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The following abstracts were presented at the International Spray Dried Milk Conference which was held February 26-28, 2007.

The Domestic Ingredient Marketplace: Volume, Value and Opportunity

D. Henkes – Technomic (USA)

Technomic, Inc., a food industry research and consulting firm, recently completed a major study for Dairy Management, Inc. on the volume of cheese and dairy ingredients used by food processors. This research approached the market from the perspective of the processor enduser, and data were gathered from these processors regarding the actual amount of dairy ingredients used within various products that are ultimately sold to the consumer. This presentation will provide topline results from this study specific to dairy ingredients, including volume and growth outlook for major categories. The data presented are intended as benchmarks for additional trend analysis and future study by Technomic on behalf of DMI.

Driving Whey Protein Sales via Health Benefits & Claims

L. Gottschalk, Dairy Management, Inc.

Whey protein is known to have functional benefits in manufactured foods, but an opportunity exists to market the nutrition of this ingredient by linking it to specific health benefits and nutritional claims. This approach is on trend with rising consumer demand for functional foods and demographic changes such as aging populations and increasing obesity rates that are making even the youngest consumers consider more healthy eating habits.

To address this opportunity, Dairy Management Inc. conducted a quantitative research study and consumer focus groups to help identify what claims would have the highest potential to drive consumer demand for whey protein. The studies also helped optimize the language and consumer target for each claim area. The research was conducted as a three-cell online conjoint test in which qualified respondents were asked to rate their purchase interest for a food or beverage product made with a variety of claims, each with a different protein descriptor, a benefit, and a qualifying statement. Respondents were also asked to evaluate the importance and uniqueness of all 29 benefits before the concept of protein was introduced.

This study identified the following claims as optimal choices for the general population within the three different test cells.

- **Muscle-based**: The protein found naturally in milk helps prevent bone loss during aging when combined with a healthy lifestyle
- **Sports and cardio**: The protein found naturally in milk helps to reduce cholesterol when

combined with a healthy lifestyle
– **Weight and longer term**: The protein found naturally in milk promotes fat loss around your waist when combined with a healthy lifestyle.

In certain cases the optimal claim differed for specific demographic groups such as men, women, 18-34 yr olds, or individuals 55+. In addition, certain claims such as those around immunity and diabetes prevention were prioritized quite differently outside the context of protein, indicating that protein has established equity in certain areas and may have some credibility hurdles in others. The results of this study provide a consumer perspective that will be balanced with nutrition research considerations to guide future claims work into areas with the highest consumer appeal and highest probability of success.

Economic Impacts of Growing US Ultrafiltered Milk and Milk Protein Concentrate Markets

Charles Nicholson and Mark Stephenson*

Dairy and food industry interest in the use of ultrafiltered (UF) milk and milk protein concentrates (MPC) has grown markedly in the past 10 years, but few economic analyses exist of processing costs or the market impacts of increased demand. In 2003, we surveyed five stand-alone plants processing cold milk using UF technology. UF plants cost between $5 mil and $7 mil to build for capacity of up to 2 mil lbs of milk /d. There are substantial economies of scale in processing; increasing milk processed from 1 mil lbs/d to 2 mil lbs/d reduces processing costs from $0.50 to $0.25/100 lbs. We developed three economic models to examine market demand for UF and MPC and the market impacts of demand growth. A spatial model of the US dairy industry indicates that UF milk would reduce overall dairy sector transportation and processing by nearly 1%, that 17 UF processing plants would process 96 mil lbs of skim/mo UF milk during the highest milk production times of the year (e.g., May) and that most of these processing plants should locate near cheese plants. Market equilibrium models indicate that the operation of MPC-producing plants processing 50 mil lbs of milk/month would increase US MPC production, decrease production of nonfat dry milk (NDM), decrease MPC imports, and increase farm milk prices from $0.02 to $0.17/100 lbs. Price and production outcomes depend on market conditions: increases in export demand for NDM and international casein prices increase incentives for MPC production and result in larger dairy product and farm milk price impacts. A dynamic simulation model of the US dairy industry indicates that increasing MPC production to 50% of 2004 US demand by 2008 would increase NDM prices $0.02 to $0.05/lb, reduce butter prices by $0.15/lb, and increase farm milk prices by $0.04/lb. Although increases in use of UF and MPC are likely, modification of FDA standards of identity for use in dairy products (especially cheese) and disposal of the permeate generated by the manufacturing process are important remaining issues.

