Impact of membrane selectivity on the cheesemaking properties of skim milk concentrates. A. Lauzin*1, I. Dussault-Chouinard1, M. Britten2, and Y. Pouliot1, 1STELA Dairy Research Center, Institute of Nutrition and Functional Foods (INAF), Department of Food Science, Université Laval, Québec, QC, Canada, 2Food Research and Development Center (FDRC), Agriculture and Agri-Food Canada, St-Hyacinthe, QC, Canada.

Ultrafiltration (UF) is a commonly used membrane process in dairy industries, especially for cheese milk concentration. Little attention has been given to other processes such as reverse osmosis (RO) and nanofiltration (NF) for milk concentration and the cheesemaking properties of the concentrates are unknown. The objective of this work was to compare the rennet-induced coagulation kinetics as well as cheesemaking properties of UF, NF, and RO concentrated milks. Batch lots of pasteurized skim milk (SM) were concentrated by means of a pilot-scale filtration system (GEA NIRO) operated at 50°C until a volume concentration factor of 3× using 3 different spiral-wound membranes (Synder Filtration): UF (10kDa), RO (99.4% rejection of NaCl), and NF (99 and 40% rejection of MgSO4 and NaCl respectively). Rennet-induced coagulation kinetics of concentrates was characterized by dynamic rheology and model cheeses were made to further study the cheesemaking properties.

Key Words: cheesemaking, milk concentrate, reverse osmosis

Impact of membrane selectivity on the compositional characteristics of liquid pre-cheese concentrates. A. Lauzin*1, M. Britten2, and Y. Pouliot1, 1STELA Dairy Research Center, Institute of Nutrition and Functional Foods (INAF), Department of Food Science, Université Laval, Université Laval, Québec, QC, Canada, 2Food Research and Development Center (FDRC), Agriculture and Agri-Food Canada, Agriculture and Agri-Food Canada, St-Hyacinthe, QC, Canada.

Ultrafiltration (UF) is the main membrane process used for cheese milk concentration; it leads to an increase in protein content while keeping the composition of the serum phase constant. Reverse osmosis (RO) and nanofiltration (NF) techniques could be used for milk concentration before cheesemaking but their selectivity toward milk salts is likely to lead to different characteristics in terms of soluble: colloidal equilibria and impair the cheesemaking properties of concentrates. The objective of this work was to compare the composition of milks concentrated using UF, RO and NF. Batch lots of pasteurized skim milk (SM) were concentrated by means of a pilot-scale filtration system (GEA NIRO) operated at 50°C until a volume concentration factor of 3× using 3 different spiral-wound membranes (Synder Filtration): UF (10kDa), RO (99.4% rejection of NaCl), and NF (99 and 40% rejection of MgSO4 and NaCl respectively). The skim milks and their corresponding concentrates were characterized for protein and salts soluble: colloidal distributions and viscosity. Phase separation was done by ultracentrifugation at 10000g for 1 h, and milks and their respective supernatants were analyzed for protein and main salts (K, Ca, Mg, Na, P). Totals solids and apparent viscosity were significantly higher for NF and RO milks (P > 0.05) compared with UF. Both divalent and monovalent ions were significantly higher in the serum phase of RO milk while only divalent ions were concentrated in NF (P > 0.05). Despite the increased ionic strength for RO and NF, ionic activities of the salts were still higher in RO and NF milks than in UF milk and SM (P > 0.05). Milk concentrates composition and milk salts soluble: colloidal distribution are significantly affected by membrane selectivity. These differences may lead to impaired cheesemaking properties of RO and NF concentrates.

Key Words: milk concentrate, colloidal distribution, salt equilibrium

On the use of polymeric microfiltration membranes for the preparation of liquid pre-cheese: Impact on process efficiency. D. Mercier-Bouchard1, I. Dussault-Chouinard*1, S. Benoît1, A. Doyen1, M. Britten2, and Y. Pouliot1, 1STELA Dairy Research Center, Institute of Nutrition and Functional Foods (INAF), Department of Food Science, Université Laval, Québec, QC, Canada, 2Food Research and Development Center (FDRC), Agriculture and Agri-Food Canada, St-Hyacinthe, QC, Canada.

