

Dairy Foods: Challenges and Opportunities of Microencapsulation Technology in Application to Dairy Foods Symposium

648 Introduction to scientific principles and engineering technologies in microencapsulation as applicable to dairy foods. K. Kailasapathy*, *University of Western Sydney, Richmond, NSW, Australia.*

Development of technology driven functional and natural health products has a number of challenges since bioactive ingredients incorporated are unstable to processing with reduced absorption, low bioavailability and reduced shelf life. Encapsulation offers a great potential for protecting and delivering bioactive components and micro-organisms through technology driven products to enhance human health. Encapsulation is the technology of packaging bioactive core materials in miniature capsules that release their contents triggered by various factors such as shear, temperature, enzymes, and pH. The available technologies for microencapsulation can be grouped into two broad categories, one which uses a liquid as a suspending medium (complex coacervation, interfacial and in situ polymerisation or solvent evaporation from emulsions) and one which uses a gas as a suspending medium into which a liquid phase is sprayed (spray-drying or spray-cooling, fluidised-bed coating or coextrusion). Currently available commercial products are based on gel particles, spray-coating, spray-drying, extrusion and emulsions. Other encapsulation techniques such as liposomes, coacervation or molecular inclusion (cyclodextrins) as well as using nano emulsions are not widely available to protect bioactives in the development of technology driven functional dairy foods. This could be either because of cost or the requirement of non-food approved polymers used in the encapsulation. A number of both laboratory and commercial scale equipment had been developed and being used to produce micro and nano scale capsules. A UWS prototype encapsulator which uses a falling film technology capable of producing high capsule production capacity suitable for application on an industrial scale has been developed. This presentation will review the recent developments in relation to the science and technology of encapsulation, challenges and opportunities in the development of innovative functional dairy foods.

Key Words: microencapsulation, bioactive substances, functional dairy foods

649 Benefits of encapsulation of probiotics during processing and storage of dairy products. C. P. Champagne*, *Agriculture and Agri-Food Canada, St. Hyacinthe, QC, Canada.*

Viability is an important component of the functionality of probiotic bacteria in foods. Unfortunately, many processing (heating, freezing) and storage conditions (redox level, pH) used in dairy technology are detrimental to the viability of the probiotic bacteria. In this review-type presentation, the benefits of encapsulation to address these viability problems will be addressed. The three most widely used encapsulation technologies of probiotic bacteria (gel microentrapment, spray coating and spray drying) will be described. The benefits of encapsulation on the viability of probiotic bacteria during processing and storage will be examined in the following products: frozen desserts, yoghurt, cheese, unfermented milk, powders. Some of the factors which influence the effectiveness of encapsulation will be discussed; these factors include: strain variability, particle size, pH, multiple coating, packaging, cell density.

Key Words: probiotics

650 Strategies to improve survival of probiotic bacteria using microencapsulation and to reduce the size of microcapsules for food applications. W.-K. Ding and N. P. Shah*, *Victoria University, Melbourne, Victoria, Australia.*

Survival and stability of probiotic organisms in functional foods have been a major concern, because a high number of organisms is needed to confer health benefits to consumers. Microencapsulation of probiotic organisms in alginate beads is one of the methods of improving their viability. However adverse sensory qualities such as grittiness result when microcapsules are added to functional foods mainly due to their large size. The aim of this study was to improve the microencapsulation technique by making smaller more palatable capsules and provide the capsules with an extra coating for enhanced stability. A microfluidizer was used to manufacture microcapsules of reduced size. The surface structure and overall size of the microcapsules was measured and analyzed using electron microscopy. Palm oil and poly-L-lysine was used as added coating materials to enhance the capsule's stability. The porosity of the coated microcapsules was measured by monitoring the release of a water soluble dye. Our results show that microencapsulation helped protect probiotic bacteria from acidic conditions during storage, high concentrations of bile salts and mild heat treatment. The added coating materials, palm oil and poly-L-lysine helped maintain the capsule's integrity during exposure to acids, and provided the capsule with a much more smooth surface structure. The added coating material made the capsules less permeable to water soluble molecules. The production of microcapsules with a microfluidizer led to a significant decrease in the average capsule size from 132 μm to 35 μm , which would be much more palatable for consumers.

