Graduate Student Competition: ADSA Dairy Foods Division Poster Competition

T102 Effect of micellar casein concentrate fortification on the acidification, physical and rheological properties of nonfat Greek-style yogurt. D. D. Bong* and C. I. Moraru, *Department of Food Science, Cornell University, Ithaca, NY.*

The rising popularity of Greek-style yogurt (GSY) in recent years was one of the most remarkable changes in food production and sales in recent history. One factor that may limit growth of GSY is the production of large quantities of acid whey during the centrifugation step. The objective of this work was to develop and optimize an alternate make process for GSY, in which the desired level of protein is reached by fortification with micellar casein concentrate (MCC) instead of whey removal. The acidification, physical and rheological properties of GSY made by these two methods were evaluated and compared. MCC preparations with 2 levels of serum proteins (SP) (65% SP reduced and 95% SP reduced) obtained from milk by microfiltration were used as sources of protein. GSY with 9.80% protein made from unfortified skim milk using straining at 4°C was the control. Skim milk fortified with 65% and 95% SP reduced MCC to 9.80% protein was used in the alternate process. All samples were inoculated with GSY culture and fermented until pH 4.5.The experiment was repeated three times. Acidification was significantly faster ($P < 0.05$) for MCC fortified GSY than the control. Physical, rheological and acidification properties of MCC fortified GSY were determined after 24 hours storage at 4°C. Water holding capacity of MCC fortified GSY was significantly lower ($P < 0.05$) than the control, due to higher casein-to-whey protein ratio. Dynamic rheological analysis showed a weak frequency dependency of G′ for all samples, with G′ > G″ over the range of frequency tested, indicating that a weak gel network was formed in all samples. Differences ($P < 0.05$) in the magnitude of viscoelastic parameters between the two types of GSY were found, with G′ control > G″ fortified, which indicates a different magnitude of protein interactions in the two types of GSY. The apparent viscosity of all samples decreased as a function of increasing shear rate, indicating shear-thinning behavior, which fitted well the power law model. This study provides a basis for potential adoption of an alternate make process for GSY by the yogurt industry.

Key Words: Greek yogurt, micellar casein, rheology

T103 The effect of feed solids concentration and inlet temperature on the flavor of spray-dried whey protein concentrate. C. W. Park*[1], E. Bastian[2], B. E. Farkas[1], and M. A. Drake[1], *[1]North Carolina State University, Raleigh, [2]Glanbia Nutritionals Inc., Twin Falls, ID.*

Off flavors in whey protein negatively influence consumer acceptance of whey ingredient applications. Previous research has demonstrated that unit operations in whey protein manufacture, such as liquid storage and bleaching, promote off-flavor production in dried whey protein. The objective of this study was to determine the effects of feed solids concentration in liquid retentate and spray drier inlet temperature on the flavor of the resulting whey protein concentrate (WPC). Cheddar cheese whey was manufactured, fat-separated, pasteurized, bleached (250 ppm hydrogen peroxide), and ultrafiltered (UF) to obtain WPC80 retentate that was 25% solids (wt/wt). The liquid retentate was then diluted with deionized water to one of the following solids concentrations: 25%, 18%, or 10%. Each of the treatments was then spray dried at one of the following temperatures: 180°C, 200°C, or 220°C. Experiments were replicated three times. Dried WPC80 were evaluated by sensory and instrumental analyses. Particle size and surface free fat were also analyzed. Both main effects (solids concentration and inlet temperature) and interactions between solids concentration and inlet temperature were investigated. A decrease in feed solids concentration resulted in increased surface free fat, intensities of overall aroma, cabbage and cardboard flavors and increased concentrations of pentanal, hexanal, heptanal, decanal, (E)2-decenal, DMTS, DMDS, and 2,4-decadienal ($P < 0.05$). A decrease in inlet temperature also resulted in increased surface free fat, cardboard flavor and increased concentrations of pentanal, (Z)4-heptenal, nonanal, decanal, 2,4-nonadienal, 2,4-decadienal, and 2- and 3-methyl butanal ($P < 0.05$). Mean particle size was higher for powders from increased feed solids concentration and increased inlet temperature ($P < 0.05$). These results demonstrate that an increase in feed solids concentration in the liquid retentate and inlet temperature within the parameters tested decreases off-flavor intensity in the resulting WPC80 powder.

