476 Measurement of moisture in high lactose whey products. Michel Pouliot*, Josee Beauchemin, and Jacques Rolland, *Agropur Dairy Cooperative, Granby, Qc, Canada.*

Dry whey products contain amorphous lactose (or lactose glass) and α-lactose monohydrate crystals. The monohydrate crystal is a non-hygroscopic and non-thermoplastic product whereas amorphous lactose is highly hygroscopic and thermoplastic. The more important is the proportion of amorphous lactose in a powder, the more susceptible it is to caking. The water of hydration in the pure α-lactose monohydrate crystal is tightly held and can only be vaporised at 120 °C. This complicates the measurement of moisture by the use of conventional loss on drying methods. We have noticed over 3 years that the moisture contents of deproteinised whey powder (whey UF permeate) were higher in winter than in summer. This study evaluates the effect of the relative humidity of the air in the oven (dry or humid) on the measurement of moisture in deproteinised whey. Moisture measurements were done according to Agriculture Canada official method (oven 100 +/- 2 °C, 16 hr) with the difference that dry ($CaSO_4$) or humid (water bubbling) air at room temperature was used to continuously flush the oven (4 volumes/hr). The temperature in the oven was monitored at 100 +/- 2 °C. Two deprotenised whey powders coming from different plants were used. Their moisture contents were measured by Karl Fischer titration. The powders were kept in thigh glass jars until used. Each powder was measured at 3 different occasions using 4 replicates each time in dry or humid air condition. Results showed that moisture measured using dry air was significantly ($p<0.001$) higher than with humid air. This difference can be as high as 1.1 g water/100g powder. This might explains the higher moisture content measured in winter compared to summer. Repeatability of the method is fair but reproducibility is poor with a significant difference ($p<0.001$) within the 3 occasions of measurements. It can be concluded that the loss on drying method is not appropriate for measurement of moisture in high lactose whey powders. Karl Fischer titration is the method of choice for these products.

Key Words: moisture, lactose, whey

477 Effect of kappa-carrageenan on microstructure of milk protein: polysaccharide mixed systems. H. D. Goff*, S. Thaiudom, and R. A. Andrew, *University of Guelph, ON, Canada.*

Milk proteins and polysaccharide stabilizers commonly exhibit phase separation when they are mixed in solution, typical of many stabilized dairy products such as ice cream mix or chocolate milk. Practical experience has shown that kappa-carrageenan can prevent phase separation, but the various phenomena are not well understood. In this study, locust bean gum, guar or xanthan (0.36%) were incorporated individually in solutions of milk solids-not-fat (11%). Phase diagrams and transmission electron microscopy (TEM) were used to investigate structural formation at the macroscopic and microscopic levels, respectively. During the evolution of phase separation, water-in-water emulsion droplets were seen to coalesce and stream, giving rise to visual mottling, and finally distinct phase separation. Electrophoresis results showed that the clear phase was devoid of casein micelles but slightly enriched in whey protein. Disappearance of phase separation between milk proteins and primary stabilizers in sucrose solution at the macroscopic level was evident with added kappa-carrageenan at concentrations of 0.025% or 0.05%, but the existence of phase separation at the microscopic level was still present. Phase separation was attributed to a depletion flocculation mechanism while disappearance of this phenomenon was attributed either to a weak filament gel-network of kappa-carrageenan, adsorbed on caseins via electrostatic interaction, or to a gelation of excess kappa-carrageenan itself.

Key Words: Stabilizer, Phase separation, Carrageenan

478 Effects of enzymatic crosslinking on the consistency and structure of probiotic goat milk yogurt. J. Farnsworth*[1], G. Hendricks[2], V. Gotcheva[1], R Akuzawa[3], and M. Guo[1], [1]*University of Vermont, Burlington VT 05405,* [2]*University of Massachusetts, Worcester, MA 01655,* [3]*Nippon Veterinary and Animal Science University, Tokyo, Japan.*

