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## DAIRY FOODS DIVISION

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**0498 Investigating the antimicrobial activity of pasteurized and raw camel milk against foodborne pathogens: *Listeria monocytogenes* and *E. coli* O157:H7.** M. Ayyash\*, *UAE University, Al-Ain, United Arab Emirates.*

The objectives of this study were to investigate the antimicrobial activity of pasteurized camel milk against foodborne pathogens (*L. monocytogenes* and *E. coli* O157:H7) at different incubation temperatures, and to examine the influence of pasteurization on antimicrobial activity of camel milk at different incubation temperatures. Pasteurized or raw camel milks were inoculated with a cocktail of *L. monocytogenes* or a cocktail of *E. coli* O157:H7, separately. Inoculated camel milk was incubated at 10°C, 25°C, and 37°C and sampled at 0, 2, 4, 8, and 24 h of incubation time. This procedure was exactly applied using pasteurized bovine milk as a control for this experiment. All experiments were repeated at least three times. Chemical compositions of all milks were determined. pHs during incubation, total bacterial count in raw camel milk, and thermophilic bacteria in pasteurized milks were monitored. During incubation time, *L. monocytogenes* growth increased dramatically after 2 h when incubated at 25°C and 37°C but no significant growth observed at 10°C. *E. coli* O157:H7 showed similar behavior. Interestingly, growth of *L. monocytogenes* and *E. coli* O157:H7 in pasteurized camel milk were significantly lower than in pasteurized bovine milk. In general, the growth of *L. monocytogenes* in camel milk was suppressed by 15–18% and 8–10% after 8 and 24 h of incubation, respectively. However, growth suppression of *E. coli* O157:H7 ranged from 5–21% and 6–14% after 8 and 24 h of incubation time, respectively. Growth suppression of *E. coli* O157:H7 was influenced significantly by temperature but not suppression of *L. monocytogenes* growth. In conclusion, our results showed that camel milk possesses antimicrobial activity against foodborne pathogens (*Listeria monocytogenes* and *E. coli* O157:H7). Moreover, pasteurization process has insignificant effect on antimicrobial activity of camel milk. Further investigations are need to identify and characterize antimicrobial agents in camel milk.

**Key Words:** camel milk, *Listeria monocytogenes*, *E. coli* O157:H7, antimicrobial activities

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**0499 Application of fluorescent probes to determine localized salt concentrations within cheese matrices and their influence on metabolic activity of entrapped bacterial cells.** C. D. Hickey<sup>1</sup>, V. Fallico<sup>1</sup>, Z. Burdikova<sup>1</sup>, M. G. Wilkinson<sup>2</sup>, and J. J. Sheehan<sup>\*1</sup>, <sup>1</sup>*Teagasc Food Research Centre Moorepark, Co. Cork, Ireland,* <sup>2</sup>*University of Limerick, Ireland.*

The influence of salt on microbial growth and activity in cheese has received much prior attention. However, the way in which salt within cheese matrices affects bacterial physiology to control cell growth is not fully elucidated. Application of advanced microscopy techniques to determine salt concentration at a localized level is of interest to understand interactions between cheese matrix physico-chemistry and microbial activity before, during and post-brining of cheese. The objective of this study was to determine the presence of and effects of localized salt gradients associated with brine salting on microflora physiology and metabolic activity of the individual starters, *S. thermophilus* and *L. helveticus* used in cheese manufacture. Cheeses were manufactured in 3 replicate trials, brined for 66 h and sampled at the high-salt outside and low-salt inside layers before, during and post-brining. Localized salt concentrations were determined using CoroNa Green Sodium Indicator by Confocal Laser Scanning Microscopy. The average salt content in the outside layer post brining was ~3.8%. The response of cytoplasmic membrane integrity of bacterial cells and levels of free reactive oxygen species to salt concentrations were assessed using fluorescent probes combined with Flow Cytometry. There were greater levels of membrane damage and oxidative stress observed in *L. helveticus* compared with *S. thermophilus* at all times. Confocal imaging clearly identified localized variations in salt concentrations and illustrated the penetration distance of the brine solution into the matrix during and post-brining. Overall, this study showed a differing impact of varying salt levels on cheese starter physiology and metabolic activity in vivo, dependant on starter type and confirmed that the methodologies used have the potential to identify ripening hotspots at a localized level. It opens up further opportunities to apply fluorescent probes to gain a deeper understanding of the influence of cheese matrix physicochemistry on the metabolic activity of entrapped bacteria and thus to control cheese manufacture processes to achieve greater consistency in ripened cheese quality.

**Key Words:** cheese, salt gradients, metabolic activity

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**0500 Inducing HT-29 colon cells apoptosis by the extracellular polymeric substances isolate from *L. casei* strains.** W. Di<sup>\*1</sup>, L. Zhang<sup>1</sup>, X. Han<sup>2</sup>,  
<sup>1</sup>Harbin Institute of Technology, China, <sup>2</sup>Harbin Institute of Technology, China.

Nine *Lactobacillus* strains (*L. casei* X11, *L. casei* X12, *L. casei* K11, *L. casei* J5, *L. rhamnosus* J10, *L. casei* M5, *L. casei* M23, *L. rhamnosus* IN4125, and *L. casei* SB27) were obtained from the Chinese traditional fermented foods of minority nationalities or infant feces based on the previous research in our laboratory (4 strains from Sinkiang, 3 strains from Gansu, 1 strain from Tibet, 1 strain from infant feces). Fermentation broths from skim milk produced by the nine *Lactobacillus* strains were screened for anti-proliferation activity on HT-29 cells by MTT assay. The results showed that four strains exerted higher anti-proliferation activity on HT-29 effects than positive control (*Lactobacillus rhamnosus* GG, LGG). Crude and acidic exopolysaccharides isolated from the 4 strains (*L. casei* K11, *L. casei* M5-L, *L. casei* SB27, *L. casei* X12) at different concentrations (10, 20, 100, 200, and 500  $\mu$ g/mL) were systematically assessed for the anti-proliferation activity on human colon cancer HT-29 cells. Further the apoptosis induced by exopolysaccharides (EPSs) were analyzed by flow cytometry (FCM) on HT-29 cells. The colon cancer cells treated with *L. casei* SB27 acidic exopolysaccharides achieved the highest rate of apoptosis, 24.3% cells were found apoptosis and 1.4% cells in necrosis. The results of cell cycle analysis on HT-29 cells cycle treated with exopolysaccharides showed that *L. casei* SB27 acidic exopolysaccharides could slow the conversion rate of HT-29 cells from G phase to S phase, prolong the cell cycle and reduce the proliferation of colorectal cancer cells. The results of HT-29 cells Caspase-3 activity treated with *L. casei* acidic SB27 fraction showed that Caspase-3 was activated and achieve the significantly highest of all the samples at 2.79- fold compared with control group at 1.2- fold. The result of Hoechst 33258 staining shown that HT-29 colon cells treated with *L. casei* SB27 acidic exopolysaccharides appeared bright condensed dots compared with untreated with exopolysaccharides samples.

