Small-scale dairy farmers in African rural communities might fail to invest in cheese making process due to limited resources to acquire temperature and humidity controlled aging chambers. The study evaluated the effect of different aging conditions on physicochemical and textural characteristics of an artisanal hard-pressed cheese during ripening. The cheeses were manufactured in summer in 2 different farms using raw milk. Aging was conducted for 60 d using either a temperature and humidity controlled chamber (control: 10–12°C, humidity 80–90%`) or a traditional simulation using portable air conditioner and humidifier. Data were analyzed using a factorial arrangement of treatments with age and chamber, and their interaction, as fixed factors and farm as a random factor. The portable systems created a chamber at 18°C and 60–70% humidity. Cheese moisture, fat, pH, water activity, and non-protein nitrogen (N) were reduced during ripening (P < 0.05). The ripening index [soluble N/Total N%] was higher in the control (6.4 ± 0.38 vs 5.6 ± 0.38; P < 0.05) compared with the traditional chamber (TC). The control yielded cheeses with higher (P < 0.05) moisture% (34.05 ± 0.65) and water activity (0.96 ± 0.002). Compared with the TC, the control had lower (P < 0.05) values for total solids (65.9 ± 0.63 vs 69.9 ± 0.63), protein% (25.6 ± 0.15 vs 27.6 ± 0.15) and ash% (3.44 ± 0.11 vs 3.70 ± 0.11). Neither chamber showed differences in cheeses textural properties (chewiness, springiness, cohesiveness, and hardness) and color. There were interactions between the aging chamber and ripening age: ash% (4.00 ± 0.12), protein% (27.7 ± 0.21), fat% (34.1 ± 1.35), hardness (149.67 ± 30.72), and chewiness (463.67 ± 15.15) were higher (P < 0.05) at d 60 in the traditional chamber. The results show that the traditional chamber could be ideal for on-farm cheese ripening, yielding good quality cheese for resource-limited cheese producers. This study forms a baseline for the development of cheese production at an artisanal level for small-scale farmers in South Africa based on their environmental conditions and resources.

Key Words: ripening, temperature, humidity

178 Nanofiltration as sustainable approach to controlling cheese acidity by adjusting lactose to casein content of milk. J. A. Stankey, Y. Lu*, S. Govindasamy-Lucey, M. Molitor, J. J. Jaeggi, M. E. Johnson, and J. A. Lucey, Center for Dairy Research, University of Wisconsin-Madison, Madison, WI.

Previously we developed a technique to standardize milk lactose content while maintaining a constant casein (CN) level through the addition of reverse osmosis (RO) water to ultrafiltrated (UF) milk. This process dilutes the water-soluble minerals, particularly shifting the Ca equilibrium, which can impact the clotting process unless cheesemakers add CaCl2 to milk to aid gelation. In regions with water scarcity a more sustainable approach could be to use water that was generated through processing of UF permeate (nanofiltered permeate; NF). Although NF permeate contains some monovalent ions, CaCl2 could be added to assist renneting. Milks were standardized with either RO or NF permeate to achieve a high (HL; 1.7% lactose) or low (LL; 0.9% lactose) lactose-to-CN ratios: LLRO, HLRO, LLNF, HLNFC; additionally both NF treatments were also fortified with 0.04% CaCl2; LLNFC and HLNFC. Total CN (2.5%) and fat (2.5%) contents were similar in all 6 milks. All 6 milk treatments were used to make low-moisture part-skim (LMPS) Mozzarella cheeses (n = 4), were aged at 4°C for 84 d, and evaluated for composition, texture, functional, and sensory properties during ripening. Cheeses had similar moisture contents (47.9% ± 0.5%). Throughout storage cheeses made with RO water were harder (texture profile analysis), firmer (sensory), and less meltable (rheology) than cheeses made with NF permeate; addition of CaCl2 to NF also decreased firmness and meltability (P < 0.05). At 28 d, HL cheeses baked on pizzas had darker blister color, more cohesive, higher strand length, and more acid and lower pH (P < 0.05) than LL cheeses. Pizzas made with LL cheeses at 28 d had lighter blister color and were less acidic (P < 0.05) than HL cheeses. Pizzas with LLRO cheese were chewy, had more blisters, higher strand thickness than pizzas with LLNF or LLNFC cheeses. Adjusting the lactose content of the milk by standardizing with NF permeate was a useful, sustainable alternative to use of RO permeate for controlling cheese pH which also positively impacted texture, functionality, and sensory properties of LMPS Mozzarella.

