Our objective was to determine the relationship between bulk tank or tanker milk fat and true protein concentration and the concentration of de novo (DN: C4 to C14), mixed origin (MO: C16 and C16:1), and preformed (PF: > C18) fatty acids (FA) expressed as g per 100 g milk. Bulk tank or tanker milk samples from 167 Holstein farms (50 to >10,000 cows/farm) were collected from a wide geographic area within the US and analyzed for fat, true protein, and milk FA composition determined using mid-infrared red (MIR) milk analysis with a Delta model FTA MIR milk analyzer. Bulk tank and tanker milk samples were preserved with Microtab II at 1 tablet per 90 mL milk, refrigerated, and shipped overnight on ice for testing. Dairy farms included both total mixed ration and grazing feeding systems. Herd average milk production per cow ranged from 22 to 47 kg per cow per d while concentrations of fat and true protein were from 3.0 to 4.3% and 2.7 to 3.35%, respectively. Mean milk fat concentration (Y) increased significantly (P < 0.05) with increased DN FA concentration (X) (Y = 2.241 X + 1.794; R² = 0.62) and increased MO FA concentration (X) (Y = 1.894 X + 1.184; R² = 0.77) when expressed as g FA/100 g milk. Bulk tank milk fat concentration increased with increasing PF FA concentration, but the relationship was not as strong (Y = 1.30 X + 1.89; R² = 0.37) as for DN and MO FA. Bulk tank milk true protein concentration increased with increasing PF FA concentration, but the relationship was not as strong (Y = 1.30 X + 1.89; R² = 0.37) as for DN and MO FA. Bulk tank milk true protein concentration increased with increasing DN FA concentration (Y = 0.714 X + 2.453; R² = 0.30). The relationships over a wide geographic area of the US and more diverse farm management practices were similar to those found in a previous study of Holstein herds in northeastern US. Using data from bulk tank or tanker milk, FA composition may be useful in understanding rumen fermentation driven changes in milk fat and protein concentration.

Key Words: milk fat, milk true protein, de novo fatty acids

Fraudulent addition of foreign substances is a usual form of milk adulteration in some countries, usually to disguise poor quality parameters or even other illegal practices, such as water addition to the milk. For example, formaldehyde and hydrogen peroxide are illegally used to reduce microbial countings, while bicarbonate is used to neutralize lactic acid formed during microbial growth. To date, not much is known about the influence of these foreign substances upon the raw milk quality evaluation using Fourier-transform infrared spectroscopy (FTIR) and flow cytometry methods. The objective of this work was to analyze the raw milk composition readings obtained by FTIR spectroscopy. Raw milk was adulterated with formaldehyde (25; 50; 100 ppm), hydrogen peroxide (100; 500; 1000 ppm) and sodium bicarbonate (300; 500; 1000 ppm) in vials containing bronopol as preservative, and stored at 2 temperatures (7°C and 25°C). Components (fat, protein, lactose, total solids, solids nonfat, MUN and SCC analyses; CombiScope FTIR, Delta Instruments), and total bacteria counting (TBC) (BactoScan FC, Foss Electric) were performed after storage (0, 3, 24, 48, 72, and 168 h). Multiple linear regression model was used for statistical analysis. The addition of these adulterants resulted in significant changes (P ≤ 0.05) for all dependent variables. Formaldehyde addition resulted in slightly increased readings for all components, except for casein, SCC, TBC and freezing point, which decreased. Hydrogen peroxide addition resulted in higher results for evaluated milk parameters, except for lactose, casein, SCC and TBC, which decreased. Finally, sodium bicarbonate addition slightly increased fat, protein, lactose, TS, SNF, TBC and decreased casein, MUN, SCC, and freezing point results. These alterations were more impacting for MUN and TBC. It is concluded that components analyzed by FTIR method may be affected by foreign substances illegally added to the raw milk. However, through chemometric techniques, these abnormal spectrum readings have the potential to be used for FTIR monitoring of milk adulteration.