Key Words: microencapsulation, probiotics, size reduction

651 Food protein micro/nano particles for controlled nutraceutical delivery in functional foods. L. Chen*¹ and M. Subirade², ¹*University of Alberta, Edmonton, AB, Canada,* ²*Université Laval, Quebec, QC, Canada.*

The incorporation of nutraceutical compounds into food systems provides a simple way to improve public health and/or reduce the risk of disease. However, many of these compounds remain unavailable by oral administration, due to instability under the conditions encountered during food processing (e.g. high temperature, exposure to oxygen and light) or in the gastro-intestinal tract (e.g. low pH, digestive enzymes, presence of other nutrients), and low permeability and/or solubility within the gut. Micro/nano encapsulation systems can be used to overcome these limitations. Although numerous synthetic polymer based delivery systems to maximize drug action and minimize side effects in the biomedical and pharmaceutical sectors have been successfully developed, these formulations cannot be used in food applications that require materials generally recognized as safe (GRAS). As a vital macronutrient in food, food proteins possess unique functional properties and excellent biodegradability, which enable them to be GRAS for encapsulation of nutraceutical compounds. This presentation focuses on the current knowledge and techniques for development of food protein-based micro/nano particles of desirable structures at precisely controlled sizes for target release of nutraceutical compounds at the site of absorption. Their potential applications in functional foods are illustrated.

Key Words: food protein, nano/microparticles, nutraceutical delivery

652 Microencapsulation of recombinant enzymes for application in accelerated cheese ripening. B. H. Lee*^{1,2}, ¹*Agriculture and Agri-Food Canada, Food R & D Centre, St-Hyacinthe, QC, Canada*, ²*McGill University, Montreal, QC, Canada*.

Direct addition of enzymes to milk during cheesemaking appears to be the simplest method to accelerate cheese ripening. However, due to loss of most enzymes in whey, poor enzyme distribution, and texture defects by extensive proteolysis, alternative encapsulation technology can eliminate these defects. Previous approaches on the addition of free enzymes during salting stage and encapsulation of natural flavour-enhancing enzymes using different food gums and liposomes will be presented. In this study, aminopeptidase (PepN) of the cheese isolate,

Lactobacillus rhamnosus S93 was genetically overproduced up to a 1,000 fold, purified and encapsulated in chitosan-coated alginate beads to investigate the effects of Cheddar cheese ripening for 6 months. The encapsulation efficiency was above 90%, and the experimental cheeses received higher scores for sensory properties than the control cheese. The amounts of PTA-N and total FAA in the cheese with the encapsulated enzyme after 2 months of ripening were close to those of the control cheese after 6 months, suggesting the acceleration of about 4 months in proteolysis. Although this study was aimed to develop an encapsulation method which can affect Cheddar cheese ripening, it would be useful for other type of cheeses.

Key Words: microencapsulation, enzymes, cheese ripening

Dairy Foods: Milk Protein and Enzymes Symposium

653 Indigenous enzymes in mammalian milk: Scientific, technological and physiological significance. A. Kelly*, *University College Cork, Cork, Ireland*.