Key Words: WPC80, flavor, processing step

T104 Enzyme hydrolysis of lactose in milk and dairy co-products. X. E. Li* and M. A. Drake, *North Carolina State University, Raleigh.*

Interest in dietary sugar reduction has led to a search for natural alternatives to sweeten dairy beverages such as chocolate milk. We recently demonstrated that parents were interested in sugar reduction in chocolate milk for their children but that desirable flavor and natural sources of sweet taste reduction were desired. The naturally existing milk sugar lactose has a lower relative sweetness compared to its monosaccharide constituents glucose and galactose. As such, lactose hydrolysis of milk or a dried dairy ingredient may be a natural and label friendly method to reduce added sugar in chocolate milk. The objective of this study was to evaluate and compare enzymatic hydrolysis of lactose from different dairy matrices with different lactase sources. Four commercial lactase enzymes were evaluated. Lactose hydrolysis of whole raw and pasteurized milk, skim pasteurized milk, fresh liquid whey and milk permeates, five rehydrated commercial spray dried whey permeates [5 and 10% (w/w) solids], and two different commercial rehydrated lactose sources [5 and 10% (w/w) lactose in phosphate buffer] were compared at 4°C. Following 12 or 24 h, an aliquot of solution was removed and subjected to 100°C for 5 min to inactivate lactase. Hydrolysis was determined by measurement of lactose in control and treated solutions by high performance liquid chromatography (HPLC). Experiments were conducted in duplicate. Lactose was efficiently hydrolyzed in skim and whole milk, liquid permeates, and lactose solutions by three lactases in 24h (>95%), however the degree of hydrolysis varied in different rehydrated spray dried whey permeates (4 to 90%) and also varied by lactase source ($P < 0.05$). These results provide a better understanding of lactose hydrolysis in milk and dairy co-products which could be applied to naturally enhance the sweetness of dairy beverages such as chocolate milk.

Key Words: lactose hydrolysis, permeate, milk

T105 Impact of gravity separation of raw milk on shelf-life of pasteurized fluid milk. S. L. Beckman* and D. M. Barbano, *Cornell University, Ithaca, NY.*

The objective of this research was to use gravity separation (GS) of raw milk to increase the microbiological shelf-life of pasteurized 2% fat milks. Raw whole milk (experiment 1), and cold (6°C) centrifugally separated (CS) raw skim (experiment 2) milk were GS (4°C, 22 h) to remove bacteria and spores prior to production of standardized 2% fat pasteurized (72 and 80°C, 25 s), homogenized milks. A standard plate count (SPC) was conducted on raw milks (d = 0), and on pasteurized milks initially and every 7 d during 70 d storage at 6°C, with a shelf-life limit of 20,000 cfu/mL. Mesophilic spores were enumerated on raw and initial pasteurized milks. Each experiment was replicated 3 times with different lots of milk. In CS raw skim milk (experiment 2), bacteria ($P < 0.05$), spores ($P < 0.05$), and fat ($P < 0.05$) GS into the top 4% (wt/wt) layer of a column of milk. When used on raw CS skim milk, GS reduced SPC and spores by 0.8 and 0.6 log cfu/mL, respectively. Both GS of raw whole milk (experiment 1) and raw CS skim milk (experiment 2) improved the shelf-life of high-temperature short-time pasteurized milks. Lower SPC ($P < 0.05$) and spores ($P < 0.05$) in GS milks prior to pasteurization created fluid milks that had microbial shelf-lives extending beyond 70 d of storage at 6°C (experiment 1 and 2). The extended shelf-life of pasteurized GS milks compared to CS (conventionally processed) milks can be attributed to the partitioning of vegetative bacteria and heat-resistant psychrotolerant sporeformers into the cream layer during GS. There was an interaction ($P < 0.05$) of day of storage by pasteurization temperature on the shelf-life of GS and CS milks, with milks pasteurized at 72°C increasing in bacteria count faster than 80°C (experiment 1 and 2). Future work should focus on determining the chemical and biological basis for the mechanism of GS (i.e., rising) of bacteria and spores in raw and minimally pasteurized whole and skim milk. Once this mechanism is understood, it may be feasible to design a continuous-flow technology for removal of bacteria and spores from raw milk that can be done at low temperatures.