Goat milk products are becoming increasingly popular as specialty products in the United States. However, because of its low casein content and seasonal changes in composition, it is difficult to produce goat milk yogurt with good consistency. In this study, the effects of enzymatic crosslinking by addition of microbial transglutaminase (MTGase) on the viscosity, microstructure, and probiotic culture survivability of goat milk yogurt containing *Lactobacillus acidophilus, Bifidobacterium*, and *Lactobacillus paracasei subsp. casei*, were investigated. The consistency of the yogurt was greatly improved by the addition of MTGase. The viscosity was 4.46 x 10^3 mPa.s for control goat milk yogurt. The values were increased to 2.72 x 10^5 mPa.s with two units MTGase and to 1.12 x 10^6 mPa.s with four units MTGase added per gram protein. Scanning electron micrographs of the yogurt showed that the microstructure of the treated yogurt seemed denser compared to that of the control sample. Survivability of the probiotics (*Bifidobacterium, Lactobacillus paracasei subsp. casei* and *Lactobacillus acidophilus*) in the yogurt was not significantly affected by enzymatic crosslinking ($p>0.05$) during storage for nine weeks at 4°C. The populations of the probiotic cultures in both control and MTGase treated yogurt slowly decreased during storage, but the levels of all three cultures remained above 10^7 per gram through the end of the study. Results of this study indicate that enzymatic cross-linking may be an effective method to improve the consistency of probiotic goat milk yogurt.

Key Words: Goat milk, enzymatic crosslinking, probiotic yogurt

479 Comparison of bulk physical properties of angel food cakes containing egg white protein or whey protein isolate. P. Luck*, C. Pernell, E.A. Foegeding, and C. Daubert, [1]*North Carolina State University.*

Investigation of functional properties of proteins and factors that influence them is necessary for modeling food systems so that processes may be optimized or cost saving substitutions made. Angel food cake is an excellent model system for study of protein functionality because it contains few ingredients, relies on no chemical leavening and is very dependent on the functional properties of its protein constituents. Research concerning angel food cake lacks information about the bulk behavior of the initial foam and cake during baking which may yield insight into the functions of proteins within the cake. In this report, bulk behaviors during angel food cake baking are studied to distinguish differences in the performance of egg white protein (EWP) and whey protein isolate (WPI).

Cakes were made from foams containing EWP and WPI (2-20% protein), WPI with xanthan gum or heat treated WPI. Final cake volume and height during baking, foaming solution viscosity, thermal transitions and rheological properties during baking were measured.

Cakes made with 10% protein foams containing WPI had roughly half the final volume of cakes made with foams containing EWP. Correlation of cake height during baking and thermal transitions indicated the occurrence of 2 events: denaturation of proteins within the cake (75°C#WPI, 85°C-EWP) and starch gelatinization (95°C). Mild heat treatment of a 10% WPI solution prior to foaming yielded a cake with increased volume although not equal to that of EWP. An increased solution viscosity contributed to cake volume increase, but was not solely responsible for that increase. Rheological analysis indicated different protein mechanisms for EWP and WPI in angel food cake. Phase angle of WPI containing cake increased (more viscous) up to roughly 87°C and then decreased (more elastic) at the end of baking. The phase angle of cakes made with EWP continually decreased as temperature decreased ending at a low phase angle. Cake volume is highly dependent on protein specific interactions and protein interactions with starch that vary according to protein type.

Key Words: angel food cake, egg white protein, whey protein

480 Effect of potassium sorbate addition on the viscosity of aqueous solutions of locust bean gum during storage at 4 and 20 C. M.S. Gigante*[1], M. Almena-Aliste[2], and P.S. Kindstedt[2], [1]*State University of Campinas, Campinas, SP/Brazil,* [2]*University of Vermont, Burlington, VT/USA.*

