Milk Protein and Enzymes Symposium: High milk protein foods—Challenges and opportunities in structures and digestion

437 The role of milk proteins in the development of high protein foods. Harjinder Singh*, *Riddet Institute, Massey University, Palmerston North, New Zealand.*

The global demand for milk protein has increased significantly in recent years due to better understanding of its nutritional value, physiological and bioactive properties. A growing body of research shows that a greater intake of protein may be beneficial in sports performance, weight management, lean muscle mass retention, satiety and general wellbeing. Much of the evidence regarding many of these health benefits focuses on milk proteins, particularly whey proteins. As a result, the demand for milk protein-enriched food and beverage products has increased enormously over the last 5 years. Several milk protein products, such as milk protein concentrates, whey protein concentrates and whey protein isolates, are now available and can be added to beverages, yogurt, soups, desserts and bars. However, some functional properties of milk proteins, such as aggregation and viscosity, pose challenges to developing acceptable food formulations at high protein concentrations. For example, the addition of protein will typically cause a food product to become excessively thick and will create stability issues during processing. In addition to maintaining suitable stability and texture, protein at high concentration has a marked impact on the taste and flavor profile of the product. Although some solutions to these problems have been developed by the food industry, we need to have better understanding of the fundamental behavior of proteins at high concentrations in various food formats.Recent studies indicate that beneficial effects of protein on health are not just dependent on sufficient protein intake; the rate at which amino acids are released and absorbed, as well as the generation of bioactive peptides influence biological potency. Thus, the interactions of milk proteins in the food and in the gastro-intestinal tract can play an important role in modulating the efficiency of protein digestion and the magnitude of its biological effects. In the future, it may be possible to design structures based on milk protein preparations to optimize the delivery of amino acids, hence modulating the postprandial physiological responses.

Key Words: milk protein, functionality, digestion

438 Structuring food for improving nutrient bioavailability: The case of dairy gels. Didier Dupont*[1], Florence Barbe[1], Steven Le Feunteun[2], Olivia Menard[1], Yann Le Gouar[1], Amelie Deglaire[1], Juliane Floury[1], Didier Remond[3], and Beatrice Laroche[4], *[1]INRA-Agrocampus Ouest, Rennes, France, [2]INRA-AgroParisTech, Grignon, France, [3]INRA-Université Clermont 1, Clermont-Ferrand, France, [4]INRA, Jouy-en-Josas, France.*

The food matrix structure is one of the key drivers to control the fate of food in the digestive tract and, consequently, the kinetics of nutrient release. Milk is “the” perfect raw material to build a wide variety of structures and can be really seen as a “Lego box” from which all the constituents can be separated (cracking) and re-assembled into different structures. The behavior in the gastrointestinal tract of milk protein matrices of identical composition but different micro and macrostructures was investigated in the present study. Six multi-cannulated and catheterized mini-pigs were fed 6 different dairy matrices (raw and heat-treated milks, acid and rennet gels). Effluents from the duodenum and mid-jejunum as well as plasma from the abdominal aorta were collected over 7h. Structure was shown to drive the time of residence of food in the stomach. The liquid-gel transition led to a significant increase in the gastric emptying time. Liquid matrices generated a fast and intense peak of proteins in the intestine and amino acids in the bloodstream. Peptidomic analysis showed different patterns between intestinal samples. Finally, rennet gels had a different behavior than the acid ones forming a compact coagulum in the stomach that slowed down the gastric emptying and delayed the release of amino acids. A mathematical model of digestion was built from these data. Therefore, controlling the time of residence of food in the stomach by playing on its structure should allow to design products with a fast release of nutrients particularly adapted for elderlies, athletes etc… whereas foods persisting in the stomach should induce satiety and be dedicated to overweight people. As an example, 2 isocaloric yogurts with 3.3 and 8.4g of protein /100g respectively were manufactured and given to 11 pigs. Gastric emptying followed by scintigraphy was significantly slowed down for the protein-enriched yogurt leading to different kinetics of proteolysis. Ongoing experiments using biophysical methods will help us in understanding the mechanisms of gel particle breakdown in the stomach to design dairy products of new generation perfectly adapted to the nutritional needs of specific populations

Key Words: digestion, dairy, bioavailability

439 Dairy protein and soluble fiber complexation: Effect on digestion and healthfulness of high protein foods. Bongkosh Vardhanabhuti*, *University of Missouri, Columbia, MO.*

