21 Hydrodynamic cavitation: A clean label approach for ice-cream formulation. J. Sim*, H. Bonnemann, L. Metzger, and S. I. Martinez-Monteagudo, Dairy and Food Science Department, South Dakota State University, Brookings, SD.

Trends in consumer’s health- and wellness-lifestyle have perceived stabilizers as undesirable ingredients. Stabilizer plays an essential role in the manufacturing of ice cream because it reduces the growth of ice crystals and prevents migration of free water. Some stabilizer has been chemically derivatized to improve its solubility in water. This derivatization does not meet consumer’s demands for the clean and natural ingredients. Our research aims was to utilize hydrodynamic cavitation (HC) to reduce the concentration of stabilizers in ice-cream mix. The central hypothesis of this research is that by appropriate choice of temperature, flow rate, and rotor speed, it is possible to regulate fat destabilization (partial coalescence and agglomeration of fat globules), and thus create an emulsion, utilizing protein rather than relying on stabilizers. An ice-cream formulation of industrial interest was used for our experiments that contained different the concentrations of the stabilizer mix (0.0.07, 0.14, 0.21, 0.28%). The stabilizer mix consisted of guar gum, mono- and diglycerides, locust bean gum, carrageenan, and polysorbate 80. The manufactured formulations were analyzed in terms of particle size distribution, microscopy and dynamic mechanical spectra. A control formula was manufactured with conventional homogenization and heat treatment and was compared with the treatments. The obtained strain sweep showed a viscoelastic region within the same range of strain (0.05–28%). No difference was observed in the viscoelastic region for samples with 0.28% of the stabilizer mix and treated with HC (100 L/h and 3600 rpm) when compared with the control formulations. In contrast, an increase of 6-fold in the linear section of the viscoelastic region was observed in formulations with 0.014% of the stabilizer mix and treated with HC. Interestingly, the viscosity did not significantly change different within formulation varied from 180 to 200 cP at a shear rate of 10 s⁻¹. Dynamic rheological measurements as strain sweeps exhibited increased product stability with the application of HC. The information generated in this study may help to develop strategies for the formulation and manufacture of ice cream with reduced concentration of stabilizers.

Key Words: clean label, hydrodynamic cavitation, ice-cream formulation


The industry solution to the increased consumer appetite for protein enriched products has been to utilize whey protein isolate and high whey protein concentrates (WPC) in formulations. However, the production of these high whey protein ingredients generates lower protein streams that are underutilized due to lower functionality. A potential solution is the utilization of targeted modification of WPC in combination with whey protein phospholipid concentrate (WPLC), a lower protein, coproduct, to stabilize emulsions. The use of strategically hydrolyzed whey protein along with WPLC, will enhance antioxidant activity and improve emulsion properties resulting in a low cost, clean label protein solution for high value applications, such as encapsulation of bioactives. Our objective was to enhance the emulsification properties and antioxidative activity of WPC through limited hydrolysis and combine with WPLC to improve the oxidative and physical stability of fish oil emulsions. WPC was hydrolyzed (HWPC) by two enzymes, and the protein/peptide profiles were characterized by gel electrophoresis and size exclusion HPLC. Changes in structural properties, namely surface hydrophobicity and zeta potential, were monitored. Antioxidant activity and emulsification properties were assessed. Fish oil was then emulsified with combinations of WPC, HWPC, and WPLC and stored for one week at elevated temperatures to test physical characteristics and hydroperoxide formation. Limited hydrolysis of WPC (7–12% degree of hydrolysis) improved both antioxidant activity and emulsification properties. Protease M hydrolysatess had enhanced emulsification properties due to targeted hydrolysis of α-lactalbumin. Whereas, trypsin targeted β-lactoglobulin reducing the surface hydrophobicity, which maintained the emulsification capacity and improved emulsion stability. Finally, antioxidant activity was improved notably for Protease M hydrolysatess. Targeted hydrolysis of WPC combined with WPLC can improve the oxidative and physical stability of fish oil emulsions, thus improving the value of these underutilized dairy products. Future work will focus on expanding utilization of these whey protein systems to microencapsulating fish oil.

