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XX 1-06 PROPERTIES OF WHEY PROTEIN ISOLATES EXTRUDED UNDER ACIDIC AND ALKALINE CONDITIONS

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To further increase the amount of whey protein isolates (WPI) that may be added to products such as extruded snacks and meats, texturization of WPI is necessary. Texturization changes the folding of globular proteins to improve interaction with other ingredients and create new functional ingredients. In this study, WPI pastes (60% solids) were extruded in a twin-screw extruder at 100°C with 4 pH-adjusted water streams: acidic (pH 2.0 ± 0.2) and alkaline (pH 12.4 ± 0.4) streams from 2 N HCl and 2 N NaOH, respectively, and acidic (pH 2.5 ± 0.2) and alkaline (pH 11.5 ± 0.4) electrolyzed water streams; these were compared with WPI extruded with deionized water. The effects of water acidity on WPI solubility at pH 7, color, microstructure, Rapid Visco Analyzer pasting properties, and physical structure were determined. Alkaline conditions increased insolubility caused yellowing and increased pasting properties significantly. Acidic conditions increased solubility and decreased WPI pasting properties. Subtle structural changes occurred under acidic conditions, but were more pronounced under alkaline conditions. Overall, alkaline conditions increased denaturation in the extruded WPI resulting in stringy texturized WPI products, which could be used in meat applications.

XX 2-06 IMPROVEMENT OF TEXTURE AND STRUCTURE OF REDUCED-FAT CHEDDAR CHEESE BY EXOPOLYSACCHARIDE-PRODUCING LACTOCOCCI

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The objective of this study was to evaluate the effect of capsular and ropy exopolysaccharide (EPS)-producing strains of *Lactococcus lactis* ssp. *cremoris* on textural and microstructural attributes during ripening of 50%-reduced-fat Cheddar cheese. Cheeses were manufactured with added capsule- or ropy-forming strains individually or in combination. For comparison, reduced-fat cheese with or without lecithin added at 0.2% (wt/vol) to cheese milk and full-fat cheeses were made using EPS-nonproducing starter, and all cheeses were ripened at 7°C for 6 mo. Exopolysaccharide-producing strains increased cheese moisture retention by 3.6 to 4.8% and cheese yield by 0.28 to 1.19 kg/100 kg compared with control cheese, whereas lecithin-containing cheese retained 1.4% higher moisture and had 0.37 kg/100 kg higher yield over the control cheese. Texture profile analyses for 0-d-old cheeses revealed that cheeses with EPS-producing strains had less firm, springy, and cohesive texture but were more brittle than control cheeses. However, these effects became less pronounced after 6 mo of ripening. Using transmission electron microscopy, fresh and aged cheeses with added EPS-producing strains showed a less compact protein matrix through which larger whey pockets were dispersed compared with control

cheese. The numerical analysis of transmission electron microscopy images showed that the area in the cheese matrix occupied by protein was smaller in cheeses with added EPS-producing strains than in control cheese. On the other hand, lecithin had little impact on both cheese texture and microstructure; after 6 mo, cheese containing lecithin showed a texture profile very close to that of control reduced-fat cheese. The protein-occupied area in the cheese matrix did not appear to be significantly affected by lecithin addition. Exopolysaccharide-producing strains could contribute to the modification of cheese texture and microstructure and thus modify the functional properties of reduced-fat Cheddar cheese.