**Key Words:** *L. casei* strains, exopolysaccharides, HT-29 colon cancer cells apoptosis

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**0501 Comparative genomics of *Lactobacillus brevis* uncovers its common capability for efficiently synthesizing neuroactive  $\gamma$ -aminobutyric acid.** Q. Wu<sup>\*1</sup>, H. M. Tun<sup>2</sup>, Y. S. Law<sup>1</sup>, E. Khafipour<sup>2</sup>, and N. P. Shah<sup>1</sup>, <sup>1</sup>School of Biological Sciences, University of Hong Kong, Pokfulam, Hong Kong, <sup>2</sup>Department of Animal Science, University of Manitoba, Winnipeg, Canada.

$\gamma$ -Aminobutyric acid (GABA) is the chief inhibitory neurotransmitter in mammalian central nervous system and has

shown anti-hypertensive and anti-depressant activities to the host after oral administration. However, its content in natural animal and plant products is too low to deliver benefits to human. Thus, GABA synthesized by food-grade bacteria such as *Lactobacillus* and *Bifidobacterium* is an important source and its producers could be used for manufacturing GABA-rich fermented dairy foods. Many GABA-producing *Lactobacillus* and *Bifidobacterium* strains have been isolated and characterized in the last decade and have shown strain-specific capability in the synthesis of GABA. Among these GABA producers, *Lactobacillus brevis* seems to be the most common cell factory for synthesizing GABA. In this study, comparative genomic approach was used to identify which LAB species have the common ability to produce high amount of GABA and to identify the essential genetic elements for GABA production. It was found that gene encoding glutamic acid decarboxylase (GAD) and an intact *gad* operon were present in all the sequenced strains of *L. brevis* at the species level, but not all the strains of other *Lactobacillus* and *Bifidobacterium* species possess an intact *gad* operon including a regulator *gadR*, a *gadA*- or *gadB*-encoding GAD, and an antiporter *gadC*. This suggests the common capability of *L. brevis* to synthesize GABA. Moreover, enzyme assay for two GADs from *L. brevis* indicated that both enzymes are functional with high activities. Carbohydrate utilization by model strain *Lb. brevis* NPS-QW-145 generated different lactic acid production, which showed strong positive correlation with its GABA yields suggesting that intracellular lactic acid production triggers its GABA biosynthesis, which was also evidenced by the intracellular pH level of the cells. Moreover, among all of acid resistance (AR) pathways in *Lb. brevis*, GAD pathway contributed to late acid resistance whereas tyrosine decarboxylation (TDC) and arginine deimination (ADI) pathways were activated during lag and log phases, which were confirmed by transcriptional profiles and concentrations of the end metabolites of each AR. The present study highlights the common capability of *Lb. brevis* for highly efficient biosynthesis of GABA.

**Key Words:** comparative genomics,  $\gamma$ -aminobutyric acid, *Lactobacillus brevis*

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**0502 Effect of incubation temperature on yield and molar mass of EPS during fermentation of milk by *Streptococcus thermophilus* DGCC 7785 and the impact on the rheological properties of acid milk gels.** S. N. Khanal<sup>\*1</sup> and J. A. Lucey<sup>2</sup>, <sup>1</sup>University of Wisconsin, Department of Food Science, Madison, <sup>2</sup>Wisconsin Center for Dairy Research, Madison.

Some strains of *Streptococcus thermophilus* produce exopolysaccharides (EPS) during milk fermentation. It is unclear if there is any change in the yield, or properties, of EPS when milk is fermented at different temperatures. We investigated the yields of both ropy and capsular forms of EPS, and the

physical properties of ropy EPS that were isolated during the fermentation of milk by *S. thermophilus* strain DGCC 7785. Reconstituted skim milk was fermented at 33, 39, and 45°C until pH reached 5.2, 4.9, 4.7 and 4.5. Fermented milk was then heated to 80°C for 10 min and whey (containing bacterial cells) was obtained by decantation. Whey was ultrafiltered with sufficient diafiltration using 100 kDa membrane at 45°C to remove soluble sugars and proteins. The UF retentate was centrifuged and the supernatant and pellet were analyzed for ropy and capsular EPS, respectively. Ultrafiltration of whey from a non-EPS producing strain was also performed as a control for estimating the amount of capsular EPS. Molar mass of ropy EPS samples were analyzed using size exclusion chromatography multi-angle laser light scattering (SEC-MALLS). Rheological properties of fermented milk gels were analyzed using small-strain dynamic oscillatory measurements. The yield of ropy EPS was 102, 108, and 55 mg/L when milk was fermented at 33, 39, and 45°C respectively, whereas the yields of capsular and total EPS were 102, 132, and 102 mg/L, and 204, 241, and 157 mg/L for these fermentation temperatures (33, 39, and 45°C). Significantly higher ( $P < 0.05$ ) yields of capsular and total EPS were produced at 39°C. Total EPS content significantly ( $P < 0.05$ ) increased from 150 mg/L to 257 mg/L when the pH of milk decreased from 5.2 to 4.5. Molar mass of ropy EPS ranged from  $2.0 \times 10^6$  to  $2.8 \times 10^6$  g/mol, exhibiting no significant ( $P > 0.05$ ) effect of temperature or pH values during fermentation. Gelation pH ( $\sim 5.3$ ) of milk did not change with incubation temperature, whereas storage modulus values of the final gel (at pH 4.5) significantly ( $P < 0.05$ ) increased (58, 135, and 410 Pa at 45, 39, and 33°C, respectively) with a decrease in fermentation temperature.

**Key Words:** exopolysaccharides, fermented milk, *Streptococcus thermophilus*

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#### 0503 Probiotic-fermented maillard reaction products: New functional food for cardiovascular health.

S. Kim\*, *Korea University, Seoul, Korea (The Republic of)*.

Cardiovascular diseases (CVDs) are the leading contributors to adult mortality worldwide and will continue to dominate mortality trend in the future. Unhealthy dietary practices of consuming foods which are high in calories and/or cholesterol are commonly associated with elevated oxidative stress and accompanied by an increased risk of CVDs. Recently, dietary approach using probiotic intervention is increasingly recognized as a natural health improving supplement, attributed to their long history of safe use with beneficial effects on gastrointestinal health. Probiotic *Lactobacillus* strains are frequently incorporated in yogurts and fermented milk products, but other dairy products are also widely available and potentially developed as functional dairy probiotic foods. Maillard Reaction Products (MRPs) are compounds that can be produced through non-enzymatic reaction between lactose

and milk protein (whey protein concentrates or sodium caseinate), which possess antioxidant activity and may exert protective effect in CVDs. Despite these suggestions, no attempt has been made to incorporate probiotics into MRPs and to evaluate their potential applicability on cardiovascular health. Thus, the potential cardiovascular health benefits of MRPs fermented by *Lactobacillus* strains were determined in the present study. In vitro studies demonstrated that hydrolysates of MRPs fermented by *L. gasseri* or *L. fermentum* strain exhibited significantly higher proteolytic, antithrombotic, and radical scavenging activities compared with unfermented MRPs. Hydrolysates of these fermented MRPs also significantly inhibited the 3-hydroxy-3-methylglutaryl-CoA reductase activity, which is the rate-limiting enzyme in the cholesterol biosynthetic pathway. In animal studies, feeding of *Lactobacillus* fermented MRPs to acute pulmonary thromboembolism-induced mice were shown to attenuate serum cholesterol levels and thrombotic activity, improve liver enzymes activity, as well as overcome severe body paralysis or death. Additionally, *Lactobacillus* fermented MRPs were also capable of regulating mRNA expression level of cholesterol metabolism related genes and modulating gut microbiome in rats fed with high-cholesterol diet. My talk highlights on the recent findings and biological mechanisms by which probiotic fermented MRPs exert their beneficial effects on cardiovascular health.