Ultrafiltration (UF) and microfiltration (MF) are widely used for cheesemilk concentration. In a recent study, we observed that filtration performances of the 0.1-µm MF membrane were very close to those of a 10-kDa UF membrane in terms of caseins and serum proteins (SP) rejection. Considering that permeate flux values obtained with a 0.1-µm MF membrane are expected to be higher than those with a 10 kDa UF membrane, it was hypothesized that using an MF membrane would improve the process efficiency. The objectives of this work were to compare 0.1-µm MF and 10 kDa UF membranes in terms of (1) hydraulic and separative performances, (2) energy consumption and fouling behavior and (3) cheesemaking ability of milk retentates. Skim milk concentration (50°C) was carried out in batch mode in triplicate by using 0.1-µm MF and 10-kDa UF membranes, mounted on a Pilot M393 system (Tetra Pak) until a 3.0× concentration factor followed by 2 sequential dialfiltration steps with 2 diavolumes. The retentates were standardized with fresh cream to a protein/fat ratio of 0.6 and cheesemaking ability (cheese yield, cheese moisture, fat and protein recovery) were determined. Results showed that the permeate flux values of MF membranes were higher (P < 0.05) than those of UF membranes (0.18 vs 0.09 kg/h·m⁻²·Pa) and the rejection coefficient was slightly lower (0.97 vs 1.00). Energy consumption for the UF system was higher (P < 0.05) than for the MF system (0.024 vs 0.016 kWh/kg of permeate collected). The hydraulic resistance from irreversible fouling was higher for the MF membrane than for the UF membrane (0.11E+13 vs 3.00E+13 m⁻¹). In terms of cheesemaking performances, cheese yield, moisture and fat retention were similar (P > 0.05) but apparent protein losses in whey were lower in cheese made from MF milk due to the removal of SP during concentration. Our results demonstrate that retentates from both processes have similar cheesemaking ability, but using MF leads to better hydraulic performances and uses less energy. The environmental
impact of these 2 processes will need to be evaluated through a life-cycle assessment before comparing their efficiency.

T75  Milk fatty acid composition and long-seasoning cheese-making qualities of milk from dairy cows given algae in pelleted or meal concentrate form. M. Morlacchinib, F. Giorgio1, C. Moranb, D. Graugnard*a and K. Jacquesc, 1CERZOO, Piacenza, Italy, 2Altech Inc., Nicholasville, KY.

Milk containing higher amounts of unsaturated long-chain fatty acids (LCFA), including docosahexaenoic acid (DHA) can provide an added value stream for producers. However, it is important to understand how milk fatty acid (FA) profiles are affected and the impact of these changes on dairy foods, particularly cheese. This experiment compared milk profiles of cows fed a high-DHA algae added in meal or pelleted concentrate. In addition, cheese-making properties were measured. Italian Friesian mid-lactation cows (36) were blocked by parity and assigned to 3 treatment groups of 12 cows in an 85-d study. Cows were given a TMR that included 0 or 150 g algae, the latter in meal or pelleted concentrate. The algae source was Aurantiochytrium limacinum CCAP 4087/2 algae (FORPLUS, Altech Inc.). Milk samples were taken at d0, 28, 56, and 84 d on 2 consecutive milking days, combining 4 milkings into 1 pooled sample made with 5% of the milk production of each milking for component analysis and FA profile. Coagulant properties, titratable acidity, and natural creaming for production of long seasoning cheese were evaluated. Data were subjected to ANOVA with means separated (P < 0.05) using Student t and Tukey tests. The C20:3n-3 acids, total LCFA and saturated FAs were higher in controls than in diets containing algae (P < 0.05). Oleic, stearic, α-linolenic, and eicosatrienoic acids were lower in diets with algae (P < 0.05). C18:1 trans, rumenic, and behenic acids were lower in controls than in diets containing algae (P < 0.05). DHA and the n-3:n-6 ratio were lowest in controls and highest in meal (P < 0.05). DHA was not detected in controls. Milk titratable acidity was numerically reduced over the study when cows received algae in concentrates meal. No statistical differences were found in milk rennet coagulation properties or natural creaming, indicating that these elements must be well controlled to achieve optimal efficiency in the manufacturing of this cheese.

