301 Temperature and vacuum conditions for removal of added carbon dioxide from milk. D. M. Barbano* and J. H. Hotchkiss, *Cornell University*, *Ithaca, NY*.

Our objective was to determine the temperature and vacuum relationships for efficient removal of added CO_2 from raw milk. Added CO_2 in milk and dairy products inhibits the growth of spoilage organisms during refrigerated storage and shipping. As milk and milk concentrates are shipped over longer distances, the use of CO_2 is becoming more common to maintain raw milk quality. In most cases, some or all of the CO_2 needs to be removed from the milk before further processing. Raw milk before CO_2 addition typically contained about 100 to 200 ppm CO_2 and had a pH of about 6.9 at 4°C. In the present study, about 1600 kg of 4°C raw milk was continuously injected with CO_2 with a holding time of 15 s at 172 kPa to achieve a concentration of 2000 ppm. Milk containing added CO_2 was stored at 4°C for 24 h before initiating the CO_2 removal process. The cold milk containing CO_2 was pumped through a plate heat exchanger at 24.5 kg/min directly into the spray nozzle inlet of a pilot-scale APV vacuum deaerator system equipped with a spray nozzle that produced a cone shaped spray pattern into a vacuum chamber. Six different milk temperatures (51.5, 57.5, 63, 68, 74, and 79.5°C) and 5 different vacuum levels at each temperature (in the range of 621 to 1293 mmHg Torr) were evaluated. The CO_2 content (Mocon CO_2 analyzer) of milk and milk pH were measured for each treatment and control milk. The experiment was replicated 3 times with a new milk source each time. The CO_2 content of milk decreased and pH increased with increasing temperature and vacuum. As temperature increased, less vacuum was required to achieve complete CO_2 removal. Milk pH was highly correlated with CO_2 removal and pH can be used as a rapid measurement method to determine if CO_2 removal is near completion. A linear regression model (r-square 0.98) was developed that defines the relationship between temperature and vacuum required to reduce the CO_2 content of the milk to a level not significantly different form the milk before CO_2 addition.

Key Words: carbon dioxide, pH, vacuum

302 Processing factors that influence casein (CN) and serum protein (SP) separation by microfiltration (MF). E. E. Hurt* and D. M. Barbano, *Cornell University*, *Ithaca, NY*.

Our objective was to demonstrate the impact of skim milk composition, heat treatment of skim milk, concentration factor (CF) and diafiltration factor (DF), control of CF and DF, and SP rejection by the membrane on the performance of a MF system designed to process skim milk to separate CN from SP. A mathematical model of a skim milk MF process was developed with 3 stages, plus a 4th stage to standardize the micellar CN concentrate (MCC) to 9% true protein (TP) and allow calculation of yield of MCC (liquid, 9% TP) and milk SP isolate (MSPI) (90% SP on a dry basis). The model predicted the effect of the 5 factors on: retentate and permeate composition, SP removal, and MCC and MSPI yield. When the TP of skim milk increased from 3.2 to 3.8% MCC and MSPI yield increased by 19% and 18%, respectively. Increased heat treatment (73 to 85°C) of skim milk caused CN as a percentage of TP in skim milk as measured by Kjeldahl analysis to increase from 82 to 86% and the yield of MSPI to decrease by 22%. A CF and DF of 2X gave a 3rd stage retentate TP concentration of 5.38% compared to 13.13% for a CF and DF of 5X and 3rd stage cumulative SP removal increased from 89 to 99%, respectively. Variation in the balance between CF and DF (instead of equal CF and DF) caused a progressive increase or decrease in TP concentration in each stageâ€™s retentate depending on whether CF > DF (increasing TP in retentate) or CF < DF (decreasing TP in retentate). Increased rejection of SP by the membrane from a SP removal factor of 1 to 0.6 caused a 17% reduction in MSPI yield and 3rd stage cumulative SP removal decreased from 97 to 80%. Within the ranges of the factors studied, the TP content of the 3rd stage retentate was most strongly impacted by the target CF and DF and skim milk composition. Cumulative SP removal was strongly impacted by heat treatment of skim milk, SP removal factor, and target CF and DF. Yield of MCC and MSPI was strongly impacted by skim milk composition. Yield of MSPI was also impacted by the heat treatment of milk and SP removal factor.

