Graduate Student Competition: ADSA Dairy Foods Graduate Student Poster Competition

T191 Characteristics of cheese powders and the role of color on consumer perception of cheese flavor. Ni Cheng*, Yeijin Jo, and M. A. Drake, *Southeast Dairy Foods Research Center, North Carolina State University, Raleigh, NC.*

Cheese powder is applied in many food applications including sauces and snacks. Cheese flavor is a consumer expectation of these applications. The objective of this study was to characterize the properties of cheese powders and to explore the role of color on consumer perception of cheese flavor on cheese powder applications. Duplicate samples of 11 commercial cheese powders were collected. Proximate analyses (moisture, fat, salt, color, pH) were conducted. Cheese powders were rehydrated and evaluated with a trained panel using an established cheese flavor lexicon. Volatile compounds were extracted by solid phase micro-extraction (SPME) followed by gas chromatography-mass spectrometry (GC-MS). Seven representative powders were selected from trained panel sensory results, applied to potato chips, and evaluated by 113 consumers. Consumers evaluated expected liking and cheese flavor before tasting (visual only) and after tasting. Moisture, fat, salt and pH of cheese powders varied (1.40–4.73%, 0.77–47.74%, 1.68–13.99% and 4.56–6.88, respectively). Color varied from white to dark orange. Cheese powders were characterized by a variety of natural cheese flavor attributes including milky, whey, diacetyl, sulfur, brothy, nutty, and free fatty acid and basic tastes. The major aroma-active volatile compounds in cheese powders were dimethyl sulfide, dimethyl disulfide, dimethyl trisulfide, methional, 2/3-methylbutanal, guaiacol, 1-octen-3-ol, diacetyl and volatile free fatty acids. Consumers associated orange color with higher cheesy color liking and higher expected cheese flavor compared with white cheese powders ($P < 0.05$). Diacetyl and whey flavors with salty and sour tastes were perceived as "cheesy" by consumers. Orange color in cheese powders enhanced consumer cheese flavor expectations while diacetyl and whey flavors and salty and sour tastes increased cheese flavor on potato chips.

Key Words: cheese powder, cheese flavor, color

T192 The effect of raw milk cooling on sensory perception and shelf life of pasteurized skim milk. Andy Lee*[1], D. M. Barbano[2], and M. A. Drake[1], [1]*Southeast Dairy Foods Research Center, North Carolina State University, Raleigh, NC,* [2]*Cornell University, Ithaca, NY.*

The cooling rate of raw milk may influence sensory properties and pasteurized shelf life. Under the Pasteurized Milk Ordinance (PMO) for grade A milk, raw milk may be cooled instantaneously by on-farm heat exchangers but is also acceptable if "cooled to 10°C or less within four (4) hours of the commencement of the first milking." The objective of this study was to determine the effect of raw milk cooling on consumer perception and shelf life. Raw milk (18–21°C) was obtained and transported within 1 h of milking to North Carolina State University. After comingling, the batch was split and a plate heat exchanger was used to quickly cool one treatment to <6°C for all milkings. The second treatment was stored in a jacketed bulk tank and slowly cooled over 4 h to <10°C. Three consecutive milkings were collected every 12 h with subsequent milkings added to the previous collections. The bulk milk was kept below 10°C while adding milk for the slow cool milk treatment. After 72 h, each whole milk was separated, pasteurized at 73 or 78°C for 20 s, homogenized, and held at 4°C. Difference tests (n = 75) and consumer acceptance tests (n = 100) were conducted to determine if consumers could detect differences among milks. Descriptive analysis (DA) and microbial testing for aerobic, psychrotrophic, and spore counts were conducted through shelf life. The entire experiment was repeated in triplicate. Raw milks averaged 4.29 Log cfu/mL by aerobic plate count, 52 cfu/mL coliforms, 300,000 SCC and 3.15 ± 0.7% protein. Spores were < 20 cfu/mL in raw milk. After processing, consumers could not detect differences ($P < 0.05$) between cooling treatments of the same pasteurization temperature nor between different temperatures of the same cooling treatment. Milks reached sensory failure 35–42 d after processing, and aerobic counts were between 5 and 7 log cfu/mL. Higher pasteurization temperature decreased shelf life. Cooling treatment had no effect on shelf life. These results suggest that pasteurized milk quality is due to a combination of many factors. Raw milk cooling rate is not the largest effect on milk quality.