**Key Words:** probiotics, functional food, cardiovascular health

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#### 0504 An ancient, species-specific tagatose-6-phosphate pathway in *Lactobacillus casei* group for galactose reduction in cultured dairy foods. N. P. Shah\*

and Q. Wu, *School of Biological Sciences, University of Hong Kong, Pokfulam.*

Residual lactose and accumulated galactose in cultured dairy foods lead to several medical and industrial concerns such as lactose intolerance, galactosemia, and browning of pizza during baking. Our previous comparative KEGG study on galactose metabolism pathways in sequenced LAB strains has uncovered the presence of tagatose-6-phosphate (T6P) pathway in all of the completely sequenced *Lactobacillus casei* group strains including *Lb. casei*, *Lb. paracasei* and *Lb. rhamnosus*. In this study, we have demonstrated that T6P pathway, but not Leloir pathway, in *Lb. casei* group is more efficient for lactose and galactose catabolism than Leloir pathway in selected strains of *Lb. acidophilus* group, *Streptococcus thermophilus* and *Lb. bulgaricus* cultured in galactose- or lactose-based MRS media. However, the activity of  $\beta$ -galactosidase, which is a key enzyme in Leloir pathway in *Lb. casei* group strains, was not detected. In the milk, *Lb. casei* group strains catabolize less lactose than *Str. thermophilus*, *Lb. bulgaricus* and *Lb. acidophilus* group, but very limited galactose was accumulated in milk. Moreover, co-cultivation



of *Lb. casei* group with *Str. thermophilus* or *Lb. bulgaricus* generated less galactose or lactose in the cultured milk. In addition, comparison of *lac-gal* gene cluster in sequenced *Lb. casei* group strains has shown the presence of an unknown PTS (PTS<sup>Unk</sup>) in this region. The EIIC of PTS<sup>Unk</sup> has conserved protein domain found in EIIC of PTS<sup>Gat</sup> (galactose-specific PTS) and its gene expression was also highly up-regulated (> 200 fold changes) in the presence of galactose suggesting its possible role for galactose phosphorylation. In addition, it was found that *lac-gal* clusters in the genomes of *Lb. casei* group strains are not associated with any HGT events suggesting that this cluster may be an ancient pathway. This study demonstrates the use of *Lb. casei* group strains as functional dairy starter for lactose or galactose depletion in milk. Further characterization of PTS<sup>Unk</sup> in *Lb. casei* group using genetic manipulation has been performed.

**Key Words:** galactose catabolism, *Lactobacillus casei* group, tagatose-6-phosphate pathway

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#### 0505 Characterization of the fatty acid composition of retail bovine milk and vegetable milk in Chile.

E. Vargas-Bello-Pérez\*, P. Toro-Mujica, D. Enriquez-Hidalgo, M. A. Fellenberg, *Pontificia Universidad Católica de Chile, Santiago.*

In Chile, there is a lack of information regarding the lipid quality of bovine and vegetable milks and this can cause consumer confusion. The objective of this study was to characterize and compare the fatty acid (FA) composition between bovine (whole, semi-skimmed and skimmed) and vegetable milks that are offered in Chile. To maximize representativeness, the availability of bovine and vegetable milks in the three biggest stores located in five of the main cities of Chile was assessed in February 2015, before sampling. Santiago's stores presented the greatest offer of those beverages and therefore the analysis of the beverages found in Santiago's stores were evaluated. During a 4-wk period in March and April (summer) 2015, retail bovine milk ( $n = 62$ ) and vegetable milk ( $n = 27$ ) samples were collected. A multivariate analysis was performed to determine which FA were responsible for the differentiation between milk by origin and type of milk. The multivariable analysis included a correlation matrix, a factorial analysis (by principal components (PC) method) and a cluster analysis. Three PC were selected from factorial analysis, those explained 0.72 [PC 1 (0.54); PC 2 (0.11); and PC 3 (0.07)] of the overall variance in the data. PC 1 was related to the saturated FA and some monounsaturated FA such as C18:1 trans-11. High scores for this PC were associated with whole milk samples. PC 2 was represented by n-3 FA and the higher scores were found in semi-skimmed milk samples. PC 3 was related with C18:2 trans-9, trans-12 and C20:4 n-6 and skimmed milk samples; and vegetable milk showed the higher scores. C18:1 trans-11 and C18:2 cis-9, trans-11 were only found in retail bovine milk. Data were analyzed by using ANOVA and when

significant differences were detected, means were separated using Tukey test. Compared with semi-skimmed, skimmed and vegetable milks, whole milk was higher ( $P < 0.05$ ) in contents of saturated FA (10.3, 1.48 and 2.23 vs. 21.9 g/L) and monounsaturated FA (3.6, 0.48 and 5.4 vs. 7.3 g/L). Compared with bovine retail milk, vegetable milk had the highest ( $P < 0.05$ ) contents of polyunsaturated FA (0.78 vs. 5.9 g/L) and this was related to its high content of C18:2 cis-9, cis-12. Data from this study can serve as a reference for estimating dietary intake for future studies. This study showed evidence that vegetable milk have a more "polyunsaturated FA profile" than retail bovine milk.

**Key Words:** milk fat composition, milk quality, oleic acid, linoleic acid, bovine

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#### 0506 Effect of milk protein intake and casein: Whey ratio in breakfast meals on postprandial glucose, satiety ratings and subsequent meal intake.

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Novel satiating dairy-based breakfast products have potential to reduce the risk of developing and improve management of type 2 diabetes and obesity. Whey and casein proteins may induce different physiological effects on blood glucose, induction of satiation and satiety. Whey proteins have been associated with acute satiation, compared with the prolonged feelings of satiety from casein. The purpose of this work is to investigate the impact of breakfast meal milk casein:whey ratio and protein concentration on postprandial blood glucose, appetite ratings, and subsequent food intake. In a randomized, controlled, double-blinded study, healthy young adults ( $n = 32$ , 16 m/f,  $23.4 \pm 3.1$  y, BMI  $22.2 \pm 2.5$  kg/m<sup>2</sup>) consumed milk (250ml) with normal (80:20) or modified (40:60) casein:whey protein ratio at normal (3.1%) or high (9.3%) protein concentration, or water (control), along with 2 servings of breakfast cereal. Following an overnight fast and up to 120 min following the breakfast meal, participants had their plasma glucose concentrations determined from finger-prick samples, completed a series of scale ratings to assess satiety and consumed a weighed ad libitumpizza lunch. Repeated measures ANOVA followed by Tukey-Kramer's post hoc testing was performed. Incremental area under the curve (AUC) glucose values showed significant attenuations in postprandial plasma glucose concentration for all milk treatments, relative to control ( $P < 0.05$ ). Also, the high protein treatments (9.3%) had significantly attenuated glucose concentrations compared with those with lower protein (3.1%). However, there was no effect of casein:whey protein ratio on blood glucose. Treatments were not associated with differences in total area under the curve for individual scale ratings of Hunger, Desire to Eat, Fullness, and Prospective Consumption. Nor were differences observed in mean appetite score ( $P = 0.86$ ) or subsequent

lunch intake ( $P = 0.06$ ). Therefore, since consumption of high protein milk treatments with breakfast cereal was associated with the lowest plasma postprandial glucose concentration, new high-protein dairy breakfast products should be considered for product development.