Developments in Milk Protein-based Ingredients

P.M.Kelly

The market for dairy protein ingredients has been driven by a combination of forces involving geographical practice (casein/caseinate usage in food formulation), economic measures (market supports), technological innovation (cost/benefit returns associated with enhanced functionality; ingredient substitution etc.) and nutritional developments. In the latter case, growth in cheese consumption runs parallel with the availability of increased supplies of whey to facilitate whey protein recovery and

further ingredient innovation. Innovation in separation technology for the preparation of casein-based ingredients includes acid precipitation (casein), acid/heat co-precipitation (proteinate), membrane (milk protein concentrate – MPC), hybrid processes (proprietary approaches to producing milk protein isolate – MPI) and wet/dry blending (casein/whey proteins). Research into the functionality of native phosphocasein, separated with the aid of microfiltration, is providing technologists with new tools and techniques with which to develop further ingredients and processes.

In the current market climate for milk protein ingredients in health enhancing beverages greater demands are being made for protein quality enhancement via whey protein incorporation and stability challenges arising during supplementation with selected minerals and other bioactive components. As the current generation of milk protein-based ingredients are based extensively on technology–induced assembly of casein and whey protein in a variety of configurations, the next generation is likely to see greater exploitation of principles involved in self-assembly behaviour of protein for enhanced functionality e.g. to facilitate nutriceutical delivery.

Whey Proteins Containing Composite Microcapsules: Preparation, Functional Properties and Microstructural Features

M. Rosenberg

In recent years we have discovered the unique microencapsulating properties of whey proteins (WP) and their role in enhancing functionality of spray dried microcapsules. Building on this knowledge we have investigated the formation, physico-chemical and functionality of spraydried composite microcapsules consisting of WP-coated lipids droplets embedded in wall matrices (WM) consisting of MSNF or maltodextrin. They hypothesized that oxidative stability of lipids, encapsulated in wall material with poor oxygen barrier properties, can be enhanced by forming WP-based films at the O/W interface. Results indicated the significant effect of emulsion preparation methodology on surface excess and protein composition of the interfacially adsorbed film (IA). Results indicated the significant effect of ratio of WP-to-WM constituents on the formation, core retention properties and on the 3D microstructural features of the capsules. Oxidative stability of the ENCAPSULATED lipid was governed by the IA WP-based films. Oxidative stability was proportionally related to surface excess and to the proportion of WP included in the IA films. The oxidative stability was enhanced by inducing inter- and intramolecular interactions between WP adsorbed at the interface.

Residence Time Distribution: A Tool to Improve Spray Drying Control and Product Quality

Pierre Schuck, Eric Blanchard, Evelyne Onillon, Anne Dolivet, Serge Méjean, Romain Jeantet*

Dairy powders are mainly obtained by spray drying, which is an effective process as it does not involve severe heat treatment and enables long time storage at ambient temperature. However, the control and design of this operation is still based on empirical knowledge. Thus, the improvement of the product quality, which is ruled by time/temperature history, implies a better understanding of this operation through physico-chemical, thermodynamic and kinetic approaches. Concerning this latter, the product residence time distribution (RTD) determination provides valuable information about the product flow pattern in the dryer. The aim of this work was to determine the skim milk RTD in a pilot plant (Bionov) for different drying configurations, with regard to the recycling of fines (top of the chamber or internal fluid bed) and the internal fluid bed thickness. First, the RTD signal of the nozzle

was established, using a skim milk – NaCl solution. In a second step, the RTD signals of the spray dryer in the different configurations were obtained by numerical deconvolution of the experimental curves obtained and the nozzle RTD signal, and modelised according to combination of reactors. The results show differences in terms of mean residence time and time distribution, with regard to the experimental configuration; it allows further correlation between process parameters and product quality.