Key Words: raw milk, fraud, FTIR

The concentration of casein and serum protein and the relative proportion of casein to true protein in milk-based beverages and microfiltration (MF) retentates will influence their sensory and functional properties. Therefore, control of protein concentration and the ratio of casein and serum protein may be important commercially. Our objective was to develop partial least square (PLS) models using mid-infrared (MIR) spectra to predict true protein (TP), casein (CN), serum protein (SP), and CN as percentage of TP (CN%TP) content of microfiltration (MF) retentates and unflavored milk-based beverages. A total of 625 milk formulations varying in fat (2.5, 3.2, 3.9, 4.6, 5.3%), TP (2.5, 3.1, 3.7, 4.3, 4.9%), CN%TP (71, 75, 79, 83, 87%), and anhydrous lactose (3.5, 4.0, 4.5, 5.0, 5.5%) were produced using different combinations of skim milk ultrafiltration permeate, serum protein isolate, microfiltration retentate, cream, lactose monohydrate, and distilled water. MIR spectra were collected for each formulation, and in addition all formulations were analyzed in duplicate by Kjeldahl for total nitrogen, non-protein nitrogen, and non-casein nitrogen. Separate PLS models were developed for prediction of TP, CN, SP concentration (g/100 g of beverage) and CN%TP using the spectral ranges: (3,000 to 2,750, 1,800 to 1,700, and 1,580 to 1,000 cm⁻¹). The relative predictive differences (RPD) for TP, CN, SP, and CN%TP PLS models were 62.70, 31.45, 14.10, and 3.79, respectively, the standard errors of cross validation (SECV) were 0.0139, 0.0220, 0.0183, and 1.2405%, respectively, and R-squared for the models were 0.999, 0.999, 0.995, and 0.930, respectively. PLS models with RPD values <8 are not accurate enough for analytical purposes. The standard deviation of the difference (SDD) between reference and PLS predicted CN%TP was 1.236%. A more accurate prediction of CN%TP was achieved by using the PLS predicted CN and TP to calculate CN%TP (SDD = 0.558%).

Key Words: mid-infrared, casein, microfiltration

Historically, lactose has been reported as a calculated residual difference of solids minus fat, protein, and a constant ash. This method generally over estimates milk lactose content by 0.2 to 0.3% lactose. Our objective was to document the within and between laboratory performance of the spectrophotometric enzymatic method (Association of Official Analytical Chemists method 2006.06) for determination of the lactose content of milk used in the USDA Federal Milk Market Order laboratories. Monthly, from January through December 2017, 6 or 7 laboratories tested 14 milk samples in duplicate and reported anhydrous lactose results. The mean relative repeatability (within lab) standard deviation (RSDw) was 0.198 ± 0.021% and relative reproducibility (between lab) standard deviation (RSDb) was 0.352 ± 0.053% for anhydrous lactose measurement in 2017 at a mean anhydrous lactose concentration of about 4.55% (mass/mass). The analytical performance of the lactose analysis method was comparable to Kjeldahl true protein analysis of milk with a mean RSD of 0.161 ± 0.014% and RSDb of 0.470 ± 0.062% for Kjeldahl true protein measurement in 2017 at a mean true protein concentration of about 3.15% (mass/mass). To achieve better accuracy of analytical results for milk payment, dairy plant accounting for milk components, and calculation of more accurate milk energy and true protein was not observed with variation in PF FA concentration.

**Key Words:** anhydrous lactose, method performance

**465 The relationship between seasonal variation in bulk tank milk fat and true protein and milk fatty acid composition for Holstein herds.** D. M. Barbano*1, C. Melilli1, M. E. Carabeau3, H. M. Dann2, and R. J. Grant2, 1Cornell University, Ithaca, NY, 2W. H. Miner Agricultural Research Institute, Chazy, NY, 3Poulin Grain Inc., Brookings, SD.

Our objective was to determine if there is a relationship between seasonal variation in bulk tank milk fat and protein concentration and the concentration of de novo (DN: C4 to C15), mixed origin (MO: C16 and C16:1), and preformed (PF: > C18) fatty acids (FA) expressed as g per 100 g milk. Bulk tank or tanker milk samples from 46 Holstein farms was analyzed for fat, true protein, and milk fatty acid composition determined using mid-infrared red (MIR) milk analysis with a Delta model FTA MIR milk analyzer. Milk from each farm was analyzed between 6 and 25 times per month for the period of January 2014 through December 2017 as part of the routine milk payment testing at the St Albans Cooperative, St Albans, Vermont. A monthly average of the milk composition was calculated for 46 farms. The seasonal variation in fat and true protein content for the group of farms had the typical seasonal pattern with fat and true protein concentration being high in the winter months and low in the summer months. Seasonal variation of fat and true protein concentration (g/100 g milk) had a similar temporal pattern as DN + MO FA concentration (g/100 g milk), while this temporal pattern in relation to fat and true protein was not observed with variation in PF FA concentration. Mean milk fat concentration (Y) increased significantly (P < 0.05) with increasing DN + MO FA concentration expressed as g FA/100 g milk (X) (R-squared 0.60) and true protein concentration (X) (R-squared = 0.59). Bulk tank milk fat (R-squared 0.22) was increased significantly (P < 0.05), while no significant relationship (P > 0.05) between PF FA and true protein was observed. The typical decrease in milk fat and protein in the summer months may be related to factors that cause changes in rumen fermentation of carbohydrates and production of rumen volatile fatty acids (VFA) as reflected by lower de novo FA content of milk fat. Identification of seasonal factors influencing rumen VFA may lead to dairy cow feeding and management strategies that minimize seasonal variation in bulk milk composition for dairy product manufacture and allow more efficient production of dairy products.