**Key Words:** appetite, dairy protein, glycemia

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#### 0507 Influence of sodium reduction on the rheological characteristics of cottage cheese cream dressing.

H. L. Damiano\*, *University of Idaho, Moscow.*

Once a popular dairy product, creamed cottage cheese consumption has decreased over the past several decades. There are a number of reasons for this, including free whey formation during storage, which consumers find unappetizing. Free whey formation is often a result of cream dressing separation. Cream dressing is added to provide flavor and texture to the curd, and its appearance, texture, and stability during storage is an important factor in consumer acceptance of creamed cottage cheese. Despite this, there is little published data on cottage cheese cream dressing; the bulk of the literature focuses on cottage cheese curd and its physicochemical properties. The objective of this study was to evaluate the effect of sodium reduction on the rheology of cottage cheese dressing over time. Dressing samples were prepared with 2.2%, 1.48%, and 0.73% w/w NaCl, with the 2.2% NaCl formulation acting as a control. Samples were acidified to pH 4.5, 5, and 5.5. Rheological tests (shear rate, strain, and frequency sweeps) were conducted in triplicate at 8°C and 25°C. Tests were conducted within 48 h after acidification and again after 14 d of storage at 4°C. Dressing viscosity increased over time regardless of salt amount and type; dressings had greater viscosity at 8°C compared with 25°C. As NaCl was reduced from 2.2% to 0.73%, viscosity generally decreased. Interactions among the hydrocolloids, proteins, and salt led to the formation of a three dimensional network, causing all formulations to display weak gel behavior under oscillatory shear. This structure increased during storage because the hydrocolloids had more time to interact with the milk proteins. Dressing pH had the most significant effect on structure, with a greater degree of solid-like behavior occurring closer to the isoelectric point of casein (pH = 4.6). Dressing made with lower salt concentrations generally saw a greater increase in  $G'$  over the 14-d storage period. Although changing NaCl concentration led to rheological differences, they were generally not significant. Thus, these results indicate that manipulating NaCl concentration in cottage cheese dressing can be made to mimic full salt formulations in terms of rheological properties by simultaneously adjusting pH

**Key Words:** cottage cheese, rheology, salt reduction

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#### 0508 A rapid and nondestructive fluorescence-based analyzer for monitoring the changes in deproteinized whey powder during storage.

K. Sajith Babu\* and J. K. Amamcharla, *Food Science Institute, Animal Sciences and Industry, Kansas State University, Manhattan.*

Deproteinized Whey (DPW) is a co-product obtained during ultrafiltration of whey. Subsequently, it undergoes unit operations like evaporation, crystallization, and spray drying resulting in a non-hygroscopic, free-flowing powder containing more than 80% lactose. Generally, DPW powder contains 2–7% protein, 3–4% moisture, and 8–11% ash. DPW is widely used as a replacer for sweet whey powder or lactose in bakery and confectionary applications, drink mixes, snack foods, and in certain ice-cream formulations. DPW powders may undergo chemical and physical changes such as caking, Maillard browning, and oxidation during storage. Amaltheys analyzer (Spectralys Innovation, Romainville, France) is a compact and portable fluorometer designed with 2 excitation light-emitting diodes at 280 and 340 nm. It is a rugged optical design with a low noise and enhanced UV sensitivity linear charge-coupled device. The objective of the present study was to use Amaltheys analyzer for monitoring Maillard changes during storage of DPW powder. For this purpose, 30 DPW samples were collected from a commercial manufacturer from different lots of production and storage periods. The FAST index (fluorescence of advanced Maillard products and soluble tryptophan) and the whey protein nitrogen index (WPNI) for DPW powders were measured by fluorescence-based Amaltheys analyzer. Additionally, colorimetric  $L^*$ ,  $a^*$ , and  $b^*$  values and water activity ( $a_w$ ) were also determined. The changes in terms of color and  $a_w$  of DPW powder effected by storage time exhibited definite correlations. The  $L^*$  values of DPW powders ranged from 85.86–92.02 and  $a_w$  values ranged from 0.307–0.418. It was observed that lightness ( $L^*$ ) was negatively correlated ( $R = -0.71$ ;  $P < 0.01$ ) with  $a_w$  of DPW powders. On the other hand, redness ( $a^*$ ) value was positively correlated ( $R = 0.82$ ;  $P < 0.01$ ) with  $a_w$  of DPW powders. From the Amaltheys analyzer, the highest FAST index was observed as 362.24 for the powder with  $a_w$  of 0.394. On the other hand, the lowest FAST index observed was 87.16 at  $a_w$  of 0.381. It was also observed that FAST index was positively correlated ( $R = 0.46$ ;  $P < 0.05$ ) with redness ( $a^*$ ) value of DPW powders. A negative correlation ( $R = -0.89$ ;  $P < 0.01$ ) between FAST index and WPNI was observed. The FAST index and WPNI obtained using Amaltheys analyzer method is a simple, rapid, and low-cost method for the detection of Maillard changes in stored DPW powders.

**Key Words:** deproteinized whey powder, Maillard changes, FAST index

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**0509 Evaluation of mineral compositions in commercial Mongolian dried yogurts (Aaruul) marketed at retail stores in Mongolia.** Y. W. Park<sup>1</sup>, B. I. Davis<sup>\*1</sup>, J. H. Ko<sup>2</sup>, K. P. Bastola<sup>3</sup>, A. Siddique<sup>1</sup>, and J. O. Jones<sup>1</sup>, <sup>1</sup>Fort Valley State University, GA, <sup>2</sup>Mongolia Huree University of ICT, Ulaanbaatar, Mongolia, <sup>3</sup>Fort Valley State University, GA.

Dried yogurt products (DYPs: Aaruul) have traditionally been produced and consumed in Mongolia in various product shapes and packages. However, information on nutrients and mineral compositions of Mongolian DYPs are almost nonexistent. The objective of this study was to determine mineral compositions of commercial Mongolian DYPs. Five varieties (MD, KA, AC, AA, HU) of Mongolian DYPs were purchased at local retail outlets at Ulaanbaatar, Mongolia. Concentrations of 20 major and trace minerals were quantified by an Inductively Coupled Plasma Optical Emissions Spectrometer (Thermo Jarrel Ash Enviro 36, Worchester, MA) using argon as carrier gas and the USEPA Method 6010 at different wavelengths for each different minerals. The respective wavelengths used for the analysis of 20 elements were: Al, 396.2; B, 249.7; Ba, 233.5; Ca, 317.9; Cd, 228.8; Co, 228.6; Cr, 267.7; Cu, 327.4; Fe, 238.2; K, 766.5; Mg, 285.2; Mn, 257.6; Mo, 202.0; Na, 589.6; Ni, 231.6; P, 213.6; Pb, 220.4; Si, 251.6; Sr, 421.6; Zn, 206.2 nm. The ranges of dry matter (DM) and ash contents of DYPs were 67.7 to 96.6 and 1.3 to 4.1%, respectively, indicating the Mongolian Aaruul products contained very high DM and ash contents. The respective mean mineral concentrations (ppm, wet basis) of the highest (AC) and lowest (MD) brands were: Ca 5183, 1236; P 8934, 2419; K 6989, 1350; Na 1523, 233; Mg 440, 123; Fe 17.3, 5.20; Mn 0.787, 0.704; Cu 8.40, 7.53; Zn 34.1, 15.6. These data indicate that the AC brand contained significantly ( $P < 0.01$ ) higher all macro and trace minerals than those of other four brands, which were apparently due to the higher levels of DM and ash in the AC compared with the other brands. The AC product contained much higher levels of P and K than those of the other brands, where the P and K contents were even greater than that of Ca in the products. Heavy metal (Pb, Cd and Ni) contents of all experimental Aaruul products appeared to be in normal ranges. It was concluded that most of the 20 mineral concentrations in Mongolian DYPs were very high, which were greater than those in powdered cow milk products reported previously.