Key Words: fluid milk, cooling, quality

T193 Reducing protein bar hardening via whey protein-polyphenol ingredients. Margaret Schneider*, Mary Ann Lila, and E. Allen Foegeding, *Department of Food, Bioprocessing and Nutrition Sciences, North Carolina State University, Raleigh, NC.*

Whey proteins serve as a structural component and source of protein in foods. When used in protein bars, whey proteins can contribute to a reduction in shelf life as a consequence of bar hardening. Bar hardening has been associated with water migration between phases and formation of a protein network in bars over time. One approach to ameliorate bar hardening is to form whey protein meso-structures that are not susceptible to water migration or protein network formation. We hypothesize such structures can be formed by using berry polyphenols to initiate whey protein aggregation that leads to formation of inert particles. Whey protein-cranberry polyphenol (WP-CP) particles were formed by adding 200 g of whey protein isolate (WPI) to 1 L of cranberry juice during continuous stirring. After mixing for 4 h, particles were pelleted (7,000 x g for 40 min), re-suspended at 0.01 g/mL in water, and spray dried. Bars were made with WP-CP particles or unmodified WPI. Textural properties were assessed using transient creep-recovery testing which measured the maximum compliance (J_{max}, indicating bar firmness) and percent creep-recovery (bar viscoelasticity). The WP-CP particles contained up to 2 mg/g of total phenolics, and the particle size ranged from 10 to 100 µm. Bars produced with WPI had a smaller J_{max} (more rigid) of 0.000053 Pa^{-1} compared with 0.0023 Pa^{-1} J_{max} for bars formulated with WP-CP particles. Bars formed with the WP-CP had a reduced percent recovery of 2.5% compared with 28.6% for bars made with WPI. Greater percent recovery indicates a more elastic system and possible network formation. Bars were placed in accelerated shelf life tests that imitate 3 weeks of storage at room temperature. The bars with WP-CP particles remained less rigid and more viscous (J_{max} of 0.0039 Pa^{-1} and 10.9% creep recovery) than control whey protein bars (J_{max} 0.000012 Pa^{-1} and 57.5% creep recovery). All differences between bars were found to be statistically significant at the $P < 0.01$ level. Rheological properties are consistent with WP-CP particles acting as inactive fillers and preventing formation of a protein network. These results suggest that WP-CP particles can be used to extend shelf life of protein bars and offer additional health benefits from plant polyphenols.

Key Words: whey protein, polyphenol, protein bar

T194 Development and characterization of whey protein nanoparticles for beverage applications. Ty B. Wagoner*[1], Loren S. Ward[2], Chris W. Pernell[1], and E. Allen Foegeding[1], *[1]North Carolina State University, Raleigh, NC, [2]Glanbia Nutritionals, Twin Falls, ID.*