Optimizing Dairy Spray Drying Processes: Modeling Agglomeration and Advanced Dynamic Sticky-Point Measurements

Maykel Verschueren, Han Straatsma, Peter de Jong, Jeroen Wouters, Ruud van Ommen*

Spray drying is an essential unit operation for the manufacture of many food products with specific powder properties. During spray drying of food products, agglomerates of dry particles are often formed. Agglomeration is a size enlargement process of powders, where small particles combine to form large relatively permanent masses, in which the original particles are still identifiable. The degree of agglomeration is strongly related to powder properties such as solubility, flowability, bulk density etc. Agglomeration is a complex process which is difficult to control. In an EC-sponsored project, coordinated by NIZO food research, entitled EDECAD (Efficient DEsign and Control of Agglomeration in spray Drying machines, www.edecad.com) an industrially validated CFD model was developed which establishes the relations between process parameters, the degree of agglomeration and the final powder properties. The CFD model is based on an Euler-Lagrange technique with built-in sub-models for collision, drying and agglomeration.

Stickiness is a critical input parameter for the agglomeration model. For many food powders stickiness is related to glass transition, but this relation is not universal and depends on the product. It is therefore necessary to measure stickiness separately. Sticky points are difficult to determine experimentally, however. Conventional techniques often depend on visual observations and show poor reproducibility. Recently, NIZO food research cooperated with Delft University to evaluate a new method to measure stickiness under dynamic conditions is presented. The method is based on a technique which can detect small hydrodynamic changes in fluid beds by analyzing high frequency pressure measurements by attractor comparison methods. Initial results of dynamic stickiness measurements of skim milk powder by attractor comparison are presented in this paper and are compared to results obtained by both static and dynamic conventional techniques.

Relative humidity of outlet air: parameter superior to outlet air temperature to optimize moisture content and water activity of dairy powders

Pierre Schuck, Anne Dolivet, Serge Méjean, Romain Jeantet*

The most widely used technique for dehydration of dairy products is spray drying. This is an effective method for preserving biological products as it does not involve severe heat treatment and allows storage of powders at an ambient temperature. The maximum moisture content of a dairy powder (max 4% for skim milk powder) is defined in the product specification in relation to the water activity and this must be close to 0.2 at 25°C for optimal preservation. From an economic point of view, it is very important to operate as close as possible to this limit. Many dairy manufacturers and researchers have demonstrated and reported that powder moisture is related to the outlet air temperature, but this is not always true. The aims of this study were to evaluate the direct and indirect relationships

between outlet air temperature and moisture content of skim milk powder in relation to the spray drying parameters (concentrate mass flow rate, absolute humidity of inlet air, inlet air temperature) and based on a thermodynamic approach. The experiments showed that moisture content of skim milk powder can be close to 5.1±0.1% with variations in outlet air temperature of 77 to 87°C. Other experiments showed that the powder moisture content can vary from 4.6±0.0% to 5.2±0.1% even when the outlet air temperature is always close to 86±1°C. These results indicate that there is no direct relationship between outlet air temperature and powder moisture content. It is preferable to use the Enthalpic Mollier-Ramzine diagram of wet air and certain transfer equations related to the Fick and Fourrier laws to demonstrate that the powder moisture content is directly related to the relative humidity (RH) of the outlet air. The moisture content and water activity of skim milk powder were close to 5.1±0.1% and 0.27 ±0.02% for outlet air RH close to 6.9±0.1%, whatever the values of the other drying parameters.

They demonstrated in this study that control of the RH of the outlet air is at least as important as control of the outlet air temperature to optimize the moisture content of dairy powder, whatever the absolute humidity of the inlet air, the concentrate mass flow rate or the inlet air temperature.