Previous studies demonstrated that the viscosity of the serum phase of cultured cream cheese (made with locust bean gum (LBG) stabilizer), and the viscosity of aqueous solutions of LBG, decreased in temperature-dependent manner during storage. The objective of the present study was to evaluate whether viscosity losses may have been associated with

microbial growth. LBG solutions (.45%) with and without added potassium sorbate (.3%) were prepared in distilled water. The solutions were divided into three treatments and lactic acid was added to adjust the pH to 5.3, 4.8 and 4.3 (±.05). The acidified solutions were dispensed into sterile culture tubes and stored at 4 or 20°C for up to 56 d. Samples were randomly chosen after 1,7,14, 21, 28, 35, 42,and 56 d and analyzed for viscosity at 25°C and for yeast and mold and aerobic plate counts. The entire experiment was replicate three times. The effects of pH, storage time, and storage temperature on viscosity were evaluated by ANOVA according to a split-split plot design. The viscosity of LBG solutions with sorbate decreased significantly but only slightly (i.e. < 10% change) during 56 d of storage. No yeast, mold or aerobic bacteria were detected throughout storage. In contrast, the viscosity of LBG solutions without sorbate decreased dramatically in a temperature dependent manner. On average, viscosity decreased by ca. 65% and 91% during storage at 4 and 20°C, respectively. Furthermore, yeast and mold and aerobic plate counts increased rapidly in LBG solutions without sorbate due to random contamination of the solutions, with higher counts occurring at 20°C. In summary, LBG was stable in aqueous solution when microbiological growth was prevented. However, when microbiological growth occurred, LBG solutions quickly lost viscosity. The data support the view that microbiological activity may contribute to loss of viscosity in the serum phase of cream cheese during storage, and thus may contribute to the development of syneresis.

Key Words: Cream cheese, Locust bean gum, Syneresis

481 Water solubility and mechanical properties of heat cured whey protein isolate-based edible films: A comparison to commercial collagen and natural casings.

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Heat curing has been shown to improve the mechanical properties of protein-based films. The purpose of this study was to determine the effect of two different heat-curing conditions on mechanical properties and water solubility of whey protein isolate-based films with different plasticizer content as compared to collagen and natural casings.
Whey protein isolate (WPI; 5% w/v) films with three levels of glycerol (Gly; 3.5, 3.3, 2.7% w/v) and candelilla wax (CW; 0.8% w/v) were prepared and heat-cured using a vacuum oven at 80°C for 24h and 90°C for 12h. Tensile strength (TS), elongation at break (%E) and wet strength (WS) were determined using standard ASTM procedures and compared to collagen and natural casings. Water solubility (23°C, 24h) of WPI-based films, collagen and natural casings were also determined.
No differences in TS were observed between WPI-based films heat cured at 90°C and collagen; natural casings had lower ($p<0.05$) TS than both. The WPI films heat cured at 80°C and natural casings had lower ($p<0.05$) TS than collagen. However, WPI-based films heat cured at 80°C with 3.3 and 2.7% Gly had higher ($p<0.05$) TS than natural casings. Heat cured WPI-based films had lower ($p<0.05$) WS than collagen and natural casings. No differences in %E were observed among WPI-based films heat cured at 90°C, collagen and natural casing. The WPI-based films heat cured at 80°C with 3.5 and 3.3% Gly had higher ($p<0.05$) %E than collagen and natural casings. All heat cured WPI-based films and collagen had higher ($p<0.05$) solubility than natural casings. Heat curing temperature/time had no effect on the solubility of WPI-based films.
Our results indicate that WPI-based edible films with solubility and mechanical properties resembling to collagen and natural casings may be produced by heat curing of the films. Films with 2.7% Gly, heat cured at 90°C for 12h produced films with properties closest to collagen.