Key Words: gravity separation, shelf-life, pasteurized milk

T106 The influence of solids concentration and bleaching agent on bleaching efficacy and flavor of sweet whey powder. M. G. Jervis* and M. A. Drake, *North Carolina State University, Raleigh.*

Recent studies have demonstrated the impact of bleaching and bleaching agent on flavor and functional properties of whey protein ingredients. Fat had minimal effects on bleaching, but protein concentration at bleaching significantly impacted bleaching efficacy and flavor effects of different bleaching agents. It is not known if these parameters influence manufacture of sweet whey powder (SWP). The purpose of this study was to determine the effects of solids concentration and bleaching agent on the flavor and bleaching efficacy of SWP. Colored Cheddar whey was manufactured, fat separated and pasteurized. Subsequently, the whey (6% solids) was bleached, concentrated using reverse osmosis (RO) to 14% solids and then spray dried, or whey was concentrated prior to bleaching and then spray dried. Bleaching treatments included: Control (CT) (no bleaching, 50°C, 60 min), hydrogen peroxide (HP) (250 mg/kg, 50°C, 60 min), benzoyl peroxide (BP) (50 mg/kg, 50°C, 60 min), lactoperoxidase (LP) (20 mg/kg, 50°C, 30 min), and Maxibright (MB) (2 dairy bleaching units/ml, 50°C, 30 min). The experiment was repeated in triplicate. Sensory properties and volatile compounds of SWP were evaluated by a trained panel and gas chromatography mass spectrometry, respectively. Bleaching efficacy (norbixin destruction) and benzoic acid were measured using high performance liquid chromatography. Differences in bleaching efficacy, sensory and volatile compound profiles and benzoic acid were observed with different bleaching agents ($P < 0.05$) consistent with previous studies. Solids concentration impacted bleaching efficacy of HP ($P < 0.05$) but not other bleaching agents. SWP from whey bleached with HP or LP following RO had increased cardboard and fatty flavors and higher concentrations of lipid oxidation compounds compared to SWP from whey bleached prior to RO. These results indicate that solids concentration impacts bleaching efficacy of HP and influences off flavors associated with specific bleaching agents in SWP.

Key Words: sweet whey powder, bleaching, flavor

T107 Detection of fat and protein differences between mid-infrared instruments used for milk producer payment testing. M. C. Adams* and D. M. Barbano, *Cornell University, Ithaca, NY.*

The USDA Federal Milk Marketing Orders are responsible for ensuring milk component testing accuracy for producer payment. Currently, there are 2 ways this can be achieved: through split-sampling or statistical analysis of routine testing data. The former is ideal, as the same sample can be measured in 2 labs. However, this is not always practiced due to duplicate sampling costs. Our objective was to determine the least significant differences (LSD) necessary to detect differences in mid-infrared (MIR) spectrophotometric payment results at various confidence levels ($P = 0.0001$ to 0.10). This robust statistical method could be used when split-sampling is not practical. Two MIR instruments' fat and protein results from 4 months (153 to 197 producers in a month) were analyzed. Models for each component during each month were constructed (i.e., Fat_{July} = producer + instrument + instrument × producer + error) using the general linear model statement (PROC GLM) of SAS software. The analyses of variance indicated that "producer" was significant ($P < 0.0001$) in all 8 models, "instrument" was significant ($P < 0.05$) in most models, and "instrument × producer" was not significant ($P > 0.05$) in any of the models. "Instrument" LSD values for fat ranged from 0.0108% to 0.0148% for the 4 months ($P = 0.05$). "Instrument" LSD values for protein ranged from 0.0045% to 0.0089% for the 4 months ($P = 0.05$). In addition to these models, the differences between instruments for each producer were plotted as function of fat or protein concentration and regression was used to estimate the slopes of the best-fit lines. Surprisingly, the slopes of the best-fit lines were different ($P < 0.001$) from 0 for all 4 months for both fat and protein. This indicated that systematic differences in the MIR calibrations across component concentrations could lead to underpayment or overpayment to producers at the extremes of the concentration range, even though the means for the 2 instruments may not be different. Given the present trend toward fewer farms producing larger volumes of milk, small errors in test values could amount to large payment errors over time.