Whey protein consumption has been linked to several health benefits including increased satiety and metabolic regulation; therefore, there is interest in increased consumption of foods rich in whey proteins. Meal replacement beverages and sports drinks are categories of foods that contain whey proteins. However, low thermal stability—especially near the protein isoelectric point (pI)—limits the pH range and protein concentrations at which beverages can be formulated. Studies have shown that at a narrow pH range close to the pI, whey proteins and pectin self assemble into soluble complexes (SCs) that have improved colloidal stability. Our objectives were to 1) determine the conditions required to form stable whey protein-pectin SCs, 2) characterize physical properties of the SCs, and 3) evaluate the effect of SCs on bulk rheological properties. Soluble complexes were formed at various protein concentrations (1, 4, 5 and 6% wt/wt) with a constant protein to pectin ratio of 8:1 by adjusting the pH from 7 to 5. After complexation, particles were stabilized by heating at 85°C for 25 min. The properties of unheated and heat-set SCs were characterized via intrinsic viscosity, particle size distribution, and rheological analysis. Laser diffraction particle size analysis revealed that heating shifted sizes toward a monomodal distribution with mean diameter of ~100 nm for all protein concentrations. Heat-stabilization significantly reduced intrinsic viscosity of SCs from 93.6 mL/g to 79.5 mL/g ($P < 0.05$), suggesting conformational changes that favor a smaller hydrodynamic size. Decreased viscosity of heat-set SCs was consistent with intrinsic viscosity and particle size results. Increasing protein concentration had very little effect on size of heat-set SCs, suggesting applications in beverages where a high protein concentration is desired. Heat-set SCs remained as 100 nm particles and did not aggregate over the pH range of 3–6. Moreover, they remained stable in this pH range after thermal processing. These results indicate that whey protein-pectin SCs can be heat-set into 100 nm particles with enhanced colloidal stability for applications in beverages.

Key Words: whey protein, beverage, thermal stability

T195 Casein and exopolysaccharide degrading activities of *Bacillus* strains isolated from the dairy environment. Dipakkumar Mehta*[1], Hasmukh Patel[1], Ashraf Hassan[2], and Brandon Nelson[2], *[1]South Dakota State University, Brookings, SD, [2]Daisy Brand, Garland, TX.*

Milk proteins and exopolysaccharides (EPS) play an important role in texture formation and stabilization of yogurt. Many *Bacillus* strains have the ability to breakdown proteins and degrade polysaccharides. To our knowledge, the ability of the *Bacillus* spp. to degrade EPS from starter cultures has not been tested. The objective of this study was to quantify proteolytic and the EPS-degrading activity of *Bacillus* strains. Twenty-five *Bacillus* strains isolated from the pasteurizer balance tank of a dairy company were pre-screened for their proteolytic ability using skim-milk agar (SMA) at 42°C. The strains that showed proteolytic activities were inoculated individually at 10^3 cfu/mL in heated (90°C for 10 min) rehydrated nonfat dry milk (11% w/v) which was then incubated at 42°C for 48h. The evidences of proteolytic activity were quantified by SDS-PAGE and measuring the non-casein nitrogen (NCN). To study EPS degradation, 2 *Bacillus* strains that were able to degrade a wide range of polysaccharides in a previous study were selected. The reduction in viscosity of a whey protein concentrate (WPC) solution (10% w/v) fermented with yogurt cultures producing high, medium, or low EPS in the presence of the test *Bacillus* strains (10^3 cfu/mL) indicated positive results. The viscosity of the fermented media was measured using the Stress-Tech rheometer at 42°C and a shear rate of 100 s^{-1}. Out of the 25 *Bacillus* strains, 20 stains showed proteolytic activities on SMA. Of these 20 strains, 8 strains showed significant ($P < 0.05$) 30–50% degradation of caseins (predominantly β- and κ-CN) as determined by SDS-PAGE and 4 fold increase in NCN contents. Highly proteolytic strains also caused sweet curdling in skim milk. Used Two *Bacillus* strains showed 20–30% reduction in viscosity was observed in the WPC medium containing the low EPS producing culture whereas only 8–10% decrease in viscosity was found in the medium fermented with the high EPS-producing culture. The results of the present study showed the potential of *Bacillus* strains to degrade EPS and reduce viscosity of the fermented dairy products. It also provided useful information on the prevalence of highly proteolytic *Bacillus* strains in a relatively large number of isolates from a dairy plant.