Key Words: microfiltration, serum protein

303 Multistage process with ceramic graded permeability (GP) microfiltration (MF) membranes to produce high casein content micellar casein concentrate (MCC) with low lactose. J. Zulewska*[2], M. W. Newbold[1], and D. M. Barbano[1], [1]*Cornell University*, *Ithaca, NY,* [2]*University of Warmia adn Mazury*, *Olsztyn, Poland*.

The objective was to determine if 0.1 μm Membralox GP membranes perform differently than 0.1 μm Membralox uniform transmembrane pressure (UTP) membranes. The 4th, 5th and final stage were run as finishing stages with purpose of lowering the lactose content of the final retentate to < 0.2% and adjusting the final protein concentration to > 9%. Raw milk was cold (4°C) separated and then the skim milk was pasteurized (72°C, 16 s) and microfiltered (320 kg) in a continuous bleed-and-feed 3X process using 0.1 μm ceramic GP membranes at 50oC. The retentate from stage 1 was diluted with pasteurized reverse osmosis (RO) water in 1:2 ratio and microfiltered (stage 2) with GP system. This was repeated 3 more times with total 5 stages (Stage 1 = MF; Stage 2 to 5 = diafiltration (DF)) of processing. To bring the protein content of the retentate to at least 9%, the final retentate from stage 5 was microfiltered using the same membrane at 1.75X CF without addition of RO water. The experiment was replicated 3 times. Data for the UTP system were obtained in a separate experiment from the GP data. Flux was significantly higher in GP than UTP system (72.5 vs. 54.0, 84.5 vs. 54.0, 92.7 vs. 54.6 kg/m^2 per hour in 1st, 2nd and 3rd stages for GP and UTP, respectively). The average retentate recirculation flow for GP and UTP were 714 and 644 L/min, respectively. The SP removal was higher in 1st stage of the UTP system than GP (63.7 vs. 56.0 for UTP and GP, respectively) with 2nd and 3rd stage being higher for GP system (26.7 vs. 21.9%, 13.8 vs. 9.7%, respectively). No difference in cumulative percentage of SP removal was detected for GP and UTP membranes, 96.5 and 95.2%, respectively. GP membranes had higher SP removal rate (kg/m^2 per hour) for 3 stages than UTP membranes: GP 0.69 and UTP 0.46 kg/m^2 per hour. Final retentate contained 0.09% lactose and 9.82% of crude protein.

Key Words: microfiltration, graded permeability, micellar casein concentrate

304 Functional modification of whey protein concentrate by microfiltration. H. Somni* and V. V. Mistry, *Midwest Dairy Foods Research Center, South Dakota State University*, *Brookings*.

Microfiltration (MF) (0.1 μm) of raw milk results in a permeate stream (MFP) with composition similar to cheese whey. The objective of this study was to compare ($P \leq 0.05$) the functional properties (gelation,

emulsion, and foaming) of whey protein concentrate (WPC) obtained from different sources. Clarified Cheddar cheese whey was pasteurized and split into 2 parts (3 replications); one part was ultrafiltered (UF) to 10X concentration and spray dried (CWPC), remaining was MF (0.1 μm) before process like CWPC (DWPC). MWPC was manufactured from MFP by UF and spray drying similar to CWPC and DWPC except that none of the stream was pasteurized (4 replications). The moisture, protein, fat, and ash content were, respectively, 6.4, 34.8, 2.8, and 5.4% in CWPC, 7.2, 37.2, 1.4, and 5.6% in DWPC, and 6.6, 48.7, 1.6, and 4.5% in MWPC. Gelation measured as 'least concentration endpoint' was lower for CWPC and DWPC. Emulsion stability of DWPC (1.3%) and MWPC (1.6%) was lower than CWPC (5.4%). While CWPC failed to produce stable foam, the overrun of DWPC (1059.7%) was higher than MWPC (952.7%). However, the foam stability after 30 min for MWPC (51%) was higher than DWPC (29%). Thus, the functional properties of WPC were different. In addition, protein solutions of DWPC and MWPC in water were devoid of turbidity unlike WPC manufactured by conventional process. Such differences are caused by major and minor compounds like glycomacropeptide (GMP), minerals, and MFGM associated compounds like phospholipids and lipoproteins. While some of these compounds like MFGM associated compounds could be removed by MF and removal of minerals depends on their state, substances like GMP are not removed by MF alone. Such compounds affect the functional properties. Microfiltration also improves shelf stability of products by removal of microorganisms and suspended matter. This opens an avenue for WPC in beverage application.