Powder Agglomeration During Spray Drying Process: Measurements of Air Properties

A. Gianfrancesco

The spray drying process is widely used in food industry to produce dry powders. An important group of food powders is formed by instant powders like milk, soups, juices, coffee, for which a further step of agglomeration is often required to enlarge particle size (from 50-80μm to 250-500μm) in order to obtain good instant properties (wettability, dispersability, solubility).

In industrial practice, agglomeration of spray dried powders is performed either outside the drying chamber in a fluid bed in which particles surface is wetted with sprayed water (or other binder solution), or by reintroduction of dry fines (particles with d < 00μm) into the drying chamber. The study of this second kind of agglomeration process is the objective of our work.

During spray drying, the viscosity of the initial liquid drop increases gradually, the surface becomes more and more dry with the possibility of stickiness, before further drying. Surface stickiness depends on surface temperature, water content and presence of some components (i.e.carbohydrates), in relation with their glass transition temperature Tg. When the particle surface reaches this state, collisions with other particles (sticky or dry) could lead to agglomeration, also depending on velocity, force, angle and time of contact between particles.

Dry fines are usually introduced at the top of the tower, but other choices might be possible with a better comprehension of the involved mechanisms. The first objective of our study was to identify zones, in the spray dryer chamber, in which specific particles were sticky (sticky region); then this sticky region could be exploited to perform controlled agglomeration with other solid particles. Varying the operating parameters of drying (liquid flow rate and concentration, air temperature and flow rate) might vary the characteristics and the efficiency of such possible agglomeration.

In this step of the work we assume that air properties evolution inside the chamber was representative of droplet drying, comparing the drying behavior of pure water droplets with the behavior of “real” solution droplets in which water is more or less bound with other constituents. The

experimental trials consisted in obtaining cartographies of air temperature (T) and relative humidity (RH) inside the chamber at steady state within a co-current pilot spray dryer (NIRO Minor Lab) equipped with a rotary atomizer.

The spray dryer chamber was equipped with a set of 12 thermocouples (K-type) to measure internal air temperatures. Air relative humidity at different positions was determined with a capacitive hygrometer (ROTRONIC) and a dew point hygrometer (GENERAL EASTERN), while psychrometry measurements were exploited for inlet and outlet air moisture content. Two sets of atomization trials were performed: one by atomizing pure water and one by atomizing aqueous solutions of maltodextrin DE12 as a model product able to stick. Drying parameters were hot air inlet temperature (144-159-174°C), atomized liquid flow rate (water to evaporate: 18 – 36 - 54 ml/min) and liquid solution dry matter content (30%, 40%, 50% w/w) while air flow rate (80 kg/h) and rotary atomizer speed (30000 rpm) were kept constant.

Final powder was analyzed for the size by laser granulometry, for the moisture content and for the instant properties (wettability, flowability, density). Pure water drying trials showed that for any tested condition air temperature falls down almost instantaneously at the entrance of the chamber while air RH increases. The decrease in temperature was 50 to 100°C depending on the liquid flow rate. A water mass balance showed that almost all the water (>95%) is quickly evaporated in the upper part of the chamber (~5cm). Below this zone, there is a small evolution of air temperature (ΔT ~ 5°C) and humidity along the chamber height (~1m) with no radial variation. For any tested condition, drying at the exit of the chamber is completed (all water evaporated). Results of pure water trials were compared with maltodextrin solutions drying trials with the same amount of water to evaporate.