Key Words: lactose, casein, nanofiltration

179 Minimizing moisture migration in large 291-kg blocks of Cheddar cheese. C. E. Collins¹*, M. E. Johnson², S. Govindasamy-Lucey², J. J. Jaeggi², and J. A. Lucey¹,², ¹University of Wisconsin-Madison, Madison, WI, ²Wisconsin Center for Dairy Research, Madison, WI.

In the industry, 291-kg blocks (known as 640-blocks) of Cheddar cheese are manufactured for ease of handling and reducing trim loss during conversion. Significant moisture (MC) migration occurs within blocks due to temperature gradients during cooling. Some manufacturers also concentrate cheese milk, resulting in higher amounts of casein and thus higher amounts of colloidal calcium phosphate (CCP). To reduce MC variation within 640-blocks, we explored the impact of pre-acidiifying milk to solubilize some CCP and varying cooling rates after pressing to reduce temperature gradients. Four replicate 640-blocks of stirred curd Cheddar cheese were manufactured at a commercial facility. Milk was ultrafiltered to 14.8 ± 0.6% solids and 3.2 ± 0.1% casein. Vats were pre-acidiified to pH levels (no pre-acidiification, pH 6.35, 6.20) using lactic acid. Blocks were stored in different coolers for 15 d (4 or 21°C for 2 d followed by 4°C). All blocks were transferred to a 1°C warehouse at 15 d. After 30 d, 640-blocks were cut into sixteen 40-lb portions. Inner core and outer samples were cut from four 40-lb blocks. Inside of 640-blocks was lower in MC than outside, as expected. Treatments reduced MC variability between inside and outside less than expected, likely due to low pH (<5.0) observed in pre-acidiified samples. Slow cooling resulted in lowered pH. Functionality was monitored by texture profile analysis and small amplitude oscillatory rheology. Cheese hardness was higher in inside of the 640-blocks compared with outside, but slightly less variation was observed with pre-acidiification and slow cooling. Higher temperatures for maximum loss tangent (an index of meltability) were observed in inside samples compared with its outside. Less variation between inside and outside samples was observed in melting point (LT = 1) for pre-acidiifed and slow cooled cheeses. A split-split plot design was used for statistical analysis, and a comparison of means was carried out (P < 0.05). Pre-acidiifying cheese milk and slowing the cooling rate appeared to reduce some functionality variation in 640-blocks of

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Cheddar cheese, but more control is needed over final cheese pH to reduce MC migration.

**Key Words:** pre-acidification, cooling, moisture


The From‘Innov process was recently proposed to increase cheesemaking control and flexibility while reducing its environmental impact. The process consists in developing cheese aroma and texture apart, thus replacing the traditional ripening process by supplementing a liquid pre-cheese with aromatic matrices fermented by traditional ripening microorganisms. Conceptually, it was hypothesized that it could improve both economic and environmental performances of cheesemaking plants. However, economic balance and electrical energy, natural gas and fresh water consumptions of industrial plants needed to be known to assess the real benefit of this process. Consequently, a process simulation was performed in 3 virtual plants processing 100,000 kg of milk per day. It enabled to compare the From‘Innov process to the traditional and the MMV processes (another liquid pre-cheese-based process) for the production of industrial bloomy soft cheese (Camembert-type), from the milk reception to the end of ripening. Globally, the virtual plants using liquid pre-cheese technologies required more energy and fresh water. However, their specific energy consumption were lower because of their higher cheese yield (20.7% and 18.3% in the From‘Innov and the MMV plants, respectively) compared with the traditional process (12.1%). The From‘Innov and the MMV plants needed 3.1 ± 0.1 and 3.7 ± 0.1 MJ per kg of cheese, respectively, while 5.2 ± 0.2 MJ per kg of cheese was required in the traditional plant. A similar pattern was observed for the fresh water consumption, where 6.6 ± 0.1, 8.0 ± 0.6 and 10.9 ± 0.8 L were required to produce one kg of cheese in the From‘Innov, the MMV and the traditional plants, respectively. Economic balances including costs associated to building construction, industrial equipment or human resources allowed to calculate the margin of the From‘Innov process, which was 2.4% and 39.0% higher than that of the MMV and the traditional processes, respectively. Being more profitable and less energy demanding, this From‘Innov process should enable to produce a wide variety of cheese on demand, thus contributing to improve the ecoefficiency of the industry.