Key Words: whey protein phospholipid concentrate, whey protein concentrate (WPC), emulsion stability

23 Manufacturing of process cheese without emulsifying salt using acid curd. A. R. A. Hammam* and L. E. Metzger, Dairy and Food Science Department, South Dakota State University, Brookings, SD.

Process cheese products (PCP) are a dairy food prepared by blending dairy ingredients (such as natural cheese, protein concentrates, butter, NFDM, whey powder, and permeate) with nondairy ingredients (such as sodium chloride, water, emulsifying salts, color, and flavors) and then heating the mixture to get a product with an extended shelf-life. Emulsifying salts (e.g., sodium citrate, disodium phosphate) are critical for the functional characteristics of PCP because they improve the emulsification characteristic of casein by displacing the calcium phosphate complexes that are present in the insoluble calcium-paracaseinate-phosphate network in natural cheese. The objective of this study was to manufacture PCP using a combination of acid curd cheese and micellar casein that would provide the required emulsion capacity without the use of emulsifying salts. The acid curd utilized was produced from micellar casein concentrate that was standardized to 3, 6, and 9% protein. In the formulation, the acid curd was blended with micellar casein so that the formula contained a 2:1 ratio of protein from acid curd relative to micellar casein. Additional dairy and non-dairy ingredients (Cheddar cheese, butter, and salt) were also used in the formulation. The PCP was prepared by mixing all ingredients in a kitchen aid to produce a homogeneous paste. Approximately 25 g of the mixture was cooked in a RVA for 3 min at 95°C with a 1000 rpm stirring speed during the first 2 min and 160 rpm for the final min. The cooked PCP was then transferred into molds and refrigerated until further analysis. This trial was repeated 3 times using acid curd (produced from 3, 6, and 9% protein MCC). No significant differences (P > 0.05) were detected in the cooked viscosity (402–483 cP), hardness (354–384 g), melting area (30.0–31.4 mm) and melting temperature (48–51°C) between PCP made from different acid curd and was similar to typical process cheese produced with conventional ingredients and emulsifying salt. We conclude that PCP can be made...
with no emulsifying salts when the formulation utilizes a 2:1 ratio of protein from acid curd relative to micellar casein.

**Key Words:** process cheese, micellar casein, acid curd

### 24 Clean label: The naturalness perception and acceptance of dairy ingredients

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Consumer demand for natural foods continues to grow and dairy processors have answered the calling offering many clean label products. However, regulatory agencies have not clearly defined “natural” labeling, and accordingly the industry and consumers may have different interpretations of the term. The current study aims to measure consumers’ naturalness perception of dairy ingredients and to investigate factors affecting their responses. An online-administered survey asked over 500 frequent yogurt consumers to evaluate naturalness, acceptability, and familiarity of common yogurt ingredients including various sugars, stabilizers, preservatives, and coloring agents. Respondents also rated the acceptability of the ingredients when their functions and sources were given. Importantly, socio-demographic (e.g., gender, income, education, household size) and personal preference (e.g., purchasing habits, ingredient knowledge) information was collected at the end of the survey. In terms of perceived naturalness, we found that coloring agents and preservatives varied substantially within each category, with some ingredients perceived as natural and others as unnatural. In contrast, sugars were perceived as generally natural, whereas all stabilizers were perceived as less natural, with rankings statistically not different within the ingredient category. Further examination of the interquartile ranges for each ingredient revealed that consumers strongly agreed on the degree of naturalness for some ingredients (e.g., vegetable juice, red 40), but not others (e.g., pectin, fructose). Considering acceptability of each ingredient, providing ingredient function had little impact on the ratings. However, providing ingredient source significantly improved the degree of ingredient acceptability. We will discuss these findings along with the impact of heterogeneity in socio-demographic and personal preference on the perceived naturalness and acceptability of common yogurt ingredients.

