Dairy Foods Symposium: Recent developments in manufacturing and applications of lactose and lactose derivatives

566 Overview of technological advances in manufacture and applications of lactose and lactose derivatives: Present and future. Shantanu Agarwal*, *Dairy Management Inc., Rosemont, IL.*

Lactose is a major component of milk and has been extensively studied over the years. Much work has focused on the manufacture and application of lactose. Lactose and it derivatives have wide physico-chemical and bioactive properties making it appropriate for a wide range of applications food, animal feed, and pharmaceuticals. Primary uses of lactose in the food industry are largely based on its relatively low sweetness, protein stabilizing ability, great crystallization attributes, ability to accentuate flavor/ color and significant nutritional value. Extensive research continues on various fronts as to how to bring added value to lactose and it derivatives in various food and nutraceutical applications. In this presentation, technological advancements and challenges in manufacture of lactose from various product streams (e.g., permeate, acid whey) will be reviewed. The presentation will also review latest research in understanding drivers and inhibitors for lactose crystallization. The role of lactose and its derivatives in various food applications will be discussed with regards to attributes such as product quality and sensory attributes (color, texture, mouthfeel, and sweetness). Nutritional significance of lactose and it derivatives will be discussed in relation to glycemic index, dietary fiber, and mineral absorption. Last, this presentation will focus on the future growth opportunities for lactose and it derivatives.

Key Words: lactose, permeate, crystallization

567 Lactose and lactose derivatives: More than prebiotics? Michael Gänzle*, *University of Alberta, Edmonton, AB, Canada.*

Commercially available lactose derivatives include lactulose (β-4'galactosylfructose), lactosucrose (β-4'galactosylsucrose), and galacto-oligosaccharides. 3-, 4-, and 6-Galactobiose, allolactose, and 6-, 3-, and 4-galactosyllactose are the major components of commercial galacto-oligosaccharide preparations. Commercial processes for lactose conversion generally employ enzymatic transglycosylation with fructose, sucrose, and lactose, respectively, as galactosyl acceptors. Because human β-galactosidase is specific for lactose, enzymatic transgalactosylation coverts lactose, a disaccharide that is indigestible in about 75% of human adults, to oligosaccharides that are indigestible in all human infants and adults. Galacto-oligosaccharides and other lactose derivatives are fermented by colonic microbiota. Galacto-oligosaccharides increase the abundance of bifidobacteria in intestinal microbiota and are thus recognized as prebiotic compounds. However, the increase of bifidobacteria in human microbiota depends on the individual composition of the microbiota and is observed in most but not in all individuals. Health benefits of consumption of galacto-oligosaccharides are predominantly derived from intestinal fermentation to short chain fatty acids and may be independent of the stimulation of specific taxa in the human gut. In analogy to lactose intolerance, over-consumption of galacto-oligosaccharides results in intestinal discomfort and osmotic diarrhea. In addition to their prebiotic activity, galacto-oligosaccharides have been shown to prevent the adhesion of enteric pathogens to mucosal surfaces. Their activity is likely mediated by specific interaction with bacterial glycan recognition proteins that are involved in early steps of pathogenesis. The prevention of pathogen adhesion is a complementary mechanism of galacto-oligosaccharides to specifically benefit host health. The concept of preventing pathogen adhesion was validated in vivo with swine models; anti-adhesive glycans may be used as functional food ingredient but also in animal production to reduce the use of antimicrobial growth promoters.

Key Words: lactose β-galactosidase galacto-oligosaccharide, pathogen adhesion

568 Role of lactose in dairy and food products: State of understanding. Tonya C. Schoenfuss*, *University of Minnesota, St. Paul, MN.*