Key Words: cheese, dairy food, industry

T76  Multivariate analysis in the study of association between Mozzarella cheese yield and processing factors. D. C. Sales1, A. H. N. Rangel1, A. R. Freitas1, J. G. B. Galvão Jr.*2, S. A. Urbano1, E. P. Silva1, and H. Tonhati3, 1Universidade Federal do Rio Grande do Norte, Macaúba, RN, Brazil, 2Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte, Ipanguaçu, RN, Brazil, 3Empresa Brasileira de Pesquisa Agropecuária (Retired), São Paulo, SP, Brazil, 4Universidade Estadual Paulista Julio de Mesquita Filho, Jaboticabal, SP, Brazil.

The aim of this study was to investigate the association between Mozzarella cheese yield (MCY) and variables of milk composition, processing and the recovery of whey constituents by multivariate analysis. The study involved tracking the processing of 30 lots of buffalo Mozzarella cheese in a dairy industry of northeast Brazil. The variables milk fat (MF), true protein (TPRO), casein (CAS), lactose, total solids (TS), solids-not-fat content (SNF), density (DS), cryoscoppy, pH, titratable acidity (ACID), and somatic cell score (SCS) of raw milk were measured before processing. The variables pH, acidity, age of starter culture (ASC), volume of calcium chloride, volume of rennet, average pH of curd during stretching, coagulation time, time between cuts, fermentation time (FIT), stretching time for the whole curd, whole fermentation time, fat (FREC), protein, casein, lactose, total solids, and solids-not-fat recovery were measured during the processing and in the whey. MCY association to the variables was verified by PROC PRINCOMP procedure of SAS. The explained variability of PC1, PC2 and PC3 was 26.37%, 17.38% and 12.44% respectively, totaling 56.18%. A direct association between milk characteristics TS, SNF, CAS, TPRO, MF, ACID and FREC was observed, as well as an antagonistic association between them vs. MCY, pH vs. DS, and FIT vs. ASC. This means that low kg milk per kg cheese ratio is lower when using buffalo milk with higher concentrations of TS, SNF, CAS, TPRO and MF, and when there is greater loss of MF in whey. A direct association can be found between those representing the loss of non-fatty constituents in whey and SCS. Thus, the volume of cheese obtained may be lower when milk with higher SCS is used. The main components of Mozzarella indicated that the yield has more relevant associations with pH, DS, ASC, time elapsed between curd cuttings, and curd stretching time, indicating that these elements must be well controlled to achieve optimal efficiency in the manufacturing of this cheese.

Key Words: cheese, dairy food, industry

T77  Tuning meltability and stretchability of pizza cheese using modified starch. X. Yang*, J. Hirsch, A. Speranza, and S. Ganesh, Ingredion Incorporated, Bridgewater, NJ.