Key Words: mid-infrared, payment, statistics

T108 Measuring consumer emotional response to flavored and unflavored milk. E. Arnade*, S. Duncan, J. Dunsmore, R. Rudd, and S. O'Keefe, *Virginia Tech, Blacksburg.*

Flavored milk in school food service settings has received significant media attention because of higher caloric content, mostly from high fructose corn syrup, and questions about contributions to childhood obesity. The goal of the experiment was to characterize emotional response to unflavored (white) vs. flavored (chocolate) milk as compared to reported behavior and hedonic preference for a young adult population to better understand the current sentiment and/or disconnect between intake and liking. Panelists consumed chocolate and white milk (1% fat) and selected emotional terms from a list (n = 43 terms) describing the way they felt immediately post-consumption of each product sample. Panelists completed demographic, knowledge and

attitudes, and beverage consumption questionnaires, and rated each sample using a 9-point hedonic scale. Frequency, similarities (shared) and differences (unique) in emotional terms selected across and between samples were compared. Chocolate milk received a statistically higher ($P = 0.0017$) mean acceptability score than white milk, 7.0 ± 1.5 and 5.7 ± 2.4, respectively (overall; n = 52). Gender segmentation showed a statistically higher ($P = 0.0047$) mean acceptability score for chocolate milk than white milk within females (n = 34); no statistical difference in acceptability scores were shown within males (n = 18). Emotional term analysis identified 14 frequently used terms as well as shared terms (calm, good) across samples. Unique terms were identified between the chocolate (satisfied, happy, warm, nostalgic, and joyful) vs. white (disgusted) milk. Gender segmentation showed that females (n = 31) differentiated between the samples with many more unique terms than males (n = 17), while males had a greater number of shared terms among the samples than females, suggesting that female and male emotional response may differ. Emotional response may provide an added value understanding for the acceptability of flavored and unflavored fluid milk, suggesting an opportunity to foster the current positive response to flavored milk by providing rationale for promotion and continued access to low-fat flavored milk options.

Key Words: milk, emotion

T109 Oxidative stability evaluation of milk from cow fed with dried distillers grains with solubles by sensory and chemical analysis. G. Li*, E. Testroet, S. Clark, and D. Beitz, *Iowa State University, Ames.*

Feeding dried distillers grains with solubles (DDGS) to dairy cows has been loosely implicated in formation of oxidized off flavors in milk. The purpose of this study was to examine the impact of feeding DDGS to dairy cows on the oxidative quality of the milk by sensory and chemical analysis. Twenty-four cows were divided into 2 groups, fed a total mixed ration, with 3 incorporation levels of DDGS (0%, 10%, 25%). Each group received each of the diets, such that they served as their own controls. Milk was collected 3 times (on days 14, 21, 28) during the feeding periods. For each treatment, pooled fresh milk was divided into 3 fortification options (no vitamin, 0.06% vitamin E, 0.06% vitamin C) then HTST pasteurized. Milk fat (%), SNF (%), and protein (%) were measured by LactiCheck. A 10-member descriptive analysis panel evaluated the milk samples on seven specific descriptors on days 1, 3, and 7 of storage. Chemical analyses [peroxides, free fatty acids (FFA)] were taken from the same milk with SafTest kits. Milk fat decreased significantly ($P < 0.0001$) from 3.3% to 2.7% in both 10% and 25% DDGS groups, while SNF and protein increased ($P < 0.1$), storage day effect ($P > 0.1$), or fortification effect ($P > 0.05$) on oxidized off-flavors. However, for the 25% diet treatment milk with vitamin C, higher light oxidized ($P < 0.05$) and metal oxidized ($P < 0.0001$) flavor scores were found. Though statistically significant, the milks did not exhibit definite oxidized flavor; the scores were lower than 1.5 on a 15-cm line scale. All peroxide and most of the FFA measurements were below detection level, with the exception of a couple of samples that had slightly elevated FFA; the elevated results were not observed in their replicates. With no apparent oxidation in any milk from any treatment, the sensory and chemical analyses support the conclusion that feeding of DDGS at 10% and 25% levels did not decrease the oxidation stability of milk. Spontaneous oxidation is a complex process that cannot be blamed on DDGS alone.