**Key Words:** Mongolian dry yogurt, minerals, composition

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**0510 Potential protective effect of camel milk and yogurt with chromium on alloxan induced hyperglycemia in rats.** M. M. Motawee<sup>\*1</sup> and A. M. Badawi<sup>2</sup>, <sup>1</sup>National Organization for Drug Control and Research, Giza, Egypt, <sup>2</sup>ph.D, Giza, Egypt.

Insulin and oral hypoglycemic agents are the main ways to treat diabetes mellitus and are effective in controlling hyperglycemia, but these kinds of drugs also have prominent side effects. Camel milk, Yogurt-Camel milk and Chromium have attracted a lot of attention for their potential effects in human health. The aim of this study was to investigate the prophylactic effects of Camel milk (CM), Yogurt-Camel milk (YCM) and Chromium Picolinate (CrPi) on diabetic animals. Oxidative stress and dyslipidemia are associated with diabetes mellitus. The samples of camel milk were collected fresh from Elareesh, Egypt, and were prepared for this study. Forty-eight adult male albino rats were classified into six groups: Group I control negative (-ve), animals of group 2 were rendered to diabetes by alloxan (145 mg/kg body weight, I.P.). Meanwhile, groups 3–6 were fed daily with CM products [(CM), (CM-CrPi), (YCM) and (YCM-CrPi)] for 6 wk then induced diabetes by alloxan. The study was assigned for 6 wk. The results revealed that the CM and YCM showed a significant decreases in serum glucose, glycosylated hemoglobin (HbA1C) and lipids level ( $p < 0.05$ ) and improved lipid per-oxidation, serum insulin level, lipid profile and total antioxidant capacity (TAC) in diabetic rats. Both CM and YCM supplementation with CrPi potentially ameliorated effect in glucose, and oxidative stress and also increased serum insulin level in diabetic rats. The histopathological examination confirmed our results. In conclusion, the administration of CM and YCM with CrPi supplementation can lower the side effects of hyperglycemia, hyperlipidemia, improve antioxidant activity and healthy status of diabetes.

**Key Words:** alloxan, camel milk, chromium, yogurt

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**0511 Characteristics, composition and sensory properties of butter from cows on pasture versus indoor feeding systems.** T. F. O'Callaghan<sup>\*1,2</sup>, H. Faulkner<sup>2</sup>, S. McAuliffe<sup>3</sup>, M. G. O'Sullivan<sup>1</sup>, D. Hennessy<sup>3</sup>, P. Dillon<sup>3</sup>, K. N. Kilcawley<sup>2</sup>, C. Stanton<sup>1,2</sup>, and R. P. Ross<sup>1</sup>, <sup>1</sup>University College Cork, Ireland, <sup>2</sup>Teagasc Food Research Centre, Cork, Ireland, <sup>3</sup>Teagasc Animal and Grassland Research and Innovation Centre, Cork, Ireland.

This study evaluated the effects of three widely practiced feeding systems of cows on the characteristics, quality and consumer perception of sweet cream butter. Fifty-four multiparous and primiparous Holstein Friesian cows were divided into three groups ( $n = 18$ ) for an entire lactation. Group 1 was housed indoors and fed a total mixed ration diet (TMR), Group 2 was maintained outdoors on perennial ryegrass only pasture



(GRASS), while Group 3 was also maintained outdoors on a perennial ryegrass/white clover pasture (CLOVER).

Mid-lactation butter was manufactured in triplicate with milk from each group in June 2015, and was analyzed over a 6-mo storage period at 4°C for textural and thermal properties, fatty acid composition, volatile analysis and sensory properties.

The nutritional value of butters was improved by pasture feeding; having lower atherogenicity index scores than that of TMR butters. With this, pasture derived milks produced butter with significantly higher concentrations of CLA ( $c_{9t11}$ ) ( $P < 0.01$ ) and  $\beta$ -carotene ( $P < 0.05$ ). Alterations in the fatty acid composition of butter resulted in significant differences in textural and thermal properties, and spreadability index scores. Volatile analysis of butter by GC/MS identified 25 compounds present in each of the butters, five of which differed significantly ( $P < 0.05$ ) based on feeding regimen including acetone, 2-butanone, 1-pentenol, toluene and  $\beta$ -pinene. Toluene was significantly ( $P < 0.00$ ) correlated with pasture derived butter. Sensory analysis revealed significantly higher scores ( $P < 0.01$ ) for GRASS derived butter in several attributes including “liking” of appearance, flavor and color. Partial least square regression plots of fatty acid profiles showed clear separation of butter from grazed pasture-based diets from that of a TMR system, offering further insight into the ability of fatty acid profiling to verify pasture derived dairy products.

**Key Words:** cows diets, butter, conjugated linoleic acid

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#### 0512 Identification of protein fractions in ripened American style natural cheese manufactured utilizing recombinant bovine and camel chymosin by capillary electrophoresis.

A. C. Biswas\* and L. Metzger, *South Dakota State University, Brookings.*

During ripening, natural cheese undergoes a series of complex proteolytic reactions that are critical for flavor development. The initial phase of proteolysis is caused by the milk clotting enzyme generally known as chymosin. Recently, recombinant camel chymosin (CHY-MAX® M) has been developed, and is commercially available as a milk coagulant for natural cheese manufacture. The objectives of this study were to identify and characterize the various protein fractions by CE in American style natural cheese manufactured utilizing CHY-MAX® Extra (recombinant bovine chymosin) and CHY-MAX® M (recombinant camel chymosin). The electropherograms obtained from CE analysis showed that there was a significantly ( $P < 0.05$ ) higher degree of hydrolysis of  $\alpha_{s1}$ -CN and  $\beta$ -CN which resulted in the formation of smaller  $\alpha_{s1}$ -CN f(1–23),  $\alpha_{s1}$ -I-CN [ $\alpha_{s1}$ -CN f(24/25–199)], and various  $\gamma$ -caseins fractions in the natural cheese manufactured utilizing bovine chymosin as compared with the natural cheese manufactured utilizing camel chymosin. It was also observed that a significantly ( $P < 0.05$ ) higher percentage of soluble nitrogen at pH 4.6 develop in the natural cheese manufactured utilizing bovine chymosin.