Important functional properties of pizza cheese, such as meltability and stretchability, depend on the structural formation and interaction of casein gel and fat globules. The aim of this study was to understand the effects of modified starch on pizza cheese microstructure, and the resulting cheese functional properties. Pizza cheeses containing modified starches from various plant sources, and 9–22% rennet casein, were prepared. Starches were chosen based on their ability to form a gel, including gel rate, meting, hardness. Cheese texture and meltability were evaluated using Texture Profile Analysis (TPA) test and modified Schreiber melt test. Stretchability was scored using a pizza bake method. Cheese microstructure was observed under light microscopy using 3 dyes (iodine, fast green and Nile red) to specifically stain starch, protein and fat phases. Results show that microstructure and functionality of pizza cheese are changed by the addition of modified starch. Microscope images show that upon heating during pizza cheese process, modified starches completely cook out, and form a separate gel phase in the matrix. The modified starches enable formation of a continuous casein network, which improves stretching texture of melted cheese. Modified starch with reduced gelling rate (slower increase of elastic modulus G’ over time) enabled more phase separation, and greater stretching. Modified starch with more melted structure (greater loss of G’ during heating) contributed to larger cheese spread area in Schreiber test, and more fusing of cheese shreds in pizza bake test. Native starch, however, tended to form small gel pieces, interfering with the casein gel network, which restricted cheese stretchability after baking. This study indicates that modified starches and their blends alter cheese microstructure, leading to improved functionality. Starches, based on their functional properties, such as gelling rate and melting, can be used to improve cheese meltability and stretchability for specific formulations and applications, by enabling creation of a continuous casein gel network.

Key Words: cheese microstructure, meltability, stretchability

T78  Utilization of konjac glucomannan as a fat replacer in low-fat and skimmed Mozzarella cheese. S. Dai*, H. Corke1,2, and

J. Dairy Sci. Vol. 100, Suppl. 2

253
The production of reduced-fat foods has been a preoccupation of scientists and industry. Konjac glucomannan (KGM) is a natural polysaccharide with several desirable nutritional characteristics, and has the potential functional properties as a fat replacer in dairy products. In our study, physicochemical, textural, pizza baking properties and structural characteristics of low-fat and skimmed Mozzarella cheese with KGM (LFKGM and SKKGM) were compared with those of full-fat, low-fat and skimmed Mozzarella cheese control (FFC, LFC and SKC) during storage. Generally, addition of KGM to Mozzarella cheese had no significant effects on protein and fat contents. The LFKGM and SKKGM exhibited higher whiteness, greenness and yellowness hues compared with those of LFC and SKC. While, LFKGM and SKKGM exhibited higher L*, lower a* and b* compared with LFC and SKC after heating, respectively. The L* decreased, a* remained stable and b* increased for all the cheese samples after heating compared with those of unheated samples during storage. The FFC, LFC and LFKGM had the same water activity ($a_w$) and moisture values, but the $a_w$ of SKKGM was higher than SKC. The SKKGM and SKC had the same moisture content and both were higher than other cheese samples. The $a_w$ and moisture content of all the cheese samples remained stable during storage. Addition of KGM to low-fat Mozzarella cheese gave it a similar firmness to FFC blocks, which was lower than that of LFC during storage. There was no significant difference in stickiness of LFKGM and SKKGM with LFC and SKC during storage, respectively. The pizza bake test of LFKGM and SKKGM performed at D 7 and D 28 showed more adequate meltability and less scorching to the cheese shreds compared with LKC and SKC. Additionally, FFC and LFC showed long protein settings allow us to compare the difference in Camembert cheese varieties on the methods of manufacture.

**Key Words:** reduced-fat cheese, pasting properties, thermal properties

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**T79 Behavior of starches with different amylose content in mixtures with casein for replacing fat in cheese.** V. R. Diamantino, M. S. Costa, C. M. L. Franco, and A. L. B. Penna*, São Paulo State University, São José do Rio Preto, SP, Brazil.