Key Words: Whey, Collagen, Casing

482 Role of polysaccharide stabilizers in the formation of yogurt structure.

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The mechanisms of interaction between casein micelles and polysaccharide stabilizers in yogurt were investigated by dynamic oscillatory rheometry. Fresh, unpasteurized skim milk was adjusted to 5% casein by addition of skim milk powder, heat-treated at 85°C for 30 min, cooled to 30°C, and inoculated with S. thermophilus and Lb. bulgaricus culture. One of five stabilizers was added after the heat-treatment step at 85°C at concentrations of 0.05% to 0.6% of the milk volume. The yogurt was set for 16 h at 30°C and stored at 4°C. pH was adjusted to 4.25 on day 1 after manufacture. Rheological measurements were made at 10°C: 1) viscosity over a shear rate range of 1000 to $0s^{-1}$, 2) strain sweep from 0.001 to 1 at 1 Hz to determine the extent of the linear viscoelastic region, and 3) frequency sweep from 0.1 to 10 Hz at a strain of 0.003. Syneresis was quantified as the serum phase remaining after centrifugation at 200×g for 10 min at 4°C. All measurements were made in triplicate, 1, 21 and 42 d after manufacture. Stabilizers that adsorb onto the surface of casein micelles (λ-carrageenan and low-methoxy pectin) higher than a characteristic concentration of 0.3% and 0.4% respectively, decreased the viscosity at day 1 from 50±6 Pa.s to 15±3 Pa.s, along with an increase in syneresis and δ values from 15±3° to 50±7° for pectin and 16±1° to 181° for carrageenan. Higher values of δ indicate more liquid-like behavior. Non-adsorbing stabilizers (xanthan, guar, and locust bean gum) increased the viscosity at stabilizer concentrations higher than 0.6%, 0.5% and 0.5% respectively at day 1; xanthan 48±2 to 92±6 Pa.s, guar 0.6±0.1 to 157±13 Pa.s, and locust bean gum 0.5±0.1 to 5.4±2.7 Pa.s. A concomitant decrease in both δ and syneresis was observed for guar at day 1. A peak was observed for δ as a function of frequency. This peak shifted to lower frequencies as the stabilizer concentration increased and as the yogurt aged. As the level of adsorbing stabilizer increased, the casein micelles passed from a region of bridging flocculation to steric repulsion. For non-adsorbing stabilizers a transition occurred from depletion flocculation of micelles, to micelles suspended in a concentrated and viscous stabilizer gel.

Key Words: Yogurt, Casein, Rheology

483 Conjugated linoleic acid and docosahexaenoic acid enriched milk altered physical properties of milk fat and polymorphic structure of butter.

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Inclusion of marine algae in dairy rations of Holstein cows produced milk enriched with docosahexaenoic acid (DHA), conjugated linoleic acid (CLA) and trans-octadecenoic acids. Significant milk fat depression resulted with an incorporation of marine algae in the dairy ration. Milk fat globule size and casein micelle size decreased in the treated milk which related to churning properties in butter-making. Butter made from enriched milk fat showed a decrease in hardness, dropping point and a lower solid fat content at 5C. Differential scanning calorimetry was used to characterize both crystallization and melting behaviors of inherent and enriched butter oil. The microstructural network of DHA milk fat was significantly different from that of native milkfat. DHA milk fat crystallized directly to a '-2 polymorphic form at 5C in contrast to native milk fat that crystallized initially in an polymorphic form. In an attempt to correlate the changes observed in the physical properties to lipid changes, an extensive identification and quantification of total fatty acid methyl esters (FAME) content ranging from C4 to C24 of both enriched milk and butter was conducted using gas chromatography (GC). Argentation thin layer chromatography (Ag-TLC) combined with GC was used to identify, elucidate and quantify overlaps between positional /italcize cis and /italicize trans isomers in the 18:1 fraction. DHA-enriched milk fats had increased levels of short chain fatty acids (4:0 to 10:0), and 14:0 and 16:0, while 18:0 decreased. There were increased levels of n-3 polyunsaturated fatty acids (20:5n-3 and 22:6n-3), conjugated linoleic acid (CLA) and total /italicizetrans 18:1. A significant increase in 10/italicizetrans-18:1 was observed which is associated with milk fat depression.