For maltodextrin solution and low liquid flow rates (25 ml/min corresponding to 18 ml/min of water to evaporate), there is a good agreement with air temperature and humidity cartographies obtained with pure water, showing that water and maltodextrin droplets follow a similar drying behavior. On the contrary, for high liquid flow rates (75 ml/min corresponding to 54 ml/min of water to evaporate) air temperature inside the chamber is some 10 degrees higher than in pure water drying trials and only less than 80% of water is evaporated in the upper part of the dryer. So drying behavior was different from pure water droplets drying maybe because of higher viscosity leading to larger drop size with lower exchange surfaces. The maltodextrin solution drying trials also allowed us to identify difficult drying conditions (low air inlet T, 144°C) and high liquid flow rate (75ml/min)) in which final powder still has high moisture content (>8%), with important powder adhesion on the walls of the chamber and loss of product. These conditions are interesting to consider for improving drying and/or performing agglomeration by fines introduction inside the chamber. The further steps of the work will consist in introducing various fine particles in defined locations inside the chamber, varying the drying parameters, to study the feasibility of the agglomeration and the effect of parameters on final products properties at different scales (pilot, semi-industrial and industrial).

Application of Rapid visco analysis to evaluate effects of seasonal factors and manufacturing conditions on functionality of nonfat dry milk.

X. Liu and L. E. Metzger

Numerous factors affect the performance characteristics of nonfat dry milk (NDM) including seasonal factor and manufacturing conditions. Consequently the performance characteristics of NDM can vary substantially. Rapid Visco Analysis (RVA) is a promising technique and can be used to measure

the functionality of NDM. The objective was to determine the influence of seasonal factors and manufacturing conditions on the functional properties of NDM. Low heat NDM samples were collected from three plant locations in July, October and February, respectively. The RVA was used to measure the hydration and thermal stability of the samples and the properties of nonfat yogurts made with the powders.

Samples collected in October and February from different plants did not show dramatic difference in functionality, whereas large variation in the functional performance of samples collected in July was observed. Moreover, both hydration and yogurt apparent viscosity of NDM were lower in July than in October and February. One sample collected in July from one plant had a low pH, high ionic calcium content, and low RVA hydration and yogurt apparent viscosity as compared to the other samples. The results showed a clear influence of the seasonal factors and manufacturing conditions on the characteristics of NDM. The results suggest that RVA analysis can be used to provide valuable information on the influence of seasonal factors and processing conditions on the functional properties of NDM. Thus it may help end-users to determine RVA based performance criteria for their particular application of NDM.

Surface Characterization of Milk Powders in Relation With Rehydration: XPS and CSLM Studies

C. Gaiani1, P. Schuck, J.J. Ehrhardt, J. Scher, S. Desobry & S. Banon*

The powder form being more stable and transportable than the liquid form, powder rehydration is an industrial process frequently performed especially in the dairy industry. Consequently, the rehydration of a dairy powder is an essential attribute of quality, that require more studies to be fully understood. In this aim, the surface composition of dairy powders was investigated by Xray Photoelectron Spectroscopy (XPS) in order to be related to data on rehydration behaviour (i.e. powder wetting time and rehydration time). These casein powders were more or less enriched in hygroscopic material (lactose and/or minerals) and their structure was more or less granulated.

The results indicated that the surface of all the powders was dominated by proteins. Fat was found over represented whereas lactose and minerals were marginal compounds. A correlation between the lactose surface content and the wetting time of the six powders was established. Moreover, as the surface was poor in minerals and lactose, it was concluded that these compounds are principally located in the bulk of the particle. Therefore, this observation could be related with a wetting time of the powders only slightly affected by the addition of hygroscopic material whereas the powder rehydration time was strongly improved; powder wetting being more affected by the surface composition whereas powder rehydration time being more influenced by the powder bulk composition. An in-depth investigation by XPS and Confocal Laser Scanning Microscopy (CLSM) indicated also an over-representation of lipids on powder surface (6%) in comparison with the bulk composition (0.4%). Detailed analysis of lipids revealed the presence of high levels of polar lipids in the powder. The amphiphilic nature of polar lipids could explain the enrichment of lipids in the powder surface during processing. It was concluded that XPS yields fundamental information allowing a better understanding of the rehydration. XPS analysis could help in the future to formulate dairy powders presenting better rehydration properties.

