

Dairy Foods: Milk Protein Fractionation Symposium

159 Introduction to milk protein fractionation symposium. L. E. Metzger*, *Midwest Dairy Foods Research Center, South Dakota State University, Brookings.*

Recent advances in processing research and membrane technology have allowed for the fractionation of whey proteins directly from milk. The differences in attributes between whey proteins isolated from milk and those isolated from cheese whey are becoming an important factor for dairy protein processors considering this new avenue for fractionating whey proteins. The symposium will cover membrane fractionation technology to produce high purity whey protein concentrates from milk. A detailed comparison of flavor chemistry, sensory properties and functional properties of whey proteins isolated from milk and from cheese whey will be presented. In addition to using membrane technologies to separate whey protein and casein, other emerging technologies have the potential of allowing for the separation of casein and whey protein fractions. This symposium will also present three new research developments: membrane fractionation of milk proteins from whole milk, charged membrane application for whey protein streams and using supercritical carbon dioxide for fractionation of milk proteins. The symposium will provide the latest in research in milk protein fractionation from various dairy research entities in the US and will serve to facilitate discussion of future development in dairy protein fractionation.

Key Words: milk protein, fractionation

160 Global use, opportunities and challenges for dairy proteins. P. Tong*, *Dairy Products Technology Center, California Polytechnic State University, San Luis Obispo.*

Several factors can impact the future global use of dairy proteins. For some parts of the world where traditional dairy products are readily available, their motivation to consumer dairy proteins may be quite different than in other regions of the world where availability of milk was limited. In developing and emerging markets, trends of increased urbanization, population growth and affluence will drive future demand for ingredients and foods containing dairy proteins. In some cases, this demand is to enhance the basic nutritional status of its population by incorporation of consuming high quality dairy proteins. As developing countries seek to improve their nutritional status they seek to incorporate more dairy protein into their diet. Here the goal is to introduce dairy proteins into the diet as economically as possible. For such products consistency in performance, availability and cost are very important. In more developed countries where disposable income is high, demonstrating added value of the protein ingredients in food is important. In particular dairy protein ingredients which provide potentially greater health and wellness benefits to food products relative to other food proteins is desired. To improve applicability in food systems, dairy protein based ingredients need to meet the process demands of the food application consistently. Hence, these ingredients need to meet customer specifications and deliver quality attributes over the storage life. Establishing common specifications using common test methods can be challenging as many customers have established many empirical tests that can have a subjective component to their interpretation. Nonetheless the basic nutritional and functional properties of dairy proteins will continue to be in demand. To successfully meet this demand requires matching the customer needs to the ingredient form and insuring dairy proteins consistently delivers value in the final product application.

Key Words: dairy proteins, dairy ingredients, milk proteins

161 Isolation of serum proteins from milk. D. M. Barbano*¹ and J. Zulewska², ¹*Cornell University, Ithaca, NY*, ²*University of Warmia and Mazury, Olsztyn, Poland.*

Milk is a rich source of organic and inorganic nutrients that can be consumed directly as a beverage, transformed into a range of traditional dairy foods and by-products, or fractionated into a wide range of milk components that can be used as food ingredients. The concept of fractionating milk directly into value-added ingredients has been called milk refining. The 1st step in milk refining became common practice over 100 years ago with the invention of the centrifugal cream separator, which allowed rapid removal of fat from milk. More recently, membrane filtration processes that rapidly separate components of skim milk (without the addition of any chemicals) are being implemented. The most recent of these cutting-edge membrane processes is microfiltration (MF) of skim, which has the capability to directly isolate different groups of proteins (milk caseins versus milk serum proteins) based on their difference in size. A wide variety of membrane materials, geometric designs, system configurations and operating approaches are available. Two major types of MF membranes exist: polymeric and ceramic. Data are just becoming available on these two types of membrane systems. They differ in cost, membrane life, flux, protein separation efficiency, ability to be cleaned, and energy consumption. MF of skim milk produces a filtrate that has some similarities to whey from rennet cheese making, but is not identical in composition, flavor, or functionality. The main component of value in whey and MF permeate is protein. Key differences between MF permeate from skim milk and rennet cheese whey are: cheese whey contains glycomacropeptide, fat, soluble components from starter media, metabolites from starter culture, lactic acid, cellular debris from starter bacteria, residual milk coagulant, and possibly residuals from added color and bleaching agents used in cheese making, while MF permeate does not. These differences may produce differences in flavor, functionality, and value of these two sources of milk soluble proteins.