**Key Words:** clean label, dairy ingredients, consumer behavior

### 25 Cloudy vs. foggy: Mystery behind high pressure-induced aggregates of milk proteins for the valorization of cheese whey

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Protein aggregation can be used to improve functionality in certain food systems, especially in gelled systems. However, in beverages application, this phenomenon is generally undesirable because it is usually related to protein insolubility and turbidity. Nonetheless, some research has demonstrated a molecular chaperone-like property of certain milk proteins that helps avoid protein aggregation. Here, we investigated the effect of β-casein (β-CN) on pressure-induced aggregation of whey proteins; β-lactoglobulin (β-LG) and α-lactalbumin (α-LA) using various qualitative and quantitative analyses (turbidity, SDS-PAGE, HPSEC and TEM). Protein model solutions containing different ratios of α-LA, β-LG and β-CN were pressurized by high hydrostatic pressure (HHP). Pressure treatment of β-LG alone generated a highly turbid solution (foggy) containing large aggregates while the addition of both proteins (α-LA and β-CN) at different ratios led to a drastic decrease in turbidity, despite the presence of larger aggregates (cloudy). In fact, TEM analysis showed larger and amorphous aggregates for β-LG with α-LA and β-CN, and globular, denser aggregates for β-LG alone. Further analysis of these aggregates by fractionation (HPSEC) followed by SDS-PAGE showed no β-CN directly involved in β-LG aggregation, suggesting a chaperone-like effect of β-CN under HHP. Our experiments, performed on model dairy solutions, demonstrated that α-LA and β-CN inhibits the formation of insoluble aggregates (decreases turbidity) under HHP treatment of β-LG that could be relevant in milk protein fortified beverages.

**Key Words:** chaperone protein, dairy protein, high hydrostatic pressure

### 26 Developing a dairy-based health formulation by combining the bioactive properties of whey protein hydrolysates and probiotic organisms

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With the increased consumer demand for nutritional foods, it is important to develop novel products with enhanced health benefits and functionality. We developed a spray dried health formulation by encapsulating probiotics in a conjugated whey protein matrix. Samples of whey protein concentrate, isolate and hydrolysates were screened for bioactivities (antimicrobial, antioxidant and antihypertensive activity) and based on highest bioactivities hydrolysate WPH10, was conjugated with maltodextrin to obtain a thermally stable conjugated solution. Probiotic cultures *Bifidobacterium animalis* ssp. *lactis* ATCC27536 and *Lactobacillus acidophilus* ATCC4356 were added in the conjugated solution at ratio of 1:1, with spiking level of log10 cfu/mL. The mixture was spray dried in 2-L batch using a Niro drier with an inlet and outlet temperature of 200°C and 90 ± 5°C. To conduct the storage stability, the dried formulation was stored in airtight bottles for 10 weeks at 4, 25, and −18°C, to monitor cell viability, moisture and functionality. The experiments were done in triplicates and one-way ANOVA was applied to differentiate the mean values. In comparison to WPH10 alone, the conjugated WPH10 solution demonstrated higher antimicrobial and antioxidant activities. Following spray drying a higher antimicrobial (18.5 ± 0.57 mm) and antioxidant activity (1268.89 ± 41.9 TEAC μmol/L) was observed with retention in the antihypertensive activity (65.6 ± 0.3%ACE inhibition). The mean probiotic counts in conjugated WPH10 matrix before and after spray drying were 10.37 log cfu/mL and 8.50 log cfu/g, respectively. These counts were maintained for at least 4 weeks under all 3 storage conditions. Beyond that, the viability gradually decreased and at 10 weeks of storage the counts were 3.79 and 4.03 cfu/g at 4 and −18°C, respectively. At this point, the moisture content was 0.94 ± 0.14%, with a slight increase in the wetting time (from 47 ± 2min to 61 ± 3min) and decrease in the solubility (from 90.7 ± 0.13% to 82.2 ± 0.4%). Such formulation can be applied in functional foods to harness their enhanced health benefits and functionality.