These findings suggested that CE is a suitable technique to determine protein fractions in cheese, and CHY-MAX® M could be an appropriate alternative for CHY-MAX® Extra in American style natural cheesemaking to limit proteolysis.

**Key Words:** proteolysis, recombinant chymosin, capillary electrophoresis

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#### 0513 Effect of $\gamma$ radiation on physicochemical properties, protein-protein interaction, and microstructure of whey proteins.

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Whey proteins are generally small globular proteins that could be modified by physical, chemical or other means to improve their functional properties. The effect of  $\gamma$  radiation on the physicochemical properties, protein-protein interaction and microstructure of whey proteins were investigated. Whey protein isolate (WPI) solutions (10–36% protein) were treated with different dosages (10–35 KGy) of  $\gamma$  radiation. The viscosity of 27% protein solution treated at 25 KGy was significantly increased from 2.19 (control) to 4.78 mPa.s ( $p < 0.01$ ). Overall, the increase in viscosity of WPI solutions was most affected by the higher dosage of  $\gamma$  radiation ( $> 25$  KGy) and viscosity also increased during the 6-mo storage after treatment. Effects of  $\gamma$  radiation level and storage time on the viscosity of whey protein solutions were significant ( $p < 0.05$ ). Turbidity of WPI solutions increased from 0.14 to 0.16 for untreated and treated samples (35 KGy), respectively. Soluble nitrogen content decreased significantly from 100 to 54.7% in WPI solution after treated by radiation at 35 KGy. Sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) showed that protein cross-linking might occur in the whey protein solutions treated by  $\gamma$  radiation. Transmission Electron Microscopy (TEM) micrographs indicated that protein-protein interactions were induced by  $\gamma$  radiation in the treated WPI solutions, which displayed more uniform whey protein cluster structures compared with control samples. Results indicated that high intensity  $\gamma$  radiation could result in structure damages of whey proteins.

**Key Words:** whey protein,  $\gamma$  radiation, interaction, microstructure

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**0514 Effects of sodium polyphosphate on distribution of particle size of polymerized whey protein.**

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Protein-based fat replacers have been used in dairy foods for many years. The objective of this study was to develop a novel fat replacer using whey protein concentrate (WPC). WPC was heated with sodium tripolyphosphate (STPP) to prepare polymerized whey protein particles as fat replacer for nonfat dairy product formulation. The effects of STPP concentration (0–1%, wt/wt), protein content (8–10%, wt/vol), pH (7.5–8.5), heating temperature (70–85°C), and time (5–25 min) on the particle size distribution were investigated. Results showed that heating WPC solution (8.0%, wt/vol) with 0.4% STPP at pH 7.5 at 85°C for 5 min resulted in 40% of particles in the range of 1–3 µm, which were as large as fat globules in dairy products. There were no large particles (> 10 µm) yielded when 0.4% STPP was added, but higher STPP levels (> 0.5%) produced larger particles (> 10 µm) at a unimodal distribution. The percentage of particle size between 1 and 3 µm decreased with increasing WPC concentration. A wide distribution or even multi-peaks with more large particles (> 10 µm) were observed when the mix was heated at higher pH values (8–8.5). When heating the mix at 70–85°C for 5 min, 20%–40% of the particles were in the range of 1–3 µm and prolonged heating time also generated large particles (> 10 µm). Results indicated that heating whey protein concentrate with STPP could produce particles/aggregates that might be suitable as fat replacer for non or low fat dairy products.

**Key Words:** fat replacer, sodium tripolyphosphate, whey protein concentrate

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**0515 Effects of ultrasound treatment on physicochemical properties of whey protein soluble aggregates.**

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Functional properties of whey protein could be improved by heat-induced aggregation. The aim of this study was to determine the effect of high-intensity ultrasound on thermal aggregation of whey proteins. Whey protein solutions were sonicated for 20 min using an ultrasonic probe (frequency: 20 kHz; amplitude: 20%) pre- and post-thermal aggregation (85°C for 30 min). Changes in particle size, zeta-potential, surface hydrophobicity, free sulphhydryl group content (-SH), protein-protein interactions, turbidity, thermal denaturation properties and viscosity were studied. Soluble aggregates

prepared with ultrasound treated post-thermal aggregation resulted in significantly smaller particle size and broader size distribution compared with those prepared by untreated or ultrasound treated pre-thermal aggregation ( $P < 0.05$ ). It was suggested that the surface hydrophobicity of the soluble aggregates was slightly but significantly increased by ultrasound treated post thermal aggregation ( $P < 0.05$ ). There was a significant reduction in turbidity of whey protein solutions by ultrasound treated post thermal aggregation ( $P < 0.05$ ). The viscosity of WPI dispersions significantly decreased by ultrasound treated post-thermal aggregation ( $P < 0.05$ ). Ultrasound treatment increased denaturation temperature (Td) and decreased DH of soluble aggregates slightly, suggesting that limited improvement of heat stability. There were no significant changes in zeta-potential, free sulphhydryl group by ultrasound treatment either pre- or post-thermal aggregation ( $P > 0.05$ ). Results indicated that ultrasound treatment on post thermal aggregation had considerable impact on particle size, surface hydrophobicity, turbidity, and viscosity of whey protein soluble aggregates.

**Key Words:** whey protein, thermal aggregation, physicochemical property

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**0516 Crystallization of calcium phosphate in stabilized-paste white mold cheese rinds.**

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Increased pH at the surface of traditional white mold cheese results in calcium phosphate (CaP) crystallization and accumulation of CaP in the rind. At the same time, this phenomenon results in depletion of CaP in the rest of the cheese wheel. An experiment was conducted to identify crystals that form in the rind of stabilized-paste white mold cheese and to correlate the crystallization phenomenon to pH gradients between the center and rind and to the diffusion of dissolved minerals from the center of the cheese to the rind. In this randomized block design, three batches of a Vermont stabilized-paste white mold cheese (batches representing blocks) were sampled throughout the aging process from 1 d post-manufacture to 4 d after packaging. Two wheels were removed from each batch on d 1, 4, 7, 10, 14, and 18, with d 0 representing the day of manufacture and packaging occurring on d 14. Three-millimeter-thick samples were cut from rind and center locations of each cheese and tested for moisture by forced draft oven drying, and the dried samples were tested for calcium and phosphorus by ashing and analyzing with ICP–AES. Rind and center pH measurements were collected from each wheel. Powder X-ray diffraction (PXRD) patterns were generated from cheese collected from the center and rind of each wheel to identify crystal phases. Petrographic microscopy (PM) images were also collected from rind and center samples to observe the size of



crystals. PXRD revealed that brushite ( $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ ) deposited in the rind by d 10 with increasingly stronger PXRD signals for brushite apparent on d 14 and 18. PM revealed that the crystals grew to a maximum of 20  $\mu\text{m}$  in diameter by d 18. The appearance of brushite corresponded to significant increases in rind pH, accumulation of CaP in the rind, and depletion of CaP in the center. Rind pH rose from approximately 5.1 on d 1 to approximately 5.3 by d 10 and to approximately 5.6 by d 18, while the center pH did not rise above 5.1. This was a considerably smaller pH increase than occurs in traditional white mold cheese. Nonetheless, the mechanism of crystallization and diffusion of dissolved CaP in stabilized-paste white mold cheese appears similar to that previously observed in traditional white mold cheese.