XX 3-06**INVITED REVIEW: SPRAY-DRIED DAIRY AND DAIRY-LIKE EMULSIONS—COMPOSITIONAL CONSIDERATIONS**

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Milk constituents [caseins, whey proteins (WP), lactose, and anhydrous milk fat] are used widely in the manufacture of dehydrated dairy and dairy-like emulsions. When sodium caseinate- (NaCas) and WP-stabilized emulsions with an oil-to-protein ratio ranging from 0.25 to 5 are dehydrated, NaCas is a more effective encapsulant than WP because of its superior emulsifying properties and resistance to heat denaturation. Denaturation degree of WP during drying has been associated with increased powder surface fat and larger droplet size after reconstitution. Encapsulation of NaCas-stabilized emulsions improves in the presence of lactose; powder surface fat was reduced from 30 to <5% when lactose was added at a 1:1 ratio to NaCas in an emulsion containing 30% (wt/wt) oil. This has been related to the ability of lactose to form solid-like (or glassy) capsules during sudden dehydration. Encapsulation of WP-stabilized emulsions is not improved by addition of lactose, although there are conflicting reports in the literature. Storage stability of dehydrated dairy-like emulsions is strongly linked to lactose crystallization as release of encapsulated material occurs during storage at high relative humidities (e.g., 75%). The use of alternative carbohydrates as “matrix-forming” materials (such as maltodextrins or gum arabic) improves storage stability but compromises the emulsion droplet size after reconstitution. The composition of the powder surface has been recognized as a key parameter in dehydrated emulsion quality. It is the chemical composition of the powder surface that dictates the behavior of the bulk in terms of wettability, flowability, and stability. Analyses, using electron spectroscopy for chemical analysis of the surface of industrial milk powders and dehydrated emulsions that mimicked the composition of milk, showed that powder surface is covered mainly by fat, even when the fat content is very low (18 and 99% surface fat coverage for skim milk and whole milk powders, respectively). The functional properties of milk constituents during emulsion dehydration are far from being thoroughly understood; future research needs include a) the encapsulation properties of pure micellar casein; b) a deeper understanding of colloidal phenomena (such as changes in the oil-water and air-oil interfaces) that occur before, during, and after dehydration, which ultimately define emulsion stability after drying; and c) reconciliation of the current different views on powder surface composition.

XX 4-06 INFLUENCE OF CONDENSED SWEET CREAM BUTTERMILK ON THE MANUFACTURE, YIELD, AND FUNCTIONALITY OF PIZZA CHEESE

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Compositional changes in raw and pasteurized cream and unconcentrated sweet cream buttermilk (SCB) obtained from a local dairy were investigated over 1 yr. Total phospholipid (PL) composition in SCB ranged from 0.113 to 0.153%. Whey protein denaturation in pasteurized cream over 1 yr ranged from 18 to 59%. Pizza cheese was manufactured from milk standardized with condensed SCB (~34.0% total solids, 9.0% casein, 17.8% lactose). Effects of using condensed SCB on composition, yield, PL recovery, and functional properties of pizza cheese were investigated. Cheesemilks were prepared by adding 0, 2, 4, and 6% (wt/wt) condensed SCB to part-skim milk, and cream was added to obtain cheesemilks with ~11.2 to 12.7% total solids and casein:fat ratio of ~1. Use of condensed SCB resulted in a significant increase in cheese moisture. Cheesemaking procedures were modified to obtain similar cheese moisture contents. Fat and nitrogen recoveries in SCB cheeses were slightly lower and higher, respectively, than in control cheeses. Phospholipid recovery in cheeses was below 40%. Values of pH and 12% trichloro-acetic acid-soluble nitrogen were similar among all treatments. Cheeses made from milk standardized with SCB showed less melt and stretch than control cheese, especially at the 4 and 6% SCB levels. Addition of SCB significantly lowered free oil at wk 1 but there were no significant differences at wk 2 and 4. Use of SCB did not result in oxidized flavor in unmelted cheeses. At low levels (e.g., 2% SCB), addition of condensed SCB improved cheese yield without affecting compositional, rheological, and sensory properties of cheese.

XX 5-06 COMPOSITIONAL AND FUNCTIONAL PROPERTIES OF BUTTERMILK: A COMPARISON BETWEEN SWEET, SOUR, AND WHEY BUTTERMILK

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The compositional and functional properties (protein solubility, viscosity, emulsifying and foaming properties) of sweet, sour, and whey buttermilk were determined at different pH levels and compared with those of skim milk and whey. Composition of sweet and cultured buttermilk was similar to skim milk, and composition of whey buttermilk was similar to whey, with the exception of fat content, which was higher in buttermilk than in skim milk or whey (6 to 20% vs. 0.3 to 0.4%). Functional properties of whey buttermilk were independent of pH, whereas sweet and cultured buttermilk exhibited lower protein solubility and emulsifying properties as well as a higher viscosity at low pH (pH ≤ 5). Sweet, sour, and whey buttermilks showed higher emulsifying properties and lower foaming capacity than milk and whey because of the presence of milk fat globule membrane components. Furthermore, among the various buttermilks, whey buttermilk was the one showing the highest emulsifying properties and the lowest foaming capacity. This could be due to a higher ratio of phospholipids to protein in whey buttermilk com-

pared with cultured or sweet buttermilk. Whey buttermilk appears to be a promising and unique ingredient in the formulation of low pH foods.