**Key Words:** cheese aroma, emotions, physiology


Higher protein fortification may result in a stiffer yogurt gel. Such effect limits the protein fortification level, because a gel with high stiffness may cause poor textural sensory attributes and poor product processability. In the current research, a partial calcium depleted milk protein concentrate 80 (CD-MPC) was manufactured. It may be used as protein fortifier in high protein yogurt without increasing gel firmness as much as a standard MPC80 (Std-MPC). Textural, rheological and stability properties of the fermented yogurt gels were characterized for presenting the functionalities of CD-MPC. The calcium content of CD-MPC is lower than a Std-MPC (P < 0.05). CD-MPC and Std-MPC were applied into 4 different fat-free model yogurt gels respectively; the 4 different models are discriminated by 4 protein contents: 4%, 6%, 8%, 10% (wt/wt). In each model, nonfat dry milk powder was used as the base ingredient for contributing 3.5% protein content and either CD-MPC or Std-MPC was used for compensating the rest protein content for each model. Textural analysis results showed that using CD-MPC instead of using Std-MPC may result in relatively lower firmness, consistency, cohesiveness, and viscosity (P < 0.05) in the models containing no less than 6% protein. Steady-state shear viscosity and dynamic oscillatory strain sweep measurements were used for characterizing rheological properties of yogurt gels. For the higher protein models, the flow behavior curves were well separated between the test and control samples, the test samples were relatively less viscous.curvature and low viscosity of which were well separated between the test and control samples, the test samples were less viscous. A similar trend was observed in the strain sweep tests, CD-MPC containing gels showed lower storage modulus and loss modulus. Both textural and rheological results confirmed that CD-MPC may result in a weaker gel when compared with Std-MPC. In the stability study, the results showed that CD-MPC may result in improved water holding capacity (WHC) compared with Std-MPC. Overall, the current
results suggest that the CD-MPC is a promising protein fortifier which may be used for improving gel stability without highly increasing gel firmness of protein fortified yogurts.

Key Words: milk protein concentrate, yogurt

183 Texture defects of fermented milk products caused by vibrations—Impact of amplitude and different process parameters. A. Körzendörfer1, P. Temme2, E. Schlücker3, and J. Hinrichs4, 1University of Hohenheim, Stuttgart, BW, Germany, 2University of Erlangen–Nuremberg, Erlangen, BY, Germany.

Machinery like pumps used for the commercial production of yogurt and related fermented milks generate vibrations that can spread to the fermentation tanks. Such vibrations can disturb the gelation by causing texture defects including lumpiness and syneresis. The aim of this study was to research the effect of vibrations on the aggregating milk proteins and evaluate their relevance with regards to the manufacture of fermented milk products. To generate defined vibrational states, an experimental setup was developed consisting of a jacketed stainless steel tank (cylindric, d = 100 mm, l = 600 mm). Vibrations are directly introduced by a piston at the bottom, which is oscillated by an electrodynamic vibration exciter. Pressure sensors are used to describe the propagation of specific vibrations within the liquid. At a frequency of 30 Hz, a linear decrease of the pressure was observed. In contrast, a standing wave was formed at 1000 Hz. Vibrations (f = 30 Hz) were then applied during yogurt fermentation at 43°C by varying the amplitude from 0 – 10 m/s². After acidification, set milks were processed and analyzed (rheology, water-holding capacity). A method based on image analysis was applied to quantify visible particles and evaluate textures. The number of independent repetitions of the experiments was i ≥ 3. Vibrations of lower amplitudes (a = 2.5 m/s²) increased the number of visible particles by a factor of 2 (P < 0.05). Higher amplitudes (a ≥ 5 m/s²) resulted in considerable syneresis of the set gel and a less homogeneous appearance of the final product. The particle number was increased by a factor of 10 to 20 (P < 0.001), however, deeper analysis revealed that particle formation was more pronounced in the lower and upper area within the fermenter. A high particle number was also linked to a reduced product viscosity and increased whey separation. In conclusion, the magnitude of a specific vibration depends on both its characteristics and other process parameters. Manufacturers of fermented milk products should consider vibrations as a further cause for quality defects.

Key Words: graininess, fermented milk product, yogurt structure

184 Dynamic structural breakdown behavior of a model Maasdam-style cheese under tensile deformation as studied using confocal scanning laser microscopy. P. Lamichhane1,2, M. A. E. Auty3, A. L. Kelly2, and J. J. Sheehan*1, 1Teagasc Food Research Centre Moorepark, Fermoy, Cork, Ireland, 2University College Cork, Cork, Ireland, 3Mondelēz International Ltd., Reading, UK.