Key Words: Fatty Acids, Gas Chromatography, Microstructure

484 Dairy fats enriched in n-3 PUFA and CLA by feeding fish meal.

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The present study was designed to evaluate changes in cheese lipids as a result of feeding cows partially protected fish meal i.e., DHA (docosahexaenoic acid), CLA (conjugated linoleic acid), *trans* 18:1, and short chain fatty acids. The control milk and cheese was obtained from cows fed a soy/corn diet. All samples were stored at -70°C until analyzed. Total milk fats were extracted using a chloroform/methanol/water system and fatty acid methyl esters (FAME) were prepared using sodium methoxide. The complete FA profile of milk and cheese lipids were obtained by gas chromatography (GC) equipped with a split/splitless injector, a flame ionization detector; and a 100 m CP-Sil 88 capillary column. Silver ion thin layer chromatography (Ag^+-TLC) was used to separate

the geometric monoenoic FAME. Each fraction was analyzed by GC, as described above with the capillary column operated isothermally at 120°C. More than one hundred FAME from C4 to C26 were resolved in the GC analysis of total milk and cheese lipids. The qualitative separation and quantitative analysis of total FAME from cheese fat was greatly affected by the sample load applied onto the GC column. At least two and occasionally three different sample loads were required to separate and identify the minor and the major fatty acids in these samples. A combination of Ag^+-TLC and GC was required to resolve and identity of the *trans* and *cis* isomers independently. Ten positional *cis* and *trans* 18:1 isomers were identified with 9c as the predominant isomer. The 10t-18:1 isomer, associated with milk fat depression, was the major *trans* isomer in DHA enriched milk and cheese, follow by the 11t-18:1. In addition, the n-3 FA of DHA cheese increased, i.e., DHA and EPA (eicosapenatenoic acid, 20:5n3). The CLA region showed that 9c,11t-18:2 was the major CLA isomer in these dairy fats on both diets, and the content was higher in the fish meal fed cows. The PUFA in cheddar cheese remained stable up to 18 months ripening at 8°C.

Key Words: docosahexaenoic acid (DHA), conjugated linoleic acid (CLA), gas chromatography

485 Milks from cloned cows: rennet coagulation properties of five clones over a single lactation cycle. J. A. Lucey*[1], S. Govindasamy-Lucey[2], J. E. Romero[2], M. M. Pace[3], and M. D. Bishop[3], [1]*Department of Food Science, University of Wisconsin, Madison, Wisconsin, USA*, [2]*Center for Dairy Research, University of Wisconsin, Madison, Wisconsin, USA*, [3]*Infigen Inc., Deforest, Wisconsin, USA*.

A group of 11 Holstein cows were derived from a single clonal line using somatic cell nuclear transfer technology. The coagulation properties of milks from five cows of this clonal group were determined using dynamic low amplitude oscillation on a Physica UDS 200 Rheometer. Milks were studied over one lactation cycle and each cow was sampled 6 times (apart from one cow which was sampled 4 times) at 2-month intervals. Coagulation was assessed at the natural pH of milk. Milks from each individual cow were obtained from the morning milking and collected separately, chilled with ice water to 4°C and tested that day. Control bulk milk samples (from a 200 cow herd of Holstein cows) were also tested at each sampling day. Milks from these cloned animals are not currently used for consumption. The large deformation properties of rennet-induced gels were determined using a low constant shear (0.01 s^{-1}) test of the preformed gel made in the rheometer. The stress required to fracture the gel and strain at fracture were determined from this shear test, which was performed 40 min after rennet addition. Coagulation time, storage modulus value at 40 min after rennet addition, and fracture stress were all significantly influenced by stage of lactation ($P < 0.05$) but not by the individual clones. Only the values for fracture strain for individual clones were significantly different ($P < 0.05$). Neither the coagulation properties nor the milk composition of the clones were exactly identical; however, the values were similar to that expected for normal milk samples. There were significant ($r > 0.7$) positive correlations between clotting time and the parameters pH and fracture strain. Clotting time was negatively correlated ($r > 0.7$) with storage modulus and fracture stress. Detailed analysis of the composition of all the milks in this clonal line is currently underway. In conclusion, it appeared that, apart from the highly significant influence of the stage of lactation, there were no significant differences in the coagulation properties of this clonal group.

Key Words: Cloning, Rennet coagulation, Rheology

486 Stability of oil in water emulsions formed in presence of skim milk powder: effect of calcium salts and heat treatments. Deepa Mathew* and Phillip S. Tong, *California Polytechnic State University*.