Key Words: milk, dried distillers grains with solubles, sensory evaluation

T110 Role of exopolysaccharide-producing starters in biofilm formation on dairy separation membranes. N. Garcia-Fernandez*, A. N. Hassan, and S. Anand, *Midwest Dairy Foods Research Center, Dairy Science Department, South Dakota State University, Brookings.*

The objective of this research was to evaluate the role of exopolysaccharides (EPS) produced by lactic starters in biofilm formation on dairy separation membranes. Exopolysaccharides are thought to play a role in biofilm formation and stability. We hypothesized that EPS-producing starters used in cheese making would increase the risk of biofilm formation on whey separation membranes. Two different EPS^+ starters and their isogenic EPS^- variants were used to study attachment of bacterial cells in the absence of growth (at 4ºC) and biofilm formation on Reverse Osmosis (RO) membranes. M17 broth and whey protein concentrate 35 solution (10% w/w) were used as growth media for biofilm formation under static conditions. *Streptococcus thermophilus* ST3534 (EPS^+) and ST5842 (EPS^-) were provided by Chr. Hansen. *Lactococcus lactis* ssp. *cremoris* JFR^+ (EPS^+) was isolated from a retail dairy product and an EPS^- mutant (JFR^-) was selected in our laboratory. Plasmid profile analysis revealed the absence of a plasmid in JFR^-. Five (2 × 2 cm) pieces of RO membrane were used in each experiment. Bacterial cells were allowed to attach and form biofilm on the retentate side only. A stomacher was used to recover cells attached to the membrane and the viable cell counts were estimated. Each experiment was repeated three times. Results showed significantly greater ($P < 0.05$) counts (cfu/cm^2) of ST3534 cells in biofilm than those of ST5842 whilst counts of cells attached to the membrane in the absence of growth did not differ ($P > 0.05$) between the isogenic pair. Interestingly, JFR^+ counts were significantly lower ($P < 0.05$) than those of JFR^-. These findings indicate that EPS produced by ST3534 may have a role in building up the three dimensional structure of the biofilm rather than assisting in the attachment to the membrane at the initial steps of biofilm formation while EPS produced by JFR^+ interfered with both cell attachment and biofilm formation. In conclusion, EPS produced by starter cultures vary in their role in bacterial attachment and biofilm formation, likely, due to variations in their molecular characteristics and interactions with the membrane.

Key Words: biofilm, exopolysaccharide, membrane

T111 Solubility and antihypertensive activity of whey protein hydrolysate subjected to Maillard-induced glycosylation. K. Ruud*, Q. Wang, and B. Ismail, *University of Minnesota, St. Paul.*

The interest in the utilization of biologically active whey protein hydrolysates (WPH) in functional foods and beverages, specifically, has significantly increased over recent years. While bioactive WPH potentially may impart physiological benefits such as antihypertensive activity, maintaining quality and shelf-life stability is a major hurdle that hinders its application in beverages. We have recently demonstrated whey protein solubility and thermal stability enhancement upon partial Maillard-induced glycosylation over a broad pH range. Our objective was to evaluate the effect of limited and controlled Maillard-induced glycosylation on the solubility, thermal stability, and antihypertensive activity of WPH. Whey protein hydrolysate (DH 5.2%) was reacted with dextran (10 kDa) at $a_w = 0.49$ and at 60°C for up to 60 h to produce partially-glycosylated WPH (PGWPH). Extent of glycosylation was assessed by monitoring absorption at 304 nm and by determining % amino-groups blockage. Extent of browning was monitored at 420 nm. The antihypertensive activity was determined by measuring the angiotensin converting enzyme (ACE) inhibitory activity following an in vitro assay. For determination of solubility and thermal stability, PGWPH samples and their controls were prepared in solutions (5% wt/

vol) at various pH values and subjected to heat treatment at 80°C for 30 min. Difference UV spectroscopy confirmed that glycosylation was initiated after 48 h of incubation. Partial glycosylation with only up to 2% amino-group blockage and minimal browning were maintained after 60h of incubation. Solubility and thermal stability of PGWPH were enhanced especially around the pI of whey protein. The antihypertensive activity of PGWPH was preserved maintaining an IC_{50} similar to or greater than that of WPH. Our results indicated that partial glycosylation has the potential to improve the solubility and thermal stability of WPH over a wide range of pH, while maintaining its bioactivity.

Key Words: whey protein hydrolysate, Maillard-induced glycosylation, antihypertensive activity