The milk of all mammals contains a range of enzymes with a range of roles and functions; even in more well-studied species such as the bovine, the exact number of enzymes, factors affecting their activity, and their exact significance remains poorly understood. Some enzymes are recognised to have roles, either positive or negative, in the quality of milk and dairy products, such as milk lipoprotein lipase and the alkaline protease, plasmin. Other enzymes are of major industrial significance not for their function but due to their exploitation as surrogate indicators of the efficiency of processing, such as the use of alkaline phosphatase as an index of the efficiency of pasteurisation. In physiological terms, the activity of many enzymes is susceptible to secretory disturbances in the udder, reflecting their cellular or blood origins, and so levels can vary with factors such as stress, lactation and, in particular, mastitis. This presentation will give a brief overview of the profile and significance of the principal enzymes in mammalian milk. In addition, the results of some new research on the enzyme system of the human milk will be discussed, for comparison with the proteolytic system of the bovine, and highlights some potential insights into the physiological significance of modulation of hydrolysis of proteins in milk in terms of enhancing protein digestibility for the neonate.

Key Words: milk, enzymes, proteins

654 Enzymes associated with the bovine milk-fat-globule membrane with special reference to xanthine oxidoreductase. J.-K. Jeong, J. Xu, and I. H. Mather*, *University of Maryland, College Park*.

The enzymes of bovine milk-fat-globule membrane (MFGM) will be reviewed, with particular emphasis on their cellular origin and functional attributes. Over forty enzymes have been identified in the MFGM, including hydrolases, transferases and oxidoreductases. Hydrolases constitute the most abundant class, within which there are a large number of GTPases in the rab family. These enzymes originate from multiple cellular sources, including the mammary epithelium and immune cells, and have diverse physiological functions in milk synthesis and secretion, membrane trafficking, and immunity. The most abundant enzyme in the MFGM of dairy cows and many other species is xanthine oxidoreductase (EC 1.17.1.4) (XOR), a redox enzyme in the molybdenum hydroxylase family. XOR constitutes approximately 20% of globule-associated protein and over 10% of isolated MFGM. Besides its function

as a purine oxidase, XOR, under certain physiological contexts can generate reactive oxygen and nitrogen species, which may function in the innate immune system and in signaling pathways. In addition, XOR binds with high affinity to the cytoplasmic domain of butyrophilin, the most abundant transmembrane protein in the bovine MFGM. Interactions between XOR and butyrophilin are postulated to be essential for formation of the MFGM, and the secretion of lipid droplets. Thus XOR is a multi-functional protein, required for diverse physiological processes in lactation and the immune system.

Key Words: xanthine oxidoreductase, butyrophilin 1A1, milk-lipid-globule membrane

655 Proteolytic enzymes associated with somatic cell count and their relevance in raw milk and dairy products. L. B. Larsen*, *Institute of Food Science, Faculty of Agricultural Sciences, Aarhus University, Denmark*.

Somatic cell count and mastitis are associated with increased activities of bovine proteases, such as plasmin, but also enzymes from somatic cells play a role. These cause proteolytic degradation of the caseins, which can lead to poorer quality of stored milk, and may also contribute to a lower cheese yield. Different proteolytic enzyme systems have been demonstrated in bovine milk, and include, apart from the plasmin system, lysosomal enzymes such as cathepsin B and D. It is, however, not clear to what extent the enzymes are actively secreted from the somatic cells, leaked from dead cells or to some extent secreted by the mammary tissue. This complex situation is reflected in the enzyme profile of e.g. the cathepsin D system, where both active enzymes and proenzymes have been demonstrated in purified preparations from milk, with procathepsin D being the major form present. The enzymes have been characterized in milk and their significance in some dairy products has been studied. The potential contribution of these different bovine enzymes to the proteolysis occurring in milk at acute mastitis as well as at low or moderately elevated somatic cell count has been further characterized by use of proteomic and peptidomic methods including 2D gel electrophoresis, LC MALDI spotting and MALDI ToF MS/MS of peptides and protein fragments. By these methods a range of casein-derived peptides, including some with apparent bioactive properties, were identified in the different milk types. Based in these identifications possibly responsible proteases have been suggested, and these included plasmin, cathepsin B, D and leucocyte elastase, in addition to apparent amino- and carboxypeptidase activities.

Key Words: cell count, proteolysis, MALDI ToF