**Key Words:** cheese, crystals, brushite

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**0517 Effect of buffalo  $\alpha_{s1}$ -casein polymorphism on the semi-hard Monterey Jack-type cheese quality.**

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The influence of  $\alpha_{s1}$ -casein polymorphisms on milk processing properties, and cheese quality of cow milk have been well researched, while the effect of buffalo milk protein polymorphisms on cheese quality is still unclear. The objective of this study was to investigate the effect of buffalo  $\alpha_{s1}$ -casein polymorphisms on the quality of semi-hard Monterey Jack-type cheese. Water buffalo milk with different  $\alpha_{s1}$ -casein genotype (BB and AB) and the same  $\kappa$ -casein (BB) and  $\beta$ -casein (BB) type was collected from local dairy farm, mixed sample from milk tank was used as control. The protein/fat ratio of buffalo milk was standardized to 0.75(g/g), then fresh Monterey Jack-type cheese was made according to the standard procedure, vacuum-packaged and stored at 4°C, samples were tested at 7 d. The composition (fat, protein, ash, Ca and P), texture and color difference (CD) of cheese samples with manufactured from milk with different  $\alpha_{s1}$ -casein (BB, AB and control) type were analyzed. Results showed that cheese made from milk with BB type  $\alpha_{s1}$ -casein (BB type cheese) contained significantly lower fat, but higher protein, ash, Ca and P content in DM than AB type ( $P < 0.05$ ). The Ca/protein content of BB type cheese was 3.78g/100g, which was also higher than AB type (3.51g/100g) and control (3.60 g/100g). For the texture, hardness and springiness of BB type cheese were 41.21 N and 6.31 mm, significant higher than AB type (29.45 N, 5.56 mm) and control (38.21 N, 5.25 mm), except that, the gumminess, adhesiveness and chewiness of BB type cheese were also higher than AB type ( $P < 0.05$ ). For the CD, b value of BB type cheese was lower than AB type ( $P < 0.05$ ), which means the cheese color of BB type was more white. In conclusion, the quality of semi-hard Monterey Jack-type buffalo milk

cheese was related with  $\alpha_{s1}$ -casein polymorphism, BB type cheese has the best texture and color for traditional Monterey Jack-type cheese.

**Key Words:**  $\alpha_{s1}$ -casein polymorphism; buffalo milk; cheese quality

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**0518 Membrane fractionation of delactosed permeate to enhance salty taste.** L. D. Alexander<sup>\*1</sup>,

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Delactosed permeate (DLP), commonly referred to as mother liquor, is a byproduct of lactose manufacture and is typically relegated to animal feed use. Previous work has established that compounds other than sodium, such as organic acids and potassium (K), contribute to the salty taste of DLP but that residual lactose suppresses salty taste. The objective of this study was to determine the viability of fractionating DLP into two components, one that would be re-cycled into the lactose manufacturing processing and one that would be used as a salt substitute. Two lots of commercial DLP were obtained from four different lactose manufacturers (totaling eight samples). The composition of these samples ranged from 27.9 to 39.7% total solids. Each DLP sample was diluted to approximately 5% TS using soft tap water and then subjected to nanofiltration (500 Da MWCO, NFW-3B-3838, Synder Filtration) in a batch process. Nanofiltration was performed until the flux rate dropped below 10 Lmh. Subsequently, the NF permeate fraction was concentrated to approximately 8% TS using reverse osmosis (RO) (RO2-3838-BS04, Parker-Hannifin). The initial DLP, NF retentate, and RO retentate were analyzed for total solids (vacuum oven) and ash (muffle furnace). Selected minerals (Ca, Na, Mg, P, S and K) were determined by plasma emission spectroscopy, lactose and organic acids by HPLC, and volatile compounds by GC-MS. A trained panel documented sensory properties of the liquid DLP and fractions at equivalent solids (8% (w/w)). The DLP displayed a variety of aromatic flavors including cardboard, beefy, and potato as well as distinct salty taste, consistent with previous studies. Nanofiltration of DLP followed by RO resulted in a fluid that was higher in salty taste ( $p < 0.05$ ) than the DLP or NF retentate with consistent low, but distinct, bitter taste. Concurrent with increased salty taste, the RO retentate had higher K and Na, higher concentrations of citric, lactic and orotic acids and decreased lactose than the NF retentate ( $p < 0.05$ ). Aromatic flavors present in DLP were detected in both NF and RO retentates suggesting the need to address removal of these flavors. Membrane fractionation of DLP can be applied to enhance its application as a salt substitute.

**Key Words:** delactosed permeate, nanofiltration, reduced sodium

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**0519 Characterization of queso fresco made with Na/K salt blends and stored for 12 wk.**

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Health-conscious consumers are looking for ways to reduce dietary sodium yet want their cheeses to have the flavor, texture, and shelf-life of full-salt cheese. The objectives of this study were to determine the effects of different Na-K salt blends and storage on the compositional, sensorial, microbial, functional, and rheological properties of Queso Fresco (QF), a fresh cheese with a distinct salty taste. QF was made in triplicate on different days with curds from each vat being divided and salted using 1.0% NaCl and 0.5, 1.0, 1.3, or 1.5% added KCl; a 2.0% NaCl QF control and a 0.75%:0.75% Na:K QF were also made. The QF were then stored at 4C for up to 12 wk.

Although the variation in salt treatments were in a fairly narrow range, 1.5 to 2.5% total salt, differences ( $P < 0.05$ ) in some of the QF characteristics were noted. Moisture and ash levels were influenced by salt content while storage impacted moisture and salt levels, water activity, and pH. Only QFs with 1.0% NaCl and 1.3 or 1.5% KCl had sensory saltiness scores similar to the 2.0% NaCl QF control. Loss of free serum from the cheese matrix significantly increased up to 7.5% over the 12 wk of the study with the samples at the higher levels of salt retaining more of the serum in the cheese matrix. Aerobic microbial counts decreased slightly after 2 wk for QF containing  $> 1.5\%$  salt, and all samples increased 1 to 2.7 logs by wk 10. The variation in the salt content did not alter the non-melt characteristic of the QF samples, while the 2% NaCl QF control had the lowest change in color when baked (130°C for 30 min) and the QF containing 1.0 to 1.5% KCl had the lowest color change when broiled (232°C for 5 min). No significant differences were noted in texture hardness, springiness, or chewiness or in the viscoelastic properties among the treatments or over time.

The minor differences in quality traits that resulted in aging QF made with 1% NaCl and 0.5 to 1.5% added KCl showed that KCl substitution was a viable route for reducing sodium in QF. The best overall Na-K blend for QFs were made using 1% NaCl and 1.3 or 1.5% KCl. Findings from this study will help in developing a reduced sodium QF that meets the demand of health-conscious consumers.

**Key Words:** cheese, queso fresco, reduced sodium

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**0520 Effect of micro-encapsulated iron salts on Cheddar cheese divalent cation balance and composition.** A. Arce\* and Z. Ustunol, *Michigan State University, East Lansing.*

Milk is considered an important source of macro- and micro-nutrients but naturally low in iron content. Cheese and other dairy products had been fortified with iron with low success

due to negative changes in composition and organoleptic attributes. There is limited information about using micro-encapsulation of iron compounds in dairy products. Minerals have the ability to displace one another in any system; consequently, it is expected that encapsulation will avoid divalent cation displacement within the cheese matrix. The objective of this study was to analyze divalent cation balance in fortified Cheddar cheese with micro-encapsulated ferrous sulfate. Furthermore, proximate analysis was done to provide more information about any compositional changes after fortification.