Key Words: microfiltration, serum proteins, whey

162 Comparison of the functional properties of whey proteins isolated from milk or whey. E. A. Foegeding*¹, J. Zulewska², D. M. Barbano², M. A. Drake¹, P. J. Luck¹, Y. H. Yong¹, B. Vardhanabuthi¹, and T. Berry¹, ¹*North Carolina State University, Raleigh*, ²*Cornell University, Ithaca, NY.*

Cheese whey can be utilized directly or serve as a source for producing protein powders containing 34 – 80% protein (whey protein concentrate, WPC). The functionality of WPC can be influenced by the cheese making process, powder composition and the processes used to make the powders. Whey protein powders could also be produced by removing proteins from milk prior to cheese making. This removes potential functionality-altering processes and compounds associated with cheese making. A comparison of functional properties of whey protein powders was conducted by producing whey protein concentrate from milk (M) or cheese whey (W) containing 34% (WPC34) or 80% (WPC80) at Cornell University and evaluating functional properties at North Carolina State University. Functional properties of solution clarity, solubility, foam formation and gelation were investigated. The most striking difference was in solution clarity, where M-WPC powders produced slightly turbid to clear solutions and those made from whey were opaque. The increased opacity of W-WPC powders suggests that the cheese making process introduced large particles into the whey that became part of the protein powders. Whey protein concentrates made

from milk had greater foaming properties than those produce from whey. As with opacity, this too is most likely related to the presence of particles in the W-WPC's. Particles are known to cause coalescence in foams due to bridging mechanisms. Finally, the M-WPC's produced stronger gels than W-WPC's. Gel strength generally scales as a square function of the network concentration and, since W-WPC's contained protein particles that most likely did not contribute to the gel network, it is logical that they would have lower gel strength. It was shown that whey protein concentrates made from milk have greater functional properties than those made from whey. This is most logically due to a higher concentration of native, non-aggregated protein present in the concentrates made from milk.

Key Words: whey, functionality, protein

163 Comparison of the flavor chemistry and sensory properties of whey proteins isolated from milk and whey. M. A. Drake*¹, D. M. Barbano², E. A. Foegeding¹, J. Zulewska², and M. Newbold², ¹*North Carolina State University, Raleigh*, ²*Cornell University, Ithaca, NY*.

Native whey or serum protein concentrates (SPC) are proteins removed from milk by microfiltration without cheese making. Relative amounts and types of proteins present in SPC and WPC differ; SPC contains no glycomacropeptide. SPC is not exposed to some enzymatic and/or chemical reactions that may lead to off-flavors. Our objectives were to identify and compare composition, flavor, and volatile components of 80% protein SPC and WPC (SPC80, WPC80). SPC80 and WPC80 were manufactured in triplicate with each pair of serum and traditional whey protein manufactured from the same lot of milk and compared to commercial WPC80. Volatile components were extracted by solid phase micro-extraction and solvent extraction followed by solvent assisted flavor evaporation with gas chromatography-mass spectrometry and gas chromatography-olfactometry. Consumer acceptance testing was conducted with 6% protein acidic beverages made with SPC80 and WPC80, as well as commercial WPC80. SPC80 had lower fat and higher pH than pilot plant produced and commercial WPC80 ($p < 0.05$). There were few sensory differences between our directly rehydrated SPC80 and WPC80, but their flavor profiles differed from rehydrated commercial WPC80 ($p < 0.05$). Our WPC80 had higher concentrations of lipid oxidation products than SPC80, however concentrations in commercial WPC80 were higher than those made in this study ($p < 0.05$). Trained panelists found protein-associated flavors in acidic beverages that were not detected in reconstituted neutral pH protein solutions. Protein beverages made with SPC80 were not liked as well as protein beverages made with WPC80 produced in this study or one commercial WPC80 ($p < 0.05$). Composition, physical properties and volatile compound composition of SPC80 and WPC80 differed. These differences may cause flavor differences in low pH applications.

Key Words: milk proteins, whey protein, flavor

164 An integrated processing system to produce beta-casein, native whey protein and casein concentrates from whole milk. J. Lucey*¹ and K. Smith², ¹*Department of Food Science, University of Wisconsin, Madison*, ²*Wisconsin Center for Dairy Research, University of Wisconsin, Madison*.