**Key Words:** conjugation, functional

### 27 Study of the interaction between whey proteins and anthocyanins using fluorescence spectroscopy

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The food industry is moving away from synthetic colorants in favor of natural alternatives. Anthocyanins (ACNs) are plant pigments with vivid colors, but their application is restricted by their limited stability, particularly at pH close to neutral. Previous research showed that addition of whey protein isolate (WPI) to model juices colored with ACNs improved their color characteristics and increased their thermal resistance when compared with model juices without whey proteins (WP).

It was hypothesized that WP may be interacting with ACNs, leading to enhancements in tintorial strength and thermal stability. In this study, we performed fluorescence quenching (FQ) experiments to assess the level of interaction between anthocyanins and whey proteins. Eleven different anthocyanins were isolated from Berberis boliviana, purple corn and black carrot using semi-preparative HPLC. Identification and purity analyses were performed using uHPLC-MS. Model solutions were prepared by diluting WPI until a concentration of 1 mg/mL (0.1%, 54 μM) was reached using pH 3 citric-acid-Na₂HPO₄ buffer, followed by the addition of purified ACNs (>90% purity) at different concentrations (1–100 μM of Cy-3-glu eq.). FQ by ACN addition was measured using a microplate reader with an excitation wavelength of 280 nm. Results were adjusted to the Stern-Volmer (SV) equation for analysis. Further, to establish whether the FQ phenomena was a result of collisional quenching or binding-related quenching, measurements were conducted at different holding temperatures (30, 35 and 40°C). Results showed that addition of anthocyanins at concentrations as small as 1 μM resulted in significant FQ of WP (P < 0.05); and that Pt-3-glu, Mv-3-glu and Cy-3-glu were the most efficient quenchers. Measurements at different pH close to neutral. Previous research showed that addition of whey protein isolate (WPI) to model juices colored with ACNs improved their color characteristics and increased their thermal resistance when compared with model juices without whey proteins (WP). It was hypothesized that WP may be interacting with ACNs, leading to enhancements in tintorial strength and thermal stability. In this study, we performed fluorescence quenching (FQ) experiments to assess the level of interaction between anthocyanins and whey proteins. Eleven different anthocyanins were isolated from Berberis boliviana, purple corn and black carrot using semi-preparative HPLC. Identification and purity analyses were performed using uHPLC-MS. Model solutions were prepared by diluting WPI until a concentration of 1 mg/mL (0.1%, 54 μM) was reached using pH 3 citric-acid-Na₂HPO₄ buffer, followed by the addition of purified ACNs (>90% purity) at different concentrations (1–100 μM of Cy-3-glu eq.). FQ by ACN addition was measured using a microplate reader with an excitation wavelength of 280 nm. Results were adjusted to the Stern-Volmer (SV) equation for analysis. Further, to establish whether the FQ phenomena was a result of collisional quenching or binding-related quenching, measurements were conducted at different holding temperatures (30, 35 and 40°C). Results showed that addition of anthocyanins at concentrations as small as 1 μM resulted in significant FQ of WP (P < 0.05); and that Pt-3-glu, Mv-3-glu and Cy-3-glu were the most efficient quenchers. Measurements at different holding temperatures showed good linearity (r² > 0.9) and no significant changes in the SV constant with increasing temperature, suggesting that the type of FQ phenomena was a binding-related one. Therefore, WP can interact with anthocyanins in a binding-related manner, improving the color characteristics and thermal resistance of the pigment.

Key Words: natural colorant, whey protein isolate (WPI), fluorescence quenching

28 Impact of stretching temperature in a waterless cooker on the functionality of Mozzarella cheese. E. K. Aversa*1, S. Govindasamy-Lucey2, M. E. Johnson2, J. J. Jaeggi2, and J. A. Lucey1,2, 1University of Wisconsin-Madison, Madison, WI, 2Wisconsin Center for Dairy Research, Madison, WI.

