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CHARACTERIZATION OF FLAVOR AND TEXTURE DEVELOPMENT WITHIN LARGE (291 kg) BLOCKS OF CHEDDAR CHEESE

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Many companies produce 291-kg blocks of Cheddar cheese, which are subsequently cut and shipped, or stored and subsequently cut. Previous research has shown that compositional differences exist within 291-kg blocks and that these differences may influence flavor and texture development. The objectives were to systematically characterize flavor and texture differences within 291-kg blocks. On 2 different occasions, a 291-kg block was manufactured at each of 4 manufacturing facilities. After 7 d, the 291-kg blocks were sliced into sixteen 18-kg sample portions using a predetermined diagram, and each portion was labeled appropriately (outer corner, inner corner, etc.) and stored at 7°C. Cheese from different locations within the 291-kg blocks was evaluated at 1, 4, 8, and 12 mo. At each time point, two 18-kg portions representing an inside and outside location with the 291-kg block cross-section (from inside to outside) were sampled. The moisture content was lower in the inner than outer locations within the 291-kg blocks. Protein hydrolysis was higher in the inner location and inner locations developed aged Cheddar flavors sulfur, nutty, and brothy more rapidly than the outer locations. However, plant-to-plant differences in aging were often larger than differences caused by block location. These differences were due to differences in cheese manufacturing practices among plants. Dynamic headspace results for flavor volatiles were consistent with descriptive sensory flavor results, documenting differences between inner and outer locations within 291-kg blocks. The inner locations were more fracturable and the outer locations were more cohesive and had more residual in the mouth. Inner locations had greater fracture strain than outer locations. Documenting the differences in aging of 291-kg blocks of Cheddar cheese is important in understanding how to make a consistent high-quality Cheddar cheese.

ULTRAFILTERED MILK REDUCES BITTERNESS IN REDUCED-FAT CHEDDAR CHEESE MADE WITH AN EXOPOLYSACCHARIDE-PRODUCING CULTURE

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The objectives were to reduce bitterness in reduced-fat Cheddar cheese made with an exopolysaccharide (EPS)-producing culture and study relationships among ultra-filtration (UF), residual chymosin activity (RCA), and cheese bitterness. In previous studies, EPS-producing cultures improved the textural, melting, and viscoelastic properties of reduced-fat Cheddar cheese. However, the EPS-positive cheese

developed bitterness after 2 to 3 mo of ripening due to increased RCA. We hypothesized that the reduced amount of chymosin needed to coagulate UF milk might result in reduced RCA and bitterness in cheese. Reduced-fat Cheddar cheeses were manufactured with EPS-producing and nonproducing cultures using skim milk or UF milk (1.2x) adjusted to a casein:fat ratio of 1.35. The EPS-producing culture increased moisture and RCA in reduced-fat Cheddar cheese. Lower RCA was found in cheese made from UF milk compared with that in cheese made from control milk. Ultrafiltration at a low concentration rate (1.2x) produced EPS-positive, reduced-fat cheese with similar RCA to that in the EPS-negative cheese. Slower proteolysis was observed in UF cheeses compared with non-UF cheeses. Panelists reported that UF EPS-positive cheese was less bitter than EPS-positive cheese made from control milk. This study showed that UF at a low concentration factor (1.2x) could successfully reduce bitterness in cheese containing a high moisture level. Because this technology reduced the RCA level (per g of protein) to a level similar to that in the control cheeses, the contribution of chymosin to cheese proteolysis would be similar in both cheeses.

THERMAL INACTIVATION OF FOOT-AND-MOUTH DISEASE VIRUS IN MILK USING HIGH-TEMPERATURE, SHORT-TIME PASTEURIZATION

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Previous studies of laboratory simulation of high temperature, short time pasteurization (HTST) to eliminate foot-and-mouth disease virus (FMDV) in milk have shown that the virus is not completely inactivated at the legal pasteurization minimum (71.7°C/15 s) but is inactivated in a flow apparatus at 148°C with holding times of 2 to 3 s. It was the intent of this study to determine whether HTST pasteurization conducted in a continuous-flow pasteurizer that simulates commercial operation would enhance FMDV inactivation in milk. Cows were inoculated in the mammary gland with the field strain of FMDV (01/UK). Infected raw whole milk and 2% milk were then pasteurized using an Arm-field pilot-scale, continuous-flow HTST pasteurizer equipped with a plate-and-frame heat exchanger and a holding tube. The milk samples, containing FMDV at levels of up to 104 plaque-forming units/mL, were pasteurized at temperatures ranging from 72 to 95°C at holding times of either 18.6 or 36 s. Pasteurization decreased virus infectivity by 4 log10 to undetectable levels in tissue culture. However, residual infectivity was still detectable for selected pasteurized milk samples, as shown by intramuscular and intradermal inoculation of milk into naïve steers. Although HTST pasteurization did not completely inactivate viral infectivity in whole and 2% milk, possibly because a fraction of the virus was protected by the milk fat and the casein proteins, it greatly reduced the risk of natural transmission of FMDV by milk.