Application of fluorescence spectroscopy to study the impact of seasonal changes in characteristics of nonfat dry milk.

X. Liu and L. E. Metzger

Due to its high content of protein, reducing sugar, and neutral pH, nonfat dry milk (NDM) is an excellent medium for occurrence of the Maillard reaction. Seasonal factors and manufacturing conditions affect the characteristics of NDM. Front Face Fluorescence Spectroscopy (FFFS) is a rapid and sensitive technique that can be used to measure the presence and environment of fluorescent compounds in solid substances. The objective was to evaluate the influence of seasonal factors and manufacturing conditions on the presence of Maillard products and oxidation of riboflavin in NDM throughout the year. Low heat NDM samples were collected from three plant locations in July, October and February, respectively. The excitation and emission spectra of Maillard products, emission spectra of tryptophan and riboflavin were recorded. Principal component analysis was applied to the FFFS spectra.

Presence of Maillard products were observed in NDM samples throughout the year. Samples collected at different time of year showed different characteristics in the FFFS spectra. July samples had more Maillard products and a greater extent of oxidation of riboflavin as compared to samples collected in October and February. Samples collected from the same manufacturer throughout the year shared some FFFS characteristics in all of their spectra. These results suggest that seasonal factor and manufacturing conditions affect the characteristics of NDM, and FFFS can provide valuable information on the quality of NDM.

Whey permeates: properties and application potential

Rene Floris, Arno Alting and Wim Engels*

With the increasing market for dairy ingredients in the USA and globally, especially higher value products such as WPC-80, WPI, MPC, MPI and UF milk, there is an increasing issue of the permeate (byproduct) created from the production of these ingredients. The issue of whey permeate (primarily from manufacture of WPC-80) has already received much attention from industry, and the concerns about milk permeate (from manufacture of UF milk, MPC, and MPI) and whey cream/whey phospholipids (from WPI manufacture except ion exchange) are becoming more common. Permeates can differ significantly due to their origin, method of preparation, processing conditions, etc. These differences will undoubtedly affect the suitability of permeates for application.

In order to understand the differences between whey permeates, different permeates were analyzed with respect to composition, capability to be used as substrate for fermentative flavor development, their color (of the dried powder) and their water binding capacity. Based on the results the possible fields of application can be suggested in order to further improve the use and application of whey permeates.

Off-flavor development in WPC during storage investigated by headspace solid-phase microextraction-gas chromatography

Michael C. Qian and Issa Javidipour*

Whey protein concentrate (WPC) is a nutritious and functional protein ingredient and has gained popularity to be used in many traditional as well as novel food products. It typically has a 9-12 months of room temperature storage shelf life. Fresh manufactured WPC has a bland or slightly dairy, whey flavor. However, inadequate flavor stability during storage is generally recognized and the off-flavor becomes one of the major factors limiting the usage of WPC. To investigate the chemical nature of the off-flavor, two WPC samples were stored at room temperature for 12 months to develop the off-flavor. Three g of samples were dissolved in 7 mL of deodorized water, and the off-flavor compounds were extracted using a DVB/Carboxen/PDMS fiber (2 cm, 50/30 m) at 45C for 3 h. The off-flavor compounds were analyzed using gas chromatography-olfactometry and GC-mass spectrometry on a DB-Wax column. Based on the aroma intensity, the most important off-flavor compounds were identified as dimethyldisulfide (sulfur, rubbery), dimethyltrisulfide (gas, cabbage), pentanal (green), hexanal (grass), heptanal (grass, rancid), octanal (green, fatty), nonanal (fatty), t-2-octenal (fatty, rancid), t-2-decenal (tallowy), t-2-nonenal (old book), t,t,2,4-nonadienal (fatty, earthy), 1-octanol (fatty, waxy, green) and 1-hexanol (green, herbaceous). To understand the flavor stability of WPC, off-flavor formation in WPC 80 and instantized WPC 80 was further investigated. Both samples were stored at 35, 45 and 55 ºC while another instantized WPC 80 sample was filled with argon and stored at the same temperatures. Samples were taken weekly for a period of three months and the off-flavor compounds were quantified. The result showed that lipids oxidation products such as aldhydes, ketones and free fatty acids were the main source of off-flavor. Protein breakdown and Maillard reaction also played a role in off-flavor development of WPC. Storage temperature seemed to be very important in the formation of those off-flavor compounds.