Lactose is the most abundant nonfat solid in milk and its properties present both opportunities and challenges for its presence in food and dairy products. Important properties that affect dairy ingredient use due to lactose are crystallization, stickiness, hygroscopicity, and reactions it participates in. Positive attributes of lactose include its low sweetness, low cost, and the ability to participate in non-enzymatic (Maillard) browning reactions because it is a reducing sugar. It is also important as a solids replacer to balance mouth feel and the solution properties in beverages, ice cream mixes, and the liquid phase during baking. The effect of lactose on the viscosity of the solution phase can alter the ability to hold gas during baking, and maintain ice crystal stability during the storage of frozen products. Thermodynamic parameters that are measured such as the glass transition (T_g), melting temperature (T_m) and temperature of crystallization (T_{cr}) are useful to evaluate the effects of processing and other ingredients on lactose state and stability. But in formulated food systems, it can be complicated to attribute the functional attributes entirely to these measured properties. This objective of this symposium talk is to focus on the challenges of using lactose in formulated foods, and what is understood about the important chemical, physical and thermodynamic properties involved in caking and crystallization. Challenges with using lactose in beverages, chocolate, frozen desserts and bars will be highlighted, as will methods to avoid undesirable changes to texture, viscosity and handling characteristics.

Key Words: lactose, food

569 Industry perspective on managing quality and yield of lactose: From food to pharmaceutical grade. A. Kent Keller*, *Keller Technologies Inc., Mantorville, MN.*

Lactose has been commercially produced since the early part of the twentieth century. Worldwide production increased phenomenally in the 1940s when it was found that lactose was the best substrate for penicillin production. Further increases in lactose production resulted when mothers started to use infant formula, which contains lactose as the major constituent. Late in the twentieth century, confectioners found many reasons to use crystalline lactose in chocolates. Today chocolates are second only to infant formulae as the major use of lactose. In this presentation, the author shares some of his 40 years of experience operating and designing commercial-scale lactose production systems. Each unit operation for lactose production is discussed with a focus of how each unit operation can affect lactose quality and yield. The following unit operations are covered: raw material supply, concentration (RO and evaporation), crystallization, refining, drying and packaging. Particular attention will be given to the current state of the art, which is not typically covered in various textbooks. Finally, a review of traditional and new methods for producing pharmaceutical grade lactose are discussed.

Key Words: lactose, lactose production

570 Processing and stability of high lactose powders . Thom Huppertz*[1,2], Inge Gazi[1], and Hasmukh Patel[2], *[1]NIZO food research, Ede, the Netherlands, [2]South Dakota State University, Brookings, SD.*

Lactose strongly affects the stability of dairy products on drying and storage. In skim milk powder, WPC35 and infant formula, lactose represents >50% of dry matter and forms an amorphous matrix in which other constituents are dispersed. When temperature and water activity exceed critical values, the amorphous lactose matrix changes to a rubber-like state, where the powder can become sticky. Lactose crystallization and Maillard reactions can also occur as self-propagating reactions due to water release from amorphous lactose on crystallization and the reaction between the carbonyl and the amino group, thus further increasing water activity. Hence strict control of heat-load and drying conditions and prevention of moisture gradients (e.g., in dry-blending ingredients) are needed to maintain powder properties. Otherwise, lumping, caking and other handling properties can occur. Moisture sorption isotherms and glass transition temperatures can be predicted based on composition and can be used as input parameters for optimization of processing conditions. For powders with even higher lactose content, e.g., permeate or whey powder, pre-crystallization of lactose in the concentrate before drying is required to avoid development of excessive stickiness during drying. Pre-crystallization is achieved by (flash) cooling and addition of seeding crystals. Optimization of pre-crystallization conditions (temperature and solids content) in relation to crystallization rate and viscosity is needed to attain sufficient crystallization within an acceptable time. Typically, up to 75% of lactose can be crystallized by pre-crystallization. Post-crystallization after drying can further increase crystallization levels, up to 95%. Failure to attain sufficiently lactose crystallization (i.e., >75%) can lead to caking, lumping and browning when powders are stored. Other constituents also influence the behavior of lactose during processing and storage. Lactose-phosphate, formed during fermentation, is a potent inhibitor of lactose crystallization, whereas lactate salts present can add considerable hygroscopicity to powders. Overall, careful control of composition, processing and storage conditions is paramount to attain and maintain high-lactose powders of desirable properties.

Key Words: lactose, powder, processing