Through controlled assembly of protein and polysaccharide, especially anionic soluble fibers, biopolymer particles with desirable functional properties can be created. The majority of research has focused on fabrication conditions under associative interaction (e.g., at pH < isoelectric point of protein) where they form complex coacervates. Much less attention has been given to their interactions under limited thermodynamic compatibility (e.g., at neutral or near neutral pH) where the positively charged patches of protein can form electrostatic attraction with negatively charged polysaccharides. Research has shown that unheated and heated soluble complexes between whey protein and anionic soluble fibers can be formed under limited thermodynamic compatibility. At optimum conditions, structuring of these complexes improves functional properties of whey protein, leading to enhanced texture and stability of food products. Using *in vitro* digestion model, recent studies have revealed that high protein beverages containing whey protein and anionic soluble fiber complexes can form intragastric gel when entering the simulated gastric environment. The transformation of liquid (e.g., beverages) to gel results in slow gastric emptying and slower protein degradation. Formation of intragastric gel also traps other ingredients including sugar, resulting in delayed sugar-release from the gel network. Potentially, intragastric gelation behavior could lead to the development of high protein food products with healthy blood sugar or high satiety claims. As the demand for high protein products continues to grow, complexes between dairy protein and soluble fibers could be utilized to improve the quality and healthfulness of high protein foods and beverages.

Key Words: dairy protein, digestion, soluble fiber

440 Milk protein ingredients for controlling hardening of protein bars. Thom Huppertz*[1,2] and Sean Hogan[3], *[1]NIZO food research, Ede, the Netherlands, [2]South Dakota State University, Brookings, SD, [3]Teagasc Dairy Products Research Centre, Moorepark, Fermoy, Ireland.*

Demand for high-protein snack bars as meal replacers and by consumers engaged in sports and dieting has grown significantly in recent years. These products provide healthy alternatives to conventional snacks because of the inclusion of high levels of protein (15–35%, w/w) and other nutritionally beneficial ingredients. Inclusion of high levels of protein in bars may result in adverse quality effects, in particular bar hardening, the degree of which is dependent on the ingredients and process used to produce the bars. Particularly water migration to the protein powder particles is a strong contributor to hardening of protein bars due to subtraction of water from different constituents, which can lead to hardening due to crystallization of carbohydrates. Protein bars containing whey protein isolate as the protein source generally developed less hardness than those containing caseinate. Part of these differences can be related to differences in moisture sorption of the protein powder particles in the water activity region of the protein bars (~0.5–0.7). For understanding protein functionality in bars, it is important to keep in mind that at these water activities, proteins should not be considered as fully hydrated proteins, but as partially hydrated. A further strong contributor to protein ingredient behavior in protein bars is powder particle size and microstructure. A broad particle size distribution and agglomeration were found to be beneficial to reduce development of hardness. Such effects can be attributed to the fact that less dense packing of powder particles is achieved in polydisperse systems, as a result of which hardness is reduced. The use of protein blends can also be beneficial from this perspective. Overall, initial hardness of protein bars can be described initially as a function of volume fraction of suspended powder particles and the efficiency of packing thereof. During storage, water migration and partial hydration and swelling of protein particles further contribute to hardness development. Hence, control of water sorption of powder particles and powder particle size and structure are prime routes to control the development of hardness in protein bars.

Key Words: whey protein, casein, protein bar hardening

441 Technological challenges of high milk protein formulations. Juan M. Gonzalez*, *Global Technology at Mead Johnson Nutrition, Evansville, IN.*

The formulation and processing of high protein nutritional dairy products present several challenges. Two product formats to be discussed: powder products to be consumed as reconstituted beverages, and ready-to-eat (RTE) liquid products. Regarding powder products, the challenges are related to the consumer experience. Regarding the RTE liquid product, the challenges are related to processing and stability. High dairy protein powder products processed via powder blending face consumer experience challenges related to preparation, such as hydration, and to the sensory perception. The use of agglomeration technologies may provide a fast wetting of the powder. However, the hydration of the proteins may become a challenge as the proteins would compete for water available for hydration. The sugars and salts that may be present in the formulation would also compete for the bulk water available for hydration. Regarding the sensory experience, the presence of insufficient bulk water may lead to a perceived graininess in the beverage. The high protein content may produce a thick beverage more suitable to be spooned or chewed rather than swallow. RTE liquid products present challenges of hydration and thermal stability of the high protein matrix through processing. The processing stability of RTE high protein liquid beverages is related to the protein components. Whey based formulations are more stable than casein based formulations. The target pH, presence of salts, carbohydrates, and the buffering capacity of the high protein slurry would present formulation and processing challenges, as is in the case of concentrated infant formulas. The presence of reducing sugars at pH > 7 would encourage the formation of Maillard reaction color and flavor compounds that may or may not be desirable. This reaction also compromises the nutritional value of the protein as it makes unavailable amino acids, such as lysine, arginine and glutamine. The use of the shockwave steam injection technology allows for the processing of high protein dairy slurries. The viscosity observed in these shockwave-processed slurries is considerably lower than the one observed in traditionally heat-treated systems. Lower protein denaturation has been observed and this may be attributed to thermodynamic relationships within the process.