Dried Whey Products with Concentrated Alkylphenols to Enhance Flavors

R. C. Lindsay, C. G. Gilmore, and A. Berres-Olivotti*

Progressive removal of milkfat from dairy foods and ingredients results in incremental losses of dairy richness, mouthfulness, and continuity flavor characteristics. Because of a seemingly logical association between milkfat content and these flavor sensations, it usually has been assumed that unique structural features of milkfat per se gave rise to these chemosensory properties. Instead, however, a group of natural, grain- and forage-derived free alkylphenols recently have been found to provide most of these flavor-enhancing effects. Since the free alkylphenols are readily fat-soluble, they remain with the milkfat component in dairy processing streams resulting in functionally ineffective levels of free alkylphenols in low-fat and fat-free dairy foods and ingredients. However, substantial quantities of bound alkylphenols are also present as flavorless, water-soluble components of milk, and these bound alkylphenols partition largely into the whey during cheesemaking. Proprietary whey processing and fractionation methods have been developed to prepare and concentrate free alkylphenols in whey products, and Teklac EnhanceTM Sweet Whey is the first spray dried ingredient available with elevated levels of free alkylphenols. Because of its dairy flavor-enhancing, whey flavor-masking, and fat-amplifying sensory properties, Teklac EnhanceTM enables users of dairy ingredients to reduce costs and improve the overall flavor of their products. Other dairy components also may be combined with whey products containing elevated levels of free alkylphenols to meet compo-

sitional requirements for flavor enhancements in many food applications.

Dairy Ingredient Performance and Applications Effects of Lactose vs. Permeate Milk Powder Standardization on Whey Protein Nitrogen Index

V. Sikand, P.S.Tong and John Walker*

The whey protein nitrogen index (WPNI) method of heat classification of nonfat dry milk powder (NDM) provides a criterion for the selection of high, medium or low heat SMP for specific food applications. The objective was to determine the effects of changing protein on WPNI value using lactose or permeate from milk ultrafiltration in the low heat or medium heat SMP. Edible lactose powder (ELP) or permeate powder (PP) was used to standardize SMP to a protein content ranging from 34.3% to 30% on a wet basis. These powders were analyzed for WPNI by the American Dairy Products Institute (ADPI) Method. Powders were also analyzed for protein, lactose, ash, fat, and moisture content by standard methods. The experiment was conducted in duplicate.

The control SMP at 34.3% protein had a mean WPNI of 6.38 mg of whey protein nitrogen/g powder (mg WPN/g). In SMP standardized to 30% protein the mean WPNI was 5.51 mg WPN/g for ELP and 5.32 mg WPN/g for PP. Using linear regression, WPNI was found to be positively related to percent protein ($P < 0.001$). No significant difference was observed between WPNI of ELP and PP samples ($P = 0.38$) after controlling for protein content. Based on the regression model, when low-heat NDM containing 34.3% protein (WPNI = 6.38 mg WPN/g) was standardized with lactose to 31.89% protein, the WPNI value decreased to less than 6 mg WPN/g, which would transform it into medium heat NDM based on the ADPI Method. For low heat NDM with ELP standardization, as protein decreased from 34.3% to 30%, mean values for ash, moisture, and lactose ranged from 7.74% to 6.74%, 3.81% to 3.50%, and 53.42% to 59.42% respectively. For low heat NDM with PP standardization mean values for ash, moisture, and lactose ranged from 7.74% to 7.70%, 3.81% to 4.13%, and 53.42% to 58.17% respectively as protein decreased from 34.3% to 30%. They conclude that there is little evidence of a statistical difference between the mean values of WPNI when NDM is standardized with either ELP or PP. However, standardization of NDM can change its composition and WPNI value, which may effect its heat classification.