Key Words: microfiltration, whey protein concentrate, functional properties

305 Ultrafiltration of milk at high temperature. M. Lewis*, A. Grandison, N. On-Nom, and D. Wang, *University of Reading*, *Reading, Berkshire, UK*.

UF of milk has been performed at temperatures between 30 to 120°C to examine the effects on mineral partitioning, permeation rate (PR) and membrane fouling. Experimental protocols were developed to measure PR and fouling of membranes at different temperatures over a period of 40 min for milk UF, followed by water rinsing for 5 min. These initial UF runs were replicated 3 times. It was found that pH, ionic calcium and soluble calcium decreased in permeates, as temperature increased, whereas freezing point depression increased. Similar trends were found when milk was dialyzed at similar temperatures. The initial PR increased as UF temperature increased up to 100°C, but rapid PR decline was observed at 80 and 100°C. In contrast, at 50°C there was no noticeable decline in PR over a 40 min period. After about 20 min, PR was higher at 50°C compared with 80°C and it was even lower at 100°C, suggesting more severe membrane fouling at higher temperatures. When average PR was measured over a period of 30 min between 50 and 80°C, it was found to increase to a maximum at 60°C and declined thereafter. During water rinsing, PR recovered much more quickly at 50°C, compared with 80 and 100°C. Ultrafiltration at high temperature is a useful tool for measuring pH and ionic calcium of milk at high temperatures and showed that pH and ionic calcium of milk were highly temperature dependent. In contrast, the properties of permeates produced at high temperature, showed little change of pH and ionic calcium with temperature, but only at temperatures below that which they had been separated by UF. Measurement of pH and ionic calcium at high temperatures will permit a better understanding of their role in heat stability of milk.

Key Words: ultrafiltration, pH, ionic calcium

306 A method for spirulina production using cheese whey. K. M. Miranda[1,2] and L. M. Fonseca*[1], [1]*Federal University of Minas Gerais*, *Belo Horizonte, MG, Brazil*, [2]*Fundação Centro Tecnológico de Minas Gerais*, *Belo Horizonte, MG, Brazil*.

Cheese whey is a product with high nutritional value. However, because of processing costs in several countries it has limited use in the dairy industry. The objective of this work was to evaluate the use of cheese whey as an alternative media for spirulina production. spirulina (*Arthrospira platensis*), a blue-green algae used as a supplement and as whole food, has a protein content of up to 70% in the dry matter. One of the media used for spirulina production is the Zarrouk media. For this experiment, cheese whey reconstituted to 3g/100mL and 6g/100mL was clarified by heating and centrifugation, and the pH corrected to pH 9.0. Samples containing 500 mL of whey, clarified or not, were inoculated with 0.1 g/L and 0.2 g/L of spirulina and submitted to alternated 12-h photoperiod (3.0 Klux) at 25°C, during 10 d. The experiment was repeated in 5 batches. The algae growth was monitored by turbidimetry (560nm). After growth, the material was filtered, washed, pressed, and dried (50°C/8 hours). The biomass final composition was analyzed using standard methods, and the results submitted to analysis of variance. Spirulina did not grow well in non-clarified cheese whey, due to turbidity and low light transmittance through the medium. The maximum growth of spirulina was obtained with clarified cheese whey reconstituted to 3g/100mL with production of up to 1.83 g of spirulina for 1000 mL of medium. This production was reached in the sixth day, and was approximately 80% higher when compared to standard Zarrouk media. It is concluded that spirulina production using cheese whey is a feasible and low cost method, with higher production when compared to the standard industrial media. However, because of turbidity, a clarification step is necessary.