Cheddar cheese was manufactured using standard Cheddar cheese procedures a total of three times. Cheddar cheese was either fortified with large micro-encapsulated ferrous sulfate (LMFS; 0.9536 g micro-encapsulated ferrous sulfate/Kg cheese, 700–1000  $\mu\text{m}$  diameter) or small micro-encapsulated ferrous sulfate (SMFS; 1.7801 g microencapsulated ferrous sulfate/Kg cheese, 220–422  $\mu\text{m}$  diameter). Iron treatment was incorporated to Cheddar cheese processing in the salting step but omitted for the control. After 90-d aging, calcium, iron, magnesium and zinc content were analyzed using Atomic Absorption Spectroscopy and percent recoveries were calculated. Moisture, ash, fat, and protein analysis were done using AOAC methods. All collected data was analyzed using one-way ANOVA and Tukey's HSD Test ( $p = 0.05$ ).

Iron content for all treatments were significantly different ( $P < 0.05$ ); approximately 0.03 mg Fe/g cheese for the control, 0.134 mg Fe/g cheese for LMFS, and 0.174 mg Fe/g cheese for SMFS. Results showed 81.3% iron recovery for LMFS and 90% iron recovery for SMFS. Proximate analysis, and magnesium, zinc and calcium content were not significantly different when comparing fortified cheeses with the control. Overall, micro-encapsulated ferrous sulfate caused no major changes in terms of Cheddar cheese composition and successfully increased iron content. Micro-encapsulated ferrous sulfate with smaller diameter showed slightly better results for iron retention in Cheddar cheese. The proposed fortified Cheddar cheese can help increase total iron intake for children, pregnant women, vegetarians and those whose diets are likely to be deficient in iron by providing at least 5 mg Fe (30% RDA) per serving.

**Key Words:** cheese, minerals, fortification

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**0521 Chemical characteristics and enhanced hepatoprotective activities of Maillard-reaction products derived from milk protein-sugar system.** N. S. Oh\*, J. Y. Lee, J. Y. Joung, and Y. K. Shin, *R&D Center, Seoul Dairy Cooperative, Ansan, Korea (The Republic of)*

The objective of this study was to investigate the characteristics, antioxidative properties, and hepatoprotective effects of Maillard reaction products (MRP) from milk protein reacted with sugars. The MRP were obtained from milk protein, whey protein concentrates and sodium caseinate, using 2 types of

sugars, lactose and glucose, by heating the mixture at 55°C for 7 d in a sodium phosphate buffer (pH 7.4). Changes in the chemical modification of the milk protein were monitored by measuring the protein-bound carbonyls and PAGE protein profiles. The results showed that the amount of protein-bound carbonyls increased after Maillard reaction (MR). In addition, sodium dodecyl sulfate-PAGE analysis indicated a formation of high-molecular weight complexes through MR. The modification sites induced by MR of milk protein were monitored by matrix assisted laser desorption/ionization time-of-flight mass spectrometry analysis of tryptic-digested gel spots of MRP. As a result, modification and their localization in AA sequence of MRP was identified. Also, the MRP showed higher antioxidant activities than the intact milk protein, and they reduced intracellular reactive oxygen species production and inhibited the depletion of the reduced glutathione concentrations in the HepG2 cells. In particular, glucose-sodium caseinate MRP showed the highest biological activities among all MRP. Therefore, these results suggest that the MRP from milk protein reacting with sugars possess effective antioxidant activity and have a protective ability against oxidative damage.

**Key Words:** Maillard-reaction, milk protein, hepatoprotective effect

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## DAIRY FOODS DIVISION: DAIRY CHEMISTRY II

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### 0522 Prediction of intact casein in cheese by using amalthey's: A front-face fluorescence analyzer.

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During cheese ripening, proteolysis is an important biochemical event which leads to texture and functionality changes over time. The intact casein content of cheese decreases during aging due to the enzymatic hydrolysis. However, because of the difference in storage history and compositional variability, it is difficult to rapidly estimate the amount of intact casein of different batches of cheese. In this study, the feasibility of using front-face fluorescence spectroscopy (FFFS) to predict the amount of intact casein in different cheese samples was evaluated by using fluorescence-based Amalthey's analyzer (Spectralys Innovation, Romainville, France). Twenty cheese samples from different manufacturers and with different storage time were used for this study. The intact casein was measured by fractionation of cheese proteins using Sharp's solution (pH = 4.6) and followed by nitrogen analysis using Kjeldahl method (6.38 conversion factor). Cheese was cut into the size which can fit the cuvette for fluorescence

measurement using Amalthey's, and 5 fluorescence scans from 5 different locations on each cheese sample were analyzed. 3D fluorescence spectra were collected on each cheese sample at room temperature and processed using parallel factor analysis (PARAFAC) algorithms. PARAFAC scores were then used to build a calibration model against the reference intact casein values. Practical utility of the model was evaluated using the range error ratio (RER) and the ratio of prediction error to deviation (RPD). The RPD was found to be over 2 and RER was over 10, indicating a good practical utility of the model. Hence, FFFS can be used as an analysis technique to predict intact casein in cheese and the results indicate that Amalthey's analyzer can be a rapid and accurate device to analyze intact casein in cheese samples.

**Key Words:** front-face fluorescence spectroscopy, intact casein, cheese ripening

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### 0523 Changes of the state of calcium and protein in low-fat and full-fat processed cheese during cheesemaking.

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"Creaming" is an increase in the viscosity of hot molten cheese during processed cheese cooking, and it is important for cheese manufacturers to control the viscosity during the production process. The objective of this study was to understand the interactions between protein, calcium, and fat in full-fat (FF)/low-fat (LF) processed cheese. Processed cheeses were made from 4-mo-old 9% fat Cheddar cheese and 2.3% tetrasodium pyrophosphate (TSPP). Anhydrous milk fat was added for FF cheese. A steam-jacketed kettle was used to heat 7 kg of the ingredients up to 80°C, and approximately 200 g of hot molten cheese was extracted during the holding process (80°C with shear) at certain points (0–40 min). It was poured into plastic bags, and rolled to a thickness of 4 mm, and cooled in chilled water. Both FF and LF cheeses had the same pH (5.6) and protein (24%) content. No moisture loss was observed during cooking. The viscosities of molten cheese were measured during holding time. The functional properties were assessed by hardness using a creepmeter, and degree of flow (DOF) values were measured using a modified UW-Melt profiler. The precipitate compositions of cheese dispersion after centrifugation were analyzed, and the serum phase of the cheese was extracted from the dispersion by ultrafiltration and the casein-bound calcium content was assessed. Creaming was observed in LF and FF cheeses. In LF cheese, the viscosity was drastically increased at 30 min holding time. Over-creaming was observed in FF cheese at 40 min holding time. As the holding time increased, the hardness of both cheeses increased, whereas the DOF of both cheeses decreased. LF cheese initially