We believe that successful adoption of new milk fractionation schemes by the dairy industry can be achieved if multiple value-added ingredients are created; it is also desirable that no reduced value by-products are

generated. In the dairy industry, a barrier to the more widespread use of microfiltration (MF) of milk is the paradigm that skim milk must be the starting raw material (presumably due to concerns over fouling or milk fat damage). For many dairy plants in order to convert all their whole milk (WM) into skim milk would require considerable capital investment and this would add another processing step into any fractionation scheme. We have developed a process to separate beta-casein from milk using polymeric, spiral-wound MF membranes operating at low temperatures. Beta-caseins were then separated from the rest of materials in milk permeate by warming permeate to room temperature where beta-caseins aggregated. The aggregated beta-caseins could then be retained by the MF membrane while native whey proteins passed into the permeate. Casein retentate that was partially depleted of beta-casein has been shown to produce cheese with improved meltability. We developed a process that uses WM as a starting material for MF. We used polymeric, spiral-wound MF membranes instead of ceramic membrane systems. WM has higher viscosity than skim milk, especially at low temperatures, which decreased flux somewhat when operated at low temperatures. Good whey protein permeations rates were observed with WM and no significant loss of flux observed during extended operation in recirculation mode for a 2 \times concentrated feed. The use of low temperatures results in beta-casein being present in milk permeates and that beta-casein fraction could be removed by the method previously developed for beta-casein purification. This fractionation scheme can use WM to produce beta-casein, native whey and casein concentrate in one processing plant. The operation of our MF system at low temperature may allow the use of raw WM; which could be advantageous in the purification of heat sensitive serum proteins.

Key Words: microfiltration, native whey, casein

165 Charged ultrafiltration membranes for whey protein fractionation. M. Etzel* and S. Bhushan, *University of Wisconsin, Madison*.

Ultrafiltration is widely used to concentrate proteins, but fractionation of one protein from another is much less common. This work examined the use of positively charged membranes to increase the selectivity of ultrafiltration, and allow the fractionation of proteins from cheese whey. By adding a positive charge to ultrafiltration membranes, and adjusting the solution pH, it was possible to permeate proteins having little or no charge, such as glycomacropeptide, and retain proteins having a positive charge. Placing a charge on the membrane increased the selectivity by over 600% compared to using an uncharged membrane. The data were fit using the stagnant film model that relates the observed sieving coefficient to membrane parameters such as the flux, mass transfer coefficient, and membrane Peclet number. The model was a useful tool for data analysis, and for the scale up of membrane separations for whey protein fractionation.

Key Words: ultrafiltration, whey, protein

166 Utilization of supercritical carbon dioxide to produce milk protein fractions. P. M. Tomasula*, L. M. Bonnaillie, and P. X. Qi, *Dairy Processing and Products Research Unit, USDA/ARS/ERRC, Wyndmoor, PA*.

The nutritional, functional and bioactive properties of the individual whey proteins are appreciated by health-conscious consumers, yet few methods have been developed to produce these proteins to satisfy demand. The methods that are available are relatively new technolo-

gies that have not been proven by development research and thus are unfamiliar to food processors. In our laboratory, we have shown that supercritical carbon dioxide (SCO₂) at pressures, P, greater than 7.4 MPa, when injected into solutions containing whey protein isolate or whey protein concentrate is effective for production of enriched fractions of the whey proteins, α -lactalbumin (α -LA) and β -lactoglobulin (β -LG). Fractions containing 70 wt% of α -LA, in solid form, and 95 wt% β -LG in a soluble liquid form uncontaminated with chemical additives have been obtained. We have also produced CO₂-casein, a high calcium-containing casein and other food protein isolates using the process under high pressure conditions in the range from 4.1 MPa to 7.4 MPa. The process is not an extraction process but relies on the production of carbonic acid that results from hydrolysis of solubilized CO₂. Separation of whole protein or the enriched whey fractions is

achieved through manipulation of P, temperature, agitation rate, protein concentration, and holding time, all factors which have been shown to affect solvent pH, protein conformation, and yield. A continuous pilot plant process was developed to produce CO₂ casein in kg quantities, and a large-scale process for production of the whey fractions is being designed. Both processes may be integrated to simultaneously produce CO₂-casein and the enriched whey fractions from milk. Processes based on CO₂ separation may be considered sustainable, because much of the CO₂ may be recovered after separation has been achieved. Other advantages are that a relatively concentrated feed stream containing the whey proteins may be processed and post-treatment washing is minimal compared to other methods. This presentation will focus on the casein and whey fractionation processes, as well as some of the properties of the proteins obtained from these processes.