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Key Words: cheese whey, spirulina, protein

307 Investigation on coagulant properties of *Calotropis procera* and stabilization of its proteolytic enzymes. G. Belvedere[1], F. La Terra[1], M. Manenti[1], S. Lortal[2], J. C. Codjia[3], S. Doko[4], and G. Licitra*[1,5], [1]*CoRFiLaC, Regione Siciliana*, *Ragusa, Italy*, [2]*UMR Science et Technologie du Lait et de L'Oeuf*, *Rennes Cedex, France*, [3]*University of Abomey-Calavi*, *Benin*, [4]*University of Parakou*, *Benin*, [5]*DACPA, Catania University*, *Catania, Italy*.

Coagulant properties present in the latex extracted from *Calotropis procera* (fam. Asclepiadaceae) are well known. This extract is used by Peuhl community in Benin to produce Wagashi, a cheese known in West African states. From literature it is known that a wide number of chemical compounds were extracted, including cardiac glycosides, flavonoids, phenol compounds, terpenoids, and 2 proteolytic enzymes: calotropain FI and calotropain FII. Proteolytic enzymes that are present in the latex of *Calotropis procera* undergo easily oxidizing phenomena and for this reason their activity declines after 1 or 2 d. The aim of this study was to investigate whether the proteolytic enzyme present in *Calotropis procera* is the only factor influencing milk coagulation, and finally if it can be stabilized. The extract from Calotropis was autoclaved at 100°C to denaturate the proteolytic enzyme used for the milk coagulation. Its gelation activity was also verified. Several trials on the stabilization of the proteolytic enzyme, which contained active sites of cystein, were performed using extract from potato or natural flour from tapioca, gari, carob gum, and an antioxidant compound rich in cystein, glycin, and glutamic acid. The best results were obtained

with extract from potato tuber and the antioxidant compound. Results showed clearly that the coagulation process of milk was exclusively enzymatic. The proteolytic enzymes calotropain FI and calotropain FII present in *Calotropis procera* were stabilized successfully for several months and preserved their proteolytic activity in both types of trials. This would allow in the future to have a proteolytic enzyme readily available to produce Wagashi cheese in a traditional way.

Key Words: Wagashi cheese, proteolytic enzymes, *Calotropis*

308 Quality of raw and pasteurized milk (invited Pioneer speaker, 30 min presentation). C. H. White*[1,2], [1]*Mississippi State University*, *Mississippi State,* [2]*Randolph Associates, Inc.*, *Birmingham, AL*.

Milk must be safe and of high quality. Fortunately, high quality milk is normally safe, especially by microbiological standards. The definition of high quality milk must encompass the various pertinent standards and testing protocols. While raw milk is being sold to consumers under certain conditions in some states, from a microbiological standpoint this practice is questionable. Raw milk is considered by some to have more cheese flavor than cheese made from pasteurized milk. Is this a safe and reasonable practice even though it may result in a delicious cheese? Raw milk quality also impacts the shelf-life of pasteurized milk. The shelf-life is the length of time milk retains desirable sensory properties at a specified temperature. In the past 50 years, the shelf-life of commercial pasteurized milk has increased from 3 or 4 d at 7°C to 21 or more days. Extended shelf-life milk, as well as, ultra high temperature (UHT) milk can last for many weeks (even under non-refrigerated conditions for UHT products). How do dairy processing plants determine a products shelf-life? What are the key factors affecting this shelf life? Beneficial bacteria, such as certain member of the genera *Lactobacillus* and *Bifidobacterium* are routinely added to selected fluid milk for the nutritional well being of the consumer. These bacteria are thought to aid in the digestive processes and are believed to prevent or at least combat various diseases. These bacteria at least help to ensure a healthy microflora in the gut, a most desirable situation. What then is the overall quality of pasteurized milk? How is this quality determined? Does the dairy industry have enough new workers entering the field to ensure this quality? The dairy industry, in general, has well trained people producing the milk, and is fortunate have a dairy processing industry that been at the foundation of our food supply.

Key Words: milk quality, shelf-life, raw milk