte life-cycles of a red seaweed, *Gigartina lanceata*, native to southern New Zealand. The seaweed was boiled in 0.5M NaCl for 15 minutes, filtered through a coarse cloth and Whatman #113 filter paper (2×), and cooled to 4°C. The carrageenan was precipitated by addition of two volumes of 2-propanol at #18°C to the filtrate, then freeze-dried. Solutions (1%) of isolated carrageenans were prepared and heated at 85°C for 30 minutes to hydrate the polysaccharides before use. Low-heat skim milk powder was hydrated for 12 hours at 4°C and adjusted to pH 5.5 and 6.5. Carrageenans were mixed at concentrations of 0.01% to 0.5% in the 10% skim milk powder solution and the size of casein micelle aggregates measured by DWS. A 1% solution of λ-carrageenan was also prepared and used for comparison. The viscosity of the continuous phase was measured over a shear rate range 10 s^{-1} to 50 s^{-1} after ultracentrifugation of the mixture at 100,000×g for 30 minutes to calculate aggregate size from DWS data. Casein micelle size at both pH values without carrageenan was 200±10 nm. DWS correlation curves suitable for analysis of the casein-carrageenan mixtures at pH 5.5 were obtainable up to 0.5% polysaccharide concentration for male and female extractions, and up to 0.2% for λ-carrageenan. Correlation curves for the mixtures at pH 6.5 were only obtainable up to 0.05% carrageenan. The size of the aggregates increased as the carrageenan concentration increased. Carrageenans are known to adsorb onto the surface of casein micelles, even though both are negatively charged, by interaction with the positively charged section of κ-casein. As the carrageenan concentration increases, bridging of micelles occurs followed by steric repulsion of micelles at higher carrageenan concentration, and finally depletion flocculation at the highest concentration once the micelle surface is saturated with adsorbed carrageenan. The DWS technique is suitable for determining the onset of depletion flocculation from the rapid increase in aggregate size.

Key Words: Carrageenan, Casein micelle, DWS

167 The lactose permease of *Streptococcus thermophilus* is phosphorylated by the doubly phosphorylated form of HPr, a phosphoprotein of the phosphoenolpyruvate:sugar phosphotransferase system.

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Streptococcus thermophilus (*St*) is used to make fermented milk products such as yogurts and cheeses. Lactose, the main sugar in milk, is taken up by *St* via a permease called LacS. The sugar is then hydrolyzed inside the cell into glucose and galactose by the enzyme beta-galactosidase. The glucose moiety is metabolized via the glycolytic pathway, while galactose is released into the extracellular medium. LacS catalyses two modes of transport: proton-motive-dependent symport and lactose/galactose exchange. LacS possesses a hydrophilic carboxyl-terminal domain called IIA^{LacS} that can be phosphorylated on His-552 by HPr(His_{15} P), a phosphocarrier protein of the phosphoenolpyruvate:sugar phosphotransferase system (PTS). Phosphorylation of IIA^{LacS} increases the rate of lactose/galactose exchange and, until now, has been reported to occur only at the expense of HPr(His P). However, streptococcal cells possess significant amounts of a doubly phosphorylated form of HPr, HPr(Ser_{46}-P)(His_{15} P), whose functions remain unclear. The goal of this study was to determine whether IIA^{LacS} of *St* could be reversibly phosphorylated by HPr(Ser-P)(His P). IIA^{LacS} phosphorylation was carried out using [^{32}P]PEP and the following purified proteins: His_6-HPr, His_6-HPr(Ser-P), His_6-EI, and the carboxyl-terminal IIA^{LacS} domain comprising 173 amino acids. Results showed that *St* IIA^{LacS} could be phosphorylated by HPr(His P) and HPr(Ser-P)(His P) at virtually the same rate. Experiments conducted with *Streptococcus salivarius* (*Ss*), a species phylogenetically closely related to *St* that does not expel galactose during growth on lactose, indicate that the rate of *Ss* IIA^{LacS} phosphorylation by *Ss* HPr(Ser-P)(His P), but not by HPr(His P), was higher than the rate of *St* IIA^{LacS} phosphorylation by *St* proteins. Experiments performed with heterologous systems showed that this difference did not result from differences in the amino acid sequences of the HPr proteins. Lastly, we demonstrated that *St* and *Ss* IIA^{LacS} P could transfer their phosphate group to HPr(Ser-P). In conclusion, our results unequivocally demonstrate that both HPr(His P) and HPr(Ser-P)(His P) play a key role in the phosphorylation state of *St* and *Ss* lactose permease.

Key Words: Lactic acid bacteria, Lactose transport, Protein phosphorylation