**Key Words:** milk fat, milk true protein, de novo fatty acids

**466 Vibrations during yogurt fermentation—Impact on particle formation and further texture defects.** A. O. Körzendörfer*1, P. Temme2, E. Schlücker2, J. Hinrichs1, and S. Nöbel1, 1Institute of Food Science and Biotechnology, University of Hohenheim, Stuttgart, BW, Germany, 2Department of Chemical and Biological Engineering, Friedrich-Alexander University Erlangen-Nürnberg, Erlangen, Germany.

The quality of stirred yoghurt is determined by texture attributes like appearance, flow behavior, and mouthfeel. In dairy industry, machines like pumps used for the commercial production generate vibrations that can spread to the fermentation tanks. During acidification, such vibrations disturb the gelation of milk proteins by causing texture defects including lumpiness and syneresis. Removal of visible particles by mechanical post-processing will lead to structure losses and lower viscosities. To study the effect of vibrations on yoghurt structure systematically, an experimental setup was developed consisting of a vibration exciter (shaker) to generate defined vibrational states and accelerometers for monitoring. Tactile and audible frequencies as occurring in dairies up to 5,000 Hz can be generated. A novel method based on image analysis was established to quantify large particles (d > 0.9 mm) and evaluate textural objectively. Skim milk (3.4% protein) was heated to 95°C for 5 min and fermented in containers (n = 900 g) until pH 4.6. During acidification, containers were put on a table mounted on the shaker and vibrated from pH 5.6 to 5.2 (approximately 20 min). At a frequency of 30 Hz, amplitudes were set to different vibration accelerations up to 25 m/s². After fermentation, set gels were examined first and then processed into stirred yoghurt for further analyses. Vibrations treatments resulted in set gels with increased whey separation and firmness (P < 0.001). Resultant stirred yoghurts showed a positive correlation between amplitude and particle number. Vibrations increased particle numbers from 37 ± 3 (control) up to 144 ± 12 (25 m/s², P < 0.001) particles per 100 g. Yogurts exhibiting a high particle number showed an inhomogeneous texture and a reduced water-holding capacity. Furthermore, the presence of large particles resulted in reduced apparent viscosities (P < 0.001). We concluded that vibrations increase the collision probability of aggregating milk proteins entailing a coarser network structure and stirred products with unfavorable texture properties. Manufacturers should consider vibrations as a further cause for quality defects.

**Key Words:** graininess, fermented milk product, yoghurt structure

**467 Development of a continuous cavitation-assisted thermal treatment for skim milk concentrate: Process characterization and microbial efficiency.** J.Y. Sim*, S. I. Martinez-Monteagudo, and S. Anand, Dairy and Food Science, South Dakota State University, Brookings, SD.

Most of the thermotolerant organisms and their spores are capable of surviving pasteurization (75°C/15 s), and they can enter downstream processes. Combinations of high temperatures and short holding times (130–150°C/2–10 s) are effective strategies to reduce the levels of thermotolerant bacteria. However, the intense application of heat often
leads to over-processing, affecting quality and nutritional content. Strategies leading to reduce the impact of thermal processing have become a topic of industrial interest. A promising technology under development at our research group consists in combining the energy released by hydrodynamic cavitation with thermal treatment to reduce the levels of thermoduric sporeformers. This study summarizes our efforts in developing a continuous cavitation-assisted thermal treatment for the reduction of thermoduric sporeformers in skim milk concentrate (SMC). The experiments were conducted using a pilot scale cavitation coupled with a custom fabricated thermal unit. The SMC temperature in different processing steps was monitored during experiments. The increased in the temperature (delta T) due to cavitation increased with the SMC total solids (TS), yielding values of 31.35 ± 2.7, 35.15 ± 1.6, and 42.85 ± 1.4°C at 11, 25, and 36%, respectively. The experimental delta T data were modeled using a polynomial equation showing a satisfactory correlation ($R^2 = 0.98$). The microbial efficiency was evaluated in SMC (36% TS) inoculated with vegetative cells of Bacillus coagulans (ATCC 12245). The inoculated samples (4.67 ± 0.18 log) were treated by cavitation (60 Hz and 50 L h$^{-1}$), thermal treatment (75°C/15 s), and combined cavitation-thermal treatment. The 4.67 log of vegetative cell was reduced to 1.17 log by cavitation-thermal treatment, while thermal treatment reduced to 1.90 log. Contrary, individual cavitation did not produce any significant reduction. The outcomes of this study present opportunities for utilizing cavitation-assisted thermal treatment for inactivating thermoduric sporeformers and potentially the spores by a single pass.