Fat reduction frequently affects texture, flavor and yield of cheese. The use of fat replacers is one of the strategies that have been used to improve reduced-fat cheese’s overall quality. In different types of cheese, starch may improve their texture by binding extra water and reducing their hardness. Additionally, it is well known that starches’ properties may considerably vary due to their amylose content. Thus, the behavior of different types of native maize starches with varying amylose contents (regular maize starch – RMS, waxy maize starch – WMS, high-amylose maize starch – HAMS) in mixtures with casein (CN) was studied, aiming to understand the potential use of starch as a fat replacer in cheese. Pasting properties (Pasting temperature and peak, breakdown, final and setback viscosities measured by a Rapid Visco-Analyzer), thermal properties (gelatinization temperatures: onset, peak and conclusion, and gelatinization enthalpy using a differential scanning calorimeter), and swelling power (by the ratio of the precipitated gel weight to the sample’s weight in dry basis) of casein/starch dispersions were evaluated. Casein/starch dispersions simulated the concentration of fat replacers frequently used in cheese (1.0% starch) and the concentration of casein normally found in milk (2.5% casein). WMS in mixture with CN presented the highest peak viscosity (196.54 ± 1.13 RVU), whereas RMS and HAMS presented 138.12 ± 3.16 RVU, and 7.31 ± 0.66 RVU, respectively, indicating that WMS has a high potential for water binding in cheese. WMS also presented high swelling power at 75°C (5.13 ± 0.03), when compared with RMS and HAMS (3.67 ± 0.05, 1.01 ± 0.00, respectively), and low peak temperature (72.72 ± 0.01°C), similar to RMS (71.06 ± 0.29°C), but considerably lower than HAMS (89.46 ± 0.00°C), therefore it requires lower gelatinization temperatures, which is important for cheese’s coagulation. Therefore, WMS could be considered a promising fat replacer in cheese and may have the potential to help industries to improve the characteristics of dairy reduced-fat products.

**Key Words:** cheese, physicochemistry

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**T80 Physiochemical and texture analysis of camembert cheese variants.** D. Batty*, J. Waite-Cusic, and L. Goddik, Oregon State University, Corvallis, OR.

Camembert is a bloomy rind cheese that can be produced by several different processes that involve altering starter culture, fermentation time and temperature, and curd handling to attain multiple varieties including the traditional lactic curd, rennet curd, and extended shelf life stabilized curd. The objective of this research was to compare different varieties of Camembert cheese and measure physicochemical characteristics of the cheeses. Multiple varieties of Camembert cheese were manufactured and analyzed for key compositional components including calcium, fat, protein, moisture, pH, sodium and color. Firmness of the paste was also analyzed using a TA.XT2i Texture Analyzer. The 2 most common varieties are rennet curd and stabilized curd. Rennet curd cheese is made using traditional mesophilic cultures and fermenting at 35°C for 180 min to a set pH of 6.20, while stabilized curd is made using thermophilic cultures fermenting at 40°C for 120 min to a set pH of 6.45. For these cheeses there were differences in both pH during ripening and firmness at the end of the initial ripening (d 14). Due to the lower initial pH, pH of the rennet curd variety (4.81 on d 1 to 7.37 on d 10) increased more than pH of the stabilized curd variety (5.20 on d 1 to 7.26 on d 10) The difference in firmness from the center of the paste (7.053 N) to the center of the paste (7.813 N) was significant. While ripening, the firmness from the center of the paste (2.876 N) to the edge of the paste (2.344 N) for the stabilized curd was not significant (P = 0.281). Comparing the 2 cheese varieties, the difference in firmness of the paste center (P = 0.015) and rind (P = 0.016) were both significant. A characteristic with an insignificant difference (P = 0.126) was moisture (dry matter basis) for the rennet curd (60.4%) and stabilized curd (61.3%). It is interesting to note that although the cheeses were made by different methods, they ended up with same moisture content and final pH while having a significant difference in firmness. These findings allow us to compare the difference in Camembert cheese varieties based on the methods of manufacture.

**Key Words:** cheese, physicochemistry

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**T81 Compositional and proteolytic study of Danish Blue cheese during ripening.** A. Mane*, F. Ciocia, T. K. Beck, S. Lillevang, and P. McSweeney, Food for Health Ireland, Dublin, Ireland, University College Cork, Cork, Ireland, Arla Foods, Vojens, Denmark.