Use of high stretch temperatures during manufacture of low moisture part-skim (LMPS) Mozzarella cheese decreases residual rennet activity (RRA) and microbial counts. High stretch temperatures could help extend the shelf-life of LMPS destined for export. The aim of this study was to determine the impact of stretching temperatures (60, 74, and 88°C) in a waterless cooker on the composition, texture, flavor, and functional properties of LMPS Mozzarella. Four LMPS Mozzarella cheeses (n = 4) were manufactured using camel chymosin and an Airdus waterless cooker. Cheeses were stored at 4°C and analyzed at 2 wk, 3 and 6 mo. Cheeses were analyzed for RRA and primary proteolysis. Changes in flavor, shred properties, and pizza performance were evaluated using quantitative descriptive analysis (QDA). Cheeses stretched at ≤74°C had similar and typical composition. Cheese stretched at 88°C had reduced fat and moisture contents due to losses during the heating process. Cheese stretched at ≥74°C had higher pH values (P < 0.05) because of low acid development due to reduced microbial starter counts. Cheese stretched at ≥74°C had decreased RRA compared with cheese stretched at 60°C, resulting in lower proteolysis during storage. Stretching temperature affected the shred and pizza characteristics of the cheeses. Cheese stretched at ≥74°C had lower shred adhesiveness during storage compared with cheese stretched at 60°C, which had high adhesiveness (P < 0.05). Cheeses stretched at ≥74°C were characterized by higher blister quantity, hardness values, and more skinning when baked. During storage, the blister quantity increased for cheeses stretched at 60°C but not for cheeses stretched ≥74°C. Proteolysis in the cheeses stretched at 60°C caused a decrease in strand length and thickness. Cheese stretched at ≥74°C retained firmness and chewiness. This was consistent with TPA data where hardness values were maintained in cheese stretched at 88°C due to decreased proteolysis and higher protein content. Use of high stretch temperatures could be a useful method for helping to extend the performance shelf life of LMPS Mozzarella.

Key Words: low moisture part-skim (LMPS) Mozzarella, performance shelf life, high stretching temperature

29 Relationship between probiotics, their lipolytic activity on milk phospholipid in buttermilk fermentation and potential health contribution. K. Wang*, I. García-Cano, D. Rocha-Mendoza, J. Ortega-Anaya, and R. Jiménez-Flores, Department of Food Science and Technology, The Ohio State University, Columbus, OH.

The objective of this project is to demonstrate the lipolytic activity of probiotics in buttermilk fermentation with added milk phospholipids (MP), yielding products that can enhance MP absorption, providing additional health benefits through higher digestibility in intestine and possible modification of gut bacteria. Probiotics are beneficial for health, improving gut function, regulating immune response and the metabolites: lipases and proteases produced by them can hydrolyze lipids and proteins, which can lead to higher absorption of dairy nutrients. However, MP are known for its low absorption in intestine. Studies showed that metabolites produced by lactic acid bacteria (LAB) are associated with increased absorption of sphingomyelin and potentially all MP. Our hypothesis is that selected LAB would work better in helping digest MP. Bacteria isolation was performed from the LAB collection from OSU-Dr. Jimenez’s laboratory and further identified by 16S rDNA sequencing. Quantitative lipolysis activity was tested using α-naphthyl acetate. Eight promising strains were tested for probiotic potential by screening the ability to resist low pH and bile salts, high values in auto-aggregation and hydrophobicity, also must have antimicrobial activity, be susceptible to antibiotics and, screened their virulence factors by PCR. Three selected strains were grown in skim milk (as control) and compared with those grown in buttermilk with or without MP added. Lipolysis products were analyzed by TLC, HPLC, SDS-PAGE, zymograms and fatty acid sequencing after fermentation. The results showed that 7 of the promising strains with high lipolytic activity were probiotics. Three selected strains (Lactobacillus casei, Lactobacillus helveticus, and Lactobacillus acidophilus) showed to grow better in buttermilk medium with added MP than other medium. They also have the enzymes to break down MP. The objective of this project is to demonstrate the lipolytic activity of probiotics in buttermilk fermentation with added milk phospholipids (MP), yielding products that can enhance MP absorption, providing additional health benefits through higher digestibility in intestine and possible modification of gut bacteria. Probiotics are beneficial for health, improving gut function, regulating immune response and the metabolites: lipases and proteases produced by them can hydrolyze lipids and proteins, which can lead to higher absorption of dairy nutrients. However, MP are known for its low absorption in intestine. Studies showed that metabolites produced by lactic acid bacteria (LAB) are associated with increased absorption of sphingomyelin and potentially all MP. Our hypothesis is that selected LAB would work better in helping digest MP. Bacteria isolation was performed from the LAB collection from OSU-Dr. Jimenez’s laboratory and further identified by 16S rDNA sequencing. Quantitative lipolysis activity was tested using α-naphthyl acetate. Eight promising strains were tested for probiotic potential by screening the ability to resist low pH and bile salts, high values in auto-aggregation and hydrophobicity, also must have antimicrobial activity, be susceptible to antibiotics and, screened their virulence factors by PCR. Three selected strains were grown in skim milk (as control) and compared with those grown in buttermilk with or without MP added. Lipolysis products were analyzed by TLC, HPLC, SDS-PAGE, zymograms and fatty acid sequencing after fermentation. The results showed that 7 of the promising strains with high lipolytic activity were probiotics. Three selected strains (Lactobacillus casei, Lactobacillus helveticus, and Lactobacillus acidophilus) showed to grow better in buttermilk medium with added MP than other medium. They also have the enzymes to break down MP and produce lipolysis products. The results of this work can be used to increase bioavailability of MP and its application in fortified dairy products and pharmaceuticals.