**Key Words:** cavitation, skim milk concentrate

468 Controlling milk oxidation during high intensity retail LED light storage requires light-blocking and oxygen-barrier packaging properties. A. Wang$^*$, C. H. Dadmun$^2$, R. M. Hand$^3$, and S. E. Duncan$^1$, $^1$Virginia Polytechnic Institute and State University, Blacksburg, VA, $^2$College of Charleston, Charleston, NC, $^3$Michigan State University, East Lansing, MI.

Lighting in dairy retail cases have largely transitioned from fluorescent lighting to light-emitting diode lights (LED) to reduce energy consumption. However, LED light intensities in excess of 5000 lx are evident in retail cases, creating high potential for rapid and detrimental oxidation and destroying milk freshness. In this study, we investigated the interaction between packaging material, LED light intensity, and lighting exposure time on limiting milk oxidation. We compared 7 packaging conditions including traditional packaging [glass, translucent high density polyethylene (HDPE)], experimental packaging [white pigmented HDPE (4.9% TiO$_2$), white pigmented polyethylene terephthalate (PET, 4% TiO$_2$)], and light-exposed (clear PET) and light-protected control (foil-wrapped HDPE and PET) against 2 LED light intensities (1052 ± 484 lx and 5691 ± 512 lx) after 4 and 24 h. Higher LED light intensity (>5000 lx) and longer lighting exposure time (>24 h) significantly decreased ($P < 0.05$) dissolved oxygen and riboflavin concentration, and increased ($P < 0.05$) TBARS (final oxidation products) value in milk packaged with traditional and light-exposed packaging. Within 4 h of light exposure, white HDPE and white PET effectively protected milk freshness at both light intensities. After 24 h of light exposure, white HDPE failed to protect milk freshness while white PET successfully slowed down the milk oxidation rate at both light intensities based on TBARS and electronic nose analysis. To understand the effect of LED light intensity on consumer’s choice of milk packaging, 72 frequent milk consumers were asked to select milk packaging from 2 retail cases with different light intensities. Among them, 50.9% of consumers preferred milk packaging displayed in low light intensity retail case while 49.1% of consumers preferred high light intensity. Light-blocking TiO$_2$-added PET provides better milk protection in high light intensity retail conditions, protecting milk nutrients and flavor, by limiting riboflavin activation and oxygen availability.

**Key Words:** milk, light intensity, packaging

469 Reconstitution of MFGM phospholipids in liposomes—Physical and chemical characterization. J. Ortega-Anaya*, I. García-Cano, D. Rocha-Mendoza, and R. Jiménez-Flores, The Ohio State University, Columbus, OH.

The MFGM is a very complex component in milk that provides phospholipids, including sphingomyelin, which are of great interest in human nutrition and have demonstrated biological activity in intestinal cells and more recently in early brain development. It is structured in a specific highly organized architecture in raw milk. After processing, we assume that this architecture/structure in the MFGM is a good model for developing functional dairy foods. MFGM and its components possess an interesting technological function as an ingredient. However, there is little information regarding the microstructure, physical and chemical features of highly pure MFGM phospholipid powders after hydration. In this work, we aimed to reconstitute and characterize MFGM phospholipids into liposomes (800 nm diameter) to investigate structural features upon hydration by confocal fluorescence microscopy. We also determined their physicochemical parameters such as z-potential by dynamic light scattering. Additionally, we conducted stability studies calculating the changes in the Tm value by fluorescence-based thermal shifts using SYPRO Orange dye as the fluorescent probe. A specific mixture of milk phospholipids kindly donated by Fonterra Co-Op, NZ was used to produce our vesicles by extrusion of a thin film. We have found that MFGM reconstituted liposomes (1.5 mg/mL in PBS buffer pH 7.4) associate into unique vesicles generating a binary mixture of liposomes (250 and 800 nm diameter) with a charge in colloidal solution of −21.5 mV indicating that negatively charged phospholipids are assembled predominantly in the surface of the liposomes.

**Key Words:** milk fat globule membrane (MFGM), liposomes, milk phospholipids