Key Words: CO₂, whey, casein

ADSA Southern Section Symposium: Dairy Replacement Health Challenges in the Southeastern U.S.

167 Advances in colostrum management. S. Godden*¹, S. Wells¹, J. Stabel², D. Haines³, R. Bey¹, J. Fetrow¹, P. Pithua¹, and M. Donahue¹, ¹University of Minnesota, St. Paul, ²USDA, ARS, National Animal Disease Center, Ames, IA., ³University of Saskatchewan, Saskatoon, SK, Canada.

Failure of passive transfer (FPT) continues to affect a significant portion of North American dairy calves, contributing to high preweaning morbidity and mortality rates as well as impaired long-term health and performance. The goal of this presentation is to review key components of a successful colostrum management program with emphasis on recent research findings of practical importance to the industry. A successful colostrum management program will require producers to consistently provide calves with a sufficient volume of clean, high quality colostrum within the first 6 hours of life. Colostrum quality may be improved through the dry cow vaccination program, proper feeding and management of the dry cow, and rapid harvest of colostrum within 6 hours after calving. Use of either a nipple bottle or esophageal tube feeder will provide equal and high levels of passive transfer of immunoglobulin (Ig), provided a large enough volume of colostrum is fed. Microorganisms that may be found in colostrum are of concern because i) pathogenic organisms can cause clinical or subclinical disease and ii) bacteria in colostrum can interfere with passive transfer of colostrum Ig, contributing to FPT. Experts recommend that fresh colostrum contain fewer than 100,000 cfu per ml total bacteria count and fewer than 10,000 cfu per ml total coliform count. Methods to reduce colostrum contamination will include careful attention to udder preparation prior to colostrum harvest, strict adherence to protocols for sanitation of milking, storage and feeding equipment, and avoiding the pooling of raw colostrum. Bacterial proliferation in stored colostrum can be reduced or minimized by feeding within 1-2 hours of collection, rapid refrigeration (feed within 48 hours) or freezing. Colostrum replacers can also be useful tools, with recent studies demonstrating a lower risk of subclinical Johne's disease in calves originally fed a colostrum replacer vs raw colostrum. If using replacers, producers should feed 150 to 200 g IgG in a product that has been tested for efficacy. Pasteurization of colostrum (60 ° for 60 min.) can reduce pathogen exposure while maintaining colostrum Ig, resulting in enhanced passive transfer of Ig.

Key Words: colostrum, bacteria, calf

168 Strategies to minimize the impact of heat stress on heifer health and performance. J. W. West*, University of Georgia, Tifton.

Heat stress research has largely focused on the lactating cow because of easily measured parameters such as milk yield and efficiency. Less emphasis has been placed on dairy heifers, either because they are not affected by heat stress (doubtful) or because economic returns to managing for heat stress are less evident. Literature suggests that heifers are impacted by heat stress through slowed growth, impaired immune function or poor reproduction. Data from the southern U. S. and Caribbean regions at latitudes less than 34°N suggests that Holstein females weigh 6 to 10 percent less at birth and average approximately 16 percent lower body weight at maturity than those in more northern latitudes, even when sired by the same bulls (NRC, 1981). Potential explanations include greater maintenance requirements with hot weather, poorer forage quality, and reduced immune function. Is there a physiologic difference in newborns which experience heat stress *in utero*? Heat-stressed ewes and beef cows exhibited reduced uterine blood flow and lower birth weight for newborns. Brains and livers of lambs from heat stressed ewes were smaller, leading to the concern that newborns from heat-stressed mothers may be smaller at birth and less vigorous and lacking the metabolic machinery to thrive following birth. Colostrum from cows exposed to heat stress during late gestation and early lactation may have lower immune globulin content and coupled with the impact of heat stress on newborn calves, mortality losses can be large. Management in heat stress environments should occur at several levels. Environmental modification is crucial for the late gestation cow and for the newborn calf. Maintenance costs are higher reducing potential growth rate for heifers, thus attention to nutrition is necessary to achieve desired rate of gain. Heifer conception rate is typically better than for mature cows; however reproduction efficiency suffers in heifers as well. Good performance in a heifer management program will result from attention to environment, nutrition and health in hot climates.

Key Words: heat stress, dairy heifers, management