Key Words: lactic acid bacteria, milk phospholipid, buttermilk

30 A cross-cultural study of the sensory perception of skim milk powder between Ireland, America, and China. C. Zeng*1, K. Kilcawley1, M. O’Sullivan2, M. Drake3, and S. Miao1,4, 1Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork, Ireland, 2The Sensory Group, School of Food and Nutritional Sciences, University College Cork, University College Cork, Cork, Ireland, 3Department of Bioprocessing and Nutrition Science, Southeast Dairy Foods Research Centre, Raleigh, NC, 4College of Food Science, Fujian Agriculture
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Understanding potential cross-cultural sensory differences in the perception of Irish dairy products is important to gain market share, especially in key target areas such as the United States and China. The objectives of this study were to investigate if consumers and sensory panellists in Ireland, United States and China could discern differences in skim milk powder (SMP) produced from different bovine diets (ryegrass [GRS], ryegrass/white clover [CLV], and trial mixed rations [TMR]). The volatile profile of each SMP sample was analyzed by SPME-GCMS. SMP samples were evaluated by Irish (n = 78), American (n = 100) and Chinese (n = 106) consumers using a hedonic sensory acceptance test. Ranking Descriptive analysis was performed using untrained panellists (n = 20) familiar with dairy products in Ireland and China and Spectrum Descriptive analysis was undertaken by a trained American panel (n = 8). Twenty 6 volatile compounds were identified in the SMP samples, with 10 statistically different based on diet. The SMP samples could be discriminated based on their volatile profile with acetoin (3-hydroxy butanone) having the greatest impact. It was most abundant in the SMP produced from TMR and is derived from carbohydrate metabolism. US consumers preferred SMP derived from TMR, and Irish consumers preferred SMP from either GRS or CLV. Chinese consumers perceived SMP samples differently to USA and Irish consumers, but preference was not influenced by diet (GRS, CLV or TMR). Both Irish and Chinese untrained assessors found it difficult to discern differences between SMP produced from either GRS or CLV, but could differentiate SMP produced from TMR. Trained US panellists found significant differences in barny aftertaste, grassy/hay, salty taste, cardboard and sweet aromatic attributes between the samples. This study has shown that bovine diet affects the sensory perception of SMP and that cultural differences in perception exist. These sensory differences result from mainly indirect (rumen metabolism and lipid oxidation) and direct (absorption and inhalation) transfer from the diet into milk and subsequently into the SMP.

**Key Words:** cross-cultural study, skim milk powder, bovine diets