XX 6-06 INFLUENCE OF CALCIUM AND PHOSPHORUS, LACTOSE, AND SALT-TO-MOISTURE RATIO ON CHEDDAR CHEESE QUALITY: MANUFACTURE AND COMPOSITION

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Eight Cheddar cheeses with 2 levels of calcium (Ca) and phosphorus (P), residual lactose, and salt-to-moisture ratio (S/M) were manufactured. All cheeses were made using a stirred-curd procedure and were replicated 3 times. Treatments with a high level of Ca and P were produced by setting the milk and drawing the whey at a higher pH (6.6 and 6.3, respectively) compared with the treatments with a low level of Ca and P (pH of 6.2 and 5.7, respectively). The lactose content in the cheeses was varied by adding lactose (2.5% by weight of milk) to the milk for high lactose cheeses, and washing the curd for low lactose cheeses. The difference in S/M was obtained by dividing the curds into halves, weighing each half, and salting at 3.5 and 2.25% of the weight of the curd for high and low S/M, respectively. All cheeses were salted at a pH of 5.4. Modifications in cheese-making protocols produced cheeses with desired differences in Ca and P, residual lactose, and S/M. Average Ca and P in the high Ca and P cheeses was 0.68 and 0.48%, respectively, vs. 0.53 and 0.41% for the low Ca and P cheeses. Average lactose content of the high lactose treatments at d 1 was 1.48% compared with 0.30% for the low lactose treatments. The S/M for the high and low S/M cheeses was 6.68 and 4.77%, respectively. Mean moisture, fat, and protein content of the cheeses ranged from 32.07 to 37.57%, 33.32 to 35.93%, and 24.46 to 26.40%, respectively. The moisture content differed among the treatments, whereas fat and protein content on dry basis was similar.

XX 7-06 ALTERING RENNETING PH CHANGES MICROSTRUCTURE, CELL DISTRIBUTION, AND LYSIS OF LACTOCOCCUS LACTIS AM2 IN CHEESE MADE FROM ULTRAFILTERED MILK

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The objective study was to investigate the lysis of a highly autolytic strain of *Lactococcus lactis* ssp. *cremoris* AM2 in a model cheese made from concentrated ultrafiltered milk. From the same initial ultrafiltered retentate inoculated with *L. lactis* AM2, 5 cheeses were made by the addition of rennet at different pH values (6.6, 6.2, 5.8, 5.4, and 5.2). Lysis was monitored by measurement of the release of lactate dehydrogenase, an intracellular marker enzyme, and by immunodetection of intracellular proteins with species-specific antibodies. Confocal scanning laser microscopy (CSLM) was used to investigate the cheese microstructure by staining for protein and fat. Dual staining with a bacterial viability kit with CSLM was performed to reveal the integrity and localization of the

bacterial cells. Levels of soluble calcium significantly increased when the pH at which the rennet was added decreased. In cheese renneted at pH 6.6, CSLM revealed an open porous structure containing a dense protein network with fat globules of different sizes distributed in the aqueous phase. In cheese renneted at pH 5.2, the protein network was homogeneous, with a less dense protein network, and an even distribution of fat globules. On d 1, bacterial cells were organized into colonies in cheese renneted at pH 6.6, whereas in cheeses renneted at pH 5.2, bacteria were evenly dispersed as single cells throughout the protein network. Lysis was detected on d 1 in cheeses renneted at high pH values and continued to increase throughout ripening, whereas induction of lysis was delayed in cheeses renneted at lower pH values until the end of ripening. This study demonstrates that alterations in the microstructure of the cheese and the distribution of cells play a role in lysis induction of *L. lactis* AM2.