Role of protein aggregation in heat-induced heat stability during milk powder manufacture.

Roderick P.W. Williams, Lynette D'Ath, Bogdan Zisu.*

Although the inherent heat stability and the processes leading to the heat induced-coagulation of milk and reconstituted milk powders have been studied extensively, the processes that lead to heat induced heat stability are less well established. As part of an investigation into the effects of standardisation with milk permeate or lactose, we have been conducting research into the heat-stabilisation of milk powders. As has been generally accepted, the heat stability may be mediated by the way in which the milk responds to the pre-heat treatment given during milk powder manufacture However causing the denaturation of the whey proteins in itself, as is indicated by analytical measure such as WPNI, is not sufficient to impart heat stability. The work suggests that the denaturation of the whey proteins has to be accompanied by the formation of the appropriate structures in the milk. Milks with good heat stability are achieved by heating to give a low WPNI, a balance of moderately sized soluble aggregates and a decrease in the proportion of smaller micelles. The formation of

these aggregates is influenced by the heating regime applied and varies at different times of year. Data on the characterization of the aggregates and their impact on model retort processing will be presented.

Microfiltration of Buttermilk and Washed Cream Buttermilk for Concentration of Milk Fat Globule Membrane Components

Pierre Morin, Michel Britten, Rafael Jiménez-Flores and Yves Pouliot*

Buttermilk has gained much attention lately because of the application potential of its milk fat globule membrane (MFGM) components as health ingredients. Microfiltration has been studied for buttermilk fractionation because of its ability to separate particles from dissolved solutes. However, the presence in this by-product of skim milk solids, especially casein micelles, restricts concentration of MFGM. The use of cream washed with skim milk utltrafiltrate to produce buttermilk with lower casein content was studied as well as fractionation of this buttermilk by MF. Results have showed that washing the cream prior to churning yields a buttermilk with 74% less protein than normal cream buttermilk. Analysis of the protein profile of washed cream buttermilk revealed that caseins and whey proteins were the main classes of proteins removed. MF of washed cream buttermilk resulted in permeation fluxes 2 folds higher than with normal cream buttermilk. The second separation of the cream induced high losses of phospholipids in the skim phase. However, retention of remaining phospholipids in washed cream buttermilk by the MF membrane was higher resulting in a phospholipids concentration factor 66% higher than that of normal cream buttermilk. The results presented in this study highlight the impact of casein micelles on the separation of MFGM components as well as their effect on permeation flux during MF.

Skim Milk Powders With Enhanced Foaming and Steam-Frothing Properties

P.T. Clarke B. Aitken and M.A. Augustin*

The feasibility of citrate addition during manufacture of skim milk powders to improve the foaming and steam-frothing properties of milk was examined. Initial trials were carried out to estimate the amount of citrate required to improve these functional properties and to determine the mixtures of citric acid / citrate salts required to maintain the natural pH on reconstitution. Mixtures of citric acid / citrate salt at the required level of total added citrate were added to skim milk concentrate prior to drying. The foaming capacity and stability of reconstituted milk solutions (at ~20°C) made from citrated low-heat or high-heat milk powders (0.2 mole added citrate / kg milk solids non-fat) confirmed the superiority of citrated powders compared to those made from corresponding conventional milk powders. Steam frothing tests on milks reconstituted from citrated low-heat milk powders showed that the citrated powders (0.1 mole added citrate / kg milk solids non-fat) had significantly higher steam-frothing capacity and stability compared to conventional milk powders. The improved foaming properties of citrated powders are attributed to the effects of added citrate on the dissociation of casein micelles. Citrated powders are an alternative to physical blends of conventional skim milk powders and citrate salts for enhancing the foaming properties at both low and high temperatures.