Stability of oil in water emulsions made with soy oil, water and skim milk powder fortified with calcium salts was studied. Four salts - calcium carbonate, calcium phosphate, calcium citrate and calcium lactate were studied separately. The amounts of skim milk powder and calcium salts were adjusted so that the protein content in the final emulsion was either 3.5% or 1.75% (w/w) and calcium content was either 0.24% (w/w) (2 times the amount naturally present in milk) or 0.36% (w/w) (3 times the amount naturally present in milk). Skim milk powder and calcium salt were blended together. The dry mixture was reconstituted in the required quantity of water and was kept at 5^0C for 18 hrs for proper hydration of the powder. The temperature was then brought up to 25^0C; soy oil was added (10% (w/v) and homogenized with a two stage homogenizer (first stage pressure of 13.8 MPa and second stage pressure of 3.45MPa). The emulsions were subjected to either pasteurization (63^0C for 30 minutes) or retorting (121^0C for 16 minutes) and then were cooled to 25^0C. Stability of emulsions was studied by measuring particle size distributions and fat analysis of the cream layer after centrifugation. Calcium phosphate caused immediate instability at both levels of calcium and protein. As a result, further studies were not pursued with calcium phosphate. It was observed that with the other three salts, instability of emulsions decreased as the protein content increased, for the same level of calcium. In all cases, retorted samples were more unstable compared to pasteurized samples. Emulsions containing calcium lactate and calcium citrate were more sensitive to heat treatments than emulsions containing calcium carbonate. The most stable emulsions were obtained when calcium carbonate was added (even more stability than control sample with no added calcium at 1.75% protein).

Key Words: Emulsion, Stability, Calcium

Extension Education

487 Pork processing inservice program for high school ag educators. K. Kephart*, R. Mikesell, and W. Henning, *Penn State University*.

The purpose of this educational program was to provide agriculture educators with technical knowledge and classroom materials for teaching the fundamentals of meat processing to high school students. Teachers from the 160 school districts in Pennsylvania with ag science programs were invited to attend; 42 individuals from 29 school districts participated. The concepts taught included methods of meat preservation, function of processing ingredients (salt, sugar, phosphate and nitrate), food safety, and examples of processed products. Written materials, including lesson plans, quizzes, laboratory instructions and data sheets were provided along with a laboratory teaching kit with sufficient materials for 45 students. Each teaching kit included cooking bags, sanitary equipment, a 50-cc syringe with attached meat injection needle, meat thermometer, and premixed and pre-weighed ingredients to be dissolved in a standard volume of water. The laboratory was designed to enable each student to inject one of three solutions into a two-pound cut of boneless pork: 1) marinate (salt, sugar, phosphate); 2) nitrite (marinate + nitrite); 3) water. After injection, students refrigerated the pork for a minimum of 24-hours, cooked each cut to an internal temperature of 71 C, and recorded color, flavor and juiciness scores. Seventy-three percent of the participants felt the inservice program was well organized, 92% like the lesson plan format, 100% were pleased with the materials in the teaching kit, and program has been successfully used in 97% of the school districts represented. We plan to build on the success of this program to offer similar programs in quality assurance, agriculture science projects, and environmental stewardship.

Key Words: Meat Processing, Secondary Education, Teacher Inservice

488 Third-party evaluation of proposed sites for swine operations and estimation of the risk of odor conflict. R. Mikesell* and K. Kephart, *Penn State University*.

The purpose of this program is to assess the potential for odor related complaints arising from the operation of proposed swine facilities. We provide the swine industry with cost-free site evaluations to prevent odor complaints associated with poorly sited swine operations. Criteria for evaluation include: 1) Nature of odor problems (both physical and personal factors affect odor perception); 2) Neighbor location (those at greatest risk are within one-half mile east or south of the proposed site); 3) Topography and vegetation (hills and vegetation help enhance odor plume dilution); 4) Physical size and orientation (overall facility size dictates odor plume width); 5) Animal inventory (number of animals dictates physical facility size and manure production volume); 6) Type of manure storage (outdoor storages are subject to wind stripping