Key Words: *Bacillus*, protein, EPS

T196 Chemosensory analysis of light-emitting diode and fluorescent light on fluid milk volatiles. Kemia N. Amin*, Maria A. Hadley, Susan E. Duncan, and Kumar Mallikarjunan, *Virginia Polytechnic Institute State University, Blacksburg, VA.*

Fluid milk deteriorates rapidly under lighted storage, affecting milk sensory and nutritional quality before purchase. Energy conservation efforts have shifted commercial retail cases from fluorescent to light emitting diode lights (LED). The effect of LED lights on milk quality has not been determined. Efficient milk freshness validation methods are needed in the dairy industry to predict sensory quality. The purpose of this study was to determine volatile differences of 2% milk under LED and fluorescent lights using a commercial conducting polymer electronic nose (ENose). This study focused on changes in volatiles within 72 h of storage under refrigerated retail case conditions. Fresh 2% milk (half gallon high density polyethylene; n = 60) was purchased from a local grocery store immediately upon delivery. Bottles (treatments: light protected control [LP; foil overwrap); light-exposed (LE)] were randomly placed in a commercial retail case with LED and fluorescent lighted sections. Milk was tested on receipt and at 4, 8, 24, 48, and 72 h. Samples (n = 3 bottles per LP and LE treatment) were collected at each time interval and tested with the ENose and thiobarbituric acid reactive substances (TBARS). Canonical distribution ($P < 0.05$) of volatile changes showed 100% separation of volatiles components detected by ENose, for each time under each light treatment for LE milk compared with LP control. As time increased, separation between LED and fluorescent clustered ENose data moved further away from the control and each light treatment resulting in greater differences. By 72 h, LED LE cluster data were farther from the ideal fresh milk than the fluorescent cluster. This suggests that milk under LED may have more differences in volatiles than milk under fluorescent light at 72 h. TBARS values were not significantly different ($P > 0.05$) between the interval light treatments. ENose technology could be more sensitive to volatile changes than TBARS. The volatile differences detected through the ENose may affect product integrity and consumer response. Understanding different light effects on milk and ENose application in the dairy industry could improve sensory and quality testing of milk.

Key Words: electronic nose (ENose), milk, light oxidation

T197 Inactivation of thermoduric bacterial endospores in milk by combined effect of cavitation and thermal treatment. Dikshi Bawa*, Sanjeev Anand, Harsh Dahiya, and Hasmukh Patel, *South Dakota State University, Brookings, SD.*

Bacillus endospores can survive milk pasteurization, and later germinate and grow during further processing of milk. Their resistance to various physical and biochemical treatments, dormancy, ability to adhere to the surfaces of process equipment resulting in biofilm formation, and prompt germination under favorable conditions, make them important contaminants in dairy processes. The objective of this research was to investigate the effect of hydrodynamic cavitation in a continuous mode, and its combination with thermal treatment, to reduce *Bacillus* spores in milk. We hypothesized that cavitation would induce germination of spores and any post cavitation heat treatment would lead to their inactivation. Spores of *Bacillus licheniformis* (ATCC 6634) were produced in lab by incubating on brain-heart infusion (BHI) agar plates for about 2 weeks, and were harvested from plates by washing and centrifugation. The vegetative cells in spore suspension were inactivated by heating at 85°C for 10 min. The resulting spores were inoculated in sterile skim milk to a level of log 2 cfu/mL. Inoculated milk samples at 10°C were passed through APV Cavitator (SPX, Denmark) at 60 Hz frequency using 4-row rotor in 6-mm housing. The exposure time of 22 s per pass was provided at 200 L/h flow rate with a back pressure of 120 kPa. The milk containing endospores was recirculated for 25 min (a total exposure time of 183 s) with a temperature rise to 99°C. Samples were cooled and held for 3 h at 30°C to let the germination process occur. Samples were then heated at 85°C for 15 min, and were plated on BHI agar medium. Experiments were conducted as replicates of 2, and were repeated thrice. Statistical significance of the data at $P < 0.05$ was determined using the SAS software. A significant difference was observed in the endospore counts after the treatments. Heat treatment alone did not result in inactivation of the spores. Whereas, cavitation with holding followed by heat treatment caused a reduction with only 0.60 log survivors. In conclusion, it was evident that a combined process with cavitation effect, holding for germination, followed by thermal treatment can be effectively used to inactivate thermoduric endospores.

Key Words: cavitation, endospore, germination