Danish Blue cheese is a semi-soft blue veined cheese, made from cow’s milk. In addition to proteolytic enzymes, present during normal
cheese ripening, the mold *Penicillium roqueforti* produces aspartyl and metalloproteases that cause considerable changes leading to the unique aroma, flavors and texture of Blue cheese. A study was carried out to investigate the compositional and proteolytic changes occurring in this cheese during 28 weeks of ripening. Moisture levels generally decreased during ripening with concomitant increases in NaCl (~45 to 42% and 3.0 to 3.5%, respectively). Levels of pH 4.6 - soluble N as a percentage of total N increased from 4.2% to 46%, indicating extensive proteolysis during ripening. Urea-PAGE was performed. Before 23 d of ripening, patterns of proteolysis could be explained through the action of chymosin from the coagulant and plasmin from the milk. The action of enzymes from *P. roqueforti* was apparent in samples ripened for longer periods up to 28 weeks. pH 4.6-Soluble fractions were analyzed by ultra-performance liquid chromatography and showed complex peptide profiles, particularly after 2 weeks of ripening. Extensive proteolysis was associated with the action of the fungal proteolytic enzymes in the cheese. Free amino acid profiling showed an increase in content as ripening proceeded. In an attempt to identify peptides in the cheese produced by mold enzymes, a commercial strain of *P. roqueforti* PRG-3 was cultured in Potato Dextrose Broth for 7 d at 25°C. Cell-free supernatants were obtained from the culture medium and the action of enzymes on αS1- and β-casein was determined with resulting peptides identified by ultra-performance liquid chromatography and mass spectrometry. Several peptides found in cheese were thus proven to be produced by the action of fungal enzymes. The results of this study show the extensive proteolysis in Blue cheese later in ripening is mediated mainly by the action of *P. roqueforti* enzymes.

**Key Words:** Danish Blue cheese, proteolysis, proteolytic cleavage

**T83** Quantification of starch through an enzymatic starch assay to quantify flow aid concentrations in shredded cheeses. A. Zumbusch and T. Schoenfuss*, University of Minnesota, St. Paul, MN.

Starch is a common ingredient in flow aids used in the production of shredded cheese. It serves as an anticaking agent as well as a carrier for antimycotics and oxygen scavengers to increase shelf-life and quality. There is no current standard method of analysis to confirm the amount of flow aid in shredded cheese. The objective of this research was to develop a total starch assay method to quantify the starch in shredded cheese blends to quantify the total amount of flow aid present. The Megazyme Total Starch HK kit K-TSHK 09/15, based on AOAC method 996.11, AACC method 76.13, and ICC standard method No. 168 was chosen as this kit does not contain glucose oxidase as a reagent. Glucose oxidase is present in many flow aids for shredded cheese to act as an oxygen scavenger. An initial extraction step was added to remove the d-glucose present in the flow aid. There was also an issue after a centrifugation step with breaking up the pellet. Glass beads were added to the test tubes to alleviate this problem. Finally, a gravity fed filtration step with grade 1 filter paper was added to remove interference from the food matrix not removed from the final centrifugation. The method was tested on 6 cheese samples consisting of 3% flow aid (wt/wt) that was hand blended. The flow aid itself was analyzed to determine the percent starch. It was determined that the flow aid contained 61.3% (±4.52%) starch. Analysis of cheese samples produced an average of 1.81% (±0.011%) starch. With analysis of flow aid resulting in 61.3%, the total calculated flow aid in cheese samples was 2.95% (±0.017), resulting in a percent relative error of 1.79%. The development of this method provides a valuable tool for the cheese industry and regulators. This method allows for manufacturers to accurately determine the amount of flow aid added to shredded cheese blends to ensure their manufacturing and regulatory specifications are being met. The total analysis time for this method is approximately 3 h. Ultimately, accurate determination of flow aid addition will improve product quality, safety, and consumer confidence for the shredded cheese industry.

**Key Words:** cheese, shredded, starch