Knowledge of the breakdown behavior of cheese is important for gaining insights into texture perception, flavor and nutrient release, as well as the origin of undesirable texture defects within the cheese matrix such as slits and cracks. In this novel study, changes in the microstructure of model Maasdam-style cheeses were observed in situ during tensile deformation by placing a microtensile stage directly under a confocal scanning laser microscope (CSLM), and recording force/displacement data simultaneously. A small indentation (called a notch) was made at a center point on the test specimens, and growth of the notch was observed under tensile deformation using CSLM. Widening of the notch, stretching of the protein network near the leading point of the notch, detachment of fat globules, and their subsequent release from the cheese matrix, as well as fracturing of the cheeses, partly along curd granule junctions, were all observed during tensile deformation. Moreover, an inherent micro-defect was observed at a curd granule junction within the cheese matrix and this micro-defect fractured along the curd granule junction under tensile deformation, suggesting that the micro-defects present within the cheese matrix could be a key underlying factor in the formation of undesirable slits or cracks. Further work showed that the fracture behavior of cheese was altered by changing ripening temperature, using different coagulant types, or by inhibition of residual chymosin. Such approaches could be applied to designing cheeses with specific texture profiles or for designing optimal cheese textures to withstand increased gas pressure during ripening in eye-type cheeses, which may help to prevent the formation of undesirable splits and cracks. Overall, this study demonstrated the potential of in situ imaging of cheese microstructure for developing a greater understanding of the breakdown behavior of cheese matrices.

Key Words: cheese, fracture behavior, in situ imaging

185 Differentiating between the effects of chymosin-mediated proteolysis, coagulant type, ripening temperature and calcium solubilization on fracture behavior of Maasdam-style cheese. P. Lamichhane1,2, P. Sharma1, D. Kennedy1, A. L. Kelly2, and J. J. Sheehan*1, 1Teagasc Food Research Centre Moorepark, Fermoy, Cork, Ireland, 2University College Cork, Cork, Ireland.

Ripening-related changes within the cheese matrix influence cheese properties, such as texture perception and development of undesirable slits and cracks. However, the individual contribution of various factors on cheese properties remains unclear; therefore, the aim of this study was to decouple and explore the individual roles of chymosin-mediated proteolysis, coagulant-type, ripening temperature and calcium solubilisation on the fracture behavior of Maasdam-style cheese. Addition of a chymosin inhibitor, i.e., pepstatin A, to the curd/whey mixture during cheese manufacture completely inhibited the breakdown of αs1-casein over 90 d of ripening, while substitution of fermentation-produced bovine chymosin with fermentation-produced camel chymosin decreased breakdown of αs1-casein by ~40%. However, neither treatment influenced the hydrolysis of β-casein or the solubilisation of colloidal calcium. Ripening of cheese at a consistent low temperature (8°C) decreased the rate of breakdown of αs1-casein and β-casein and solubilisation of colloidal calcium as compared with cheeses ripened for a period at higher temperature (warm-room stage at 23°C between 20 and 48 d ripening). A significant positive correlation was found between intact αs1-casein content and fracture stress, suggesting that the hydrolysis of αs1-casein has an important role in the softening of cheese texture. However, no significant association between levels of intact αs1-casein and strain at fracture was observed, suggesting that breakdown of αs1-casein had no pronounced influence on the brittleness of Maasdam-style cheese. In contrast, the strain at fracture was significantly positively correlated with the level of intact β-casein and insoluble calcium content. Results from this study provide a new perspective on potential opportunities for cheese-makers to reduce the incidence of slits and cracks in cheese.

Key Words: proteolysis, insoluble calcium, fracture properties

186 Prototype protein characterization unit (PCU) to study the dissociation of casein micelles by sodium and potassium citrates

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There is a growing demand for drinks and shakes containing high dairy protein contents. The effect of ionic environments in complex protein quaternary structures (e.g., casein micelles), can only be transformed into technological applications using an empirical approach where a broad set of environmental conditions are tested (e.g., emulsifying salt, salt concentration, casein concentration, temperature, and pH). For this purpose, a prototype protein characterization unit (PCU) was designed and assembled to autonomously look thorough a wide range of sample conditions rapidly to generate a clear picture of how the parameters effect salt-protein interactions. The PCU was tested for environmental conditions including pH (6.0, 6.5 and 7.0), temperature (5, 15, 25, 35, 45 and 55°C), salt concentration (0–200 mM), exposure time (0–240 s), and measuring absorbance (400 nm), fluorescence (excitation: 380 nm; emission: 470 nm) and viscosity (gauge pressure) of the liquid systems containing milk proteins and salts. The absorbance values were then interpreted as micelle dissociation through the critical salt concentration (C*) using an exponential decay model [absorbance = absorbance(c = 0)×Exp(−C/C*); where C is the salt concentration]. Sodium and potassium citrates were effective in dissociating casein micelles with critical concentrations leading to micellar dissociation ~2 to 4 mM. An increase in temperature shortened the required exposure time for dissociation and decreased system viscosity by nearly 50%. Increase in pH however, increased the critical concentration values from nearly 5 mM at pH = 6.0 to 7 mM at pH = 7.0. Furthermore, tartrates were also able to deliver the similar effects but at higher concentrations (~15–50 mM). Effects of anions were significantly more profound compared with cations where the average initial critical concentration for citrates was ~3 to 4 mM and for tartrates was ~20 mM. In summary, the mapping of protein-salt interactions will allow for better understanding of protein functionality toward liquid system containing high protein contents.

**Key Words:** casein, ionic environment, emulsifying salt

**187 Ice cream from milk from cows supplemented with unsaturated fatty acid sources: Physicochemical and sensory characteristics.** E. Vargas-Bello-Pérez1,2, N. Cancino-Padilla1, C. Geldsetzer-Mendoza1, M. S. Morales2, J. Romero5, P. C. Garnsworthy4, and R. A. Ibáñez1, 1Departamento de Ciencias Animales, Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Santiago, Chile, 2Department of Veterinary and Animal Sciences, Faculty of Health and Medical Sciences, University of Copenhagen, Frederiksberg C, Denmark, 3Departamento de Fomento de la Producción Animal, Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Santiago, Chile, 4Laboratorio de Biotecnología, Instituto de Nutrición y Tecnología de los Alimentos, Universidad de Chile, Santiago, Chile, 5Sutton Bonington Campus, The University of Nottingham, Loughborough, UK.

The objective of this study was to evaluate effects of supplementation of dairy cows with different fatty acid sources [soybean oil (SO) and fish oil (FO)] on the physicochemical and sensory characteristics of ice cream. Fifteen Holstein cows averaging 198 ± 35 d in milk were assigned to 3 groups: control diet with no added lipid (n = 5 cows); and supplemented diets with SO (n = 5 cows; unrefined SO; 30 g/kg DM) or FO (n = 5 cows; FO from unrefined salmon oil; 30 g/kg DM). Diets were based on corn silage and alfalfa silage. Cows received treatments during 63 d, milk was registered daily, and individual milk samples were taken on d 21, 42 and 63 for milk composition. At the sampling days, milk collected from individual cows from the same treatment was pooled and made into ice cream. Sensory evaluation of ice creams was carried out in relation to 7 attributes: appearance, texture, melting resistance, taste, aroma, milkfat and generally acceptability. All parameters were analyzed using the PROC MIXED of SAS. Milk production (42.9 ± 1.5 kg/d), milk fat (1.5 ± 0.10 kg/d) and milk protein (1.5 ± 0.06 kg/d) were not affected by treatments. Fat (16.1 ± 0.001 g/100g), lactose (3.99 ± 0.001 g/100g), and sucrose (17.1 ± 0.01 g/100g) in ice creams were not affected by treatments (P > 0.05). Protein contents in ice creams were higher (P < 0.05) with SO. Milk fat (g/100g total FAME) saturated fatty acids were decrease (P < 0.05) with SO and FO compared with control. C18:2n6t, C18:2n6c and C18:2c9,t11 were increased (P < 0.05) in SO compared with control and FO ice creams. Overrun and melting rate were higher (P < 0.05) in SO and FO ice creams. Melting resistance was higher (P < 0.05) in FO compared with control and SO ice creams. Overall, supplementation of dairy cow diets with SO and FO did not have detrimental effects on milk production, ice cream physicochemical and sensory characteristics. From a human standpoint, SO and FO improved the FA profile of milk. This study was sponsored by a research grant from FONDECYT 1170400, Chile.

**Key Words:** ice cream, fatty acids, oil supplements