PREVALENCE OF MYCOBACTERIUM AVIUM SUBSPECIES PARATUBERCULOSIS IN SWISS RAW MILK CHEESES COLLECTED AT THE RETAIL LEVEL

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A total of 143 raw milk cheese samples (soft cheese, n = 9; semihard cheese, n = 133; hard cheese, n =

1), collected at the retail level throughout Switzerland, were tested for Mycobacterium avium ssp. paratuberculosis (MAP) by immunomagnetic capture plus culture on 7H10-PANTA medium and in supplemented BAC-TEC 12B medium, as well as by an F57-based real-time PCR system. Furthermore, pH and water activity values were determined for each sample. Although no viable MAP cells could be cultured, 4.2% of the raw milk cheese samples tested positive with the F57-based real-time PCR system, providing evidence for the presence of MAP in the raw material. As long as the link between MAP and Crohn's disease in humans remains unclear, measures designed to minimize public exposure should also include a focus on milk products.

REDUCED FAT PROCESS CHEESE MADE FROM YOUNG REDUCED FAT CHEDDAR CHEESE MANUFACTURED WITH EXOPOLYSACCHARIDE-PRODUCING CULTURES

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In a previous study, exopolysaccharide (EPS)-producing cultures improved textural and functional properties of reduced fat Cheddar cheese. Because base cheese has an impact on the characteristics of process cheese, we hypothesized that the use of EPS-producing cultures in making base reduced fat Cheddar cheese (BRFCC) would allow utilization of more young cheeses in making reduced fat process cheese. The objective of this study was to evaluate characteristics of reduced fat process cheese made from young BRFCC containing EPS as compared with those in cheese made from a 50/50 blend of young and aged EPS-negative cheeses. Reduced fat process cheeses were manufactured using young (2 d) or 1-mo-old EPS-positive or negative BRFCC. Moisture and fat of reduced fat process cheese were standardized to 49 and 21%, respectively. Enzyme modified cheese was incorporated to provide flavor of aged cheese. Exopolysaccharide-positive reduced fat process cheese was softer, less chewy and gummy, and exhibited lower viscoelastic moduli than the EPS-negative cheeses. The hardness, chewiness, and viscoelastic moduli were lower in reduced fat process cheeses made from 1-mo-old BRFCC than in the corresponding cheeses made from 2-d-old BRFCC. This could be because of more extensive proteolysis and lower pH in the former cheeses. Sensory scores for texture of EPS-positive reduced fat process cheeses were higher than those of the EPS-negative cheeses. Panelists did not detect differences in flavor between cheeses made with enzyme modified cheese and aged cheese. No correlations were found between the physical and melting properties of base cheese and process cheese.

INFRARED SPECTROSCOPY TECHNIQUE FOR THE NONDESTRUCTIVE MEASUREMENT OF FAT CONTENT IN MILK POWDER

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The aim was to investigate the potential of the infrared spectroscopy technique for nondestructive measurement of fat content in milk powder. Fat is an important component of milk powder. It is very important to be able to detect the fat content in milk powder using a rapid and nondestructive method. Near and mid infrared spectroscopy techniques were used to achieve this purpose. Least-squares support vector machine (LS-SVM) was applied to developing the fat-content prediction model based on the infrared

spectral transmission values. The results based on LS-SVM were better than those of back-propagation artificial neural networks. The determination coefficient for prediction of the results predicted by the LS-SVM model was 0.9796 and the root mean square error was 0.836708. It was concluded that infrared spectroscopy technique could quantify the fat content in milk powder rapidly and nondestructively. The process is simple and easy to operate. Moreover, the prediction results were compared between near infrared and mid infrared spectral data. The results showed that the performances of model with both mid infrared and near infrared spectral data were a little worse than that of the whole infrared spectral data. The results could be beneficial for designing a simple and nondestructive spectral sensor for the quantification of fat content in milk powder.

LACTOSE CRYSTALLIZATION DELAY IN MODEL INFANT FOODS MADE WITH LACTOSE, ß-LACTOGLOBULIN, AND STARCH

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Handling and storage alter infant food powders due to lactose crystallization and interactions among components. Model infant foods were prepared by colyophilization of lactose, ß-lactoglobulin (ß-LG), and gelatinized starch. A mixture design was used to define the percentage of each mixture component to simulate a wide range of infant food powders. The kinetics of crystallization was studied by a gravimetric method (dynamic vapor sorption) at 70% relative humidity (RH). After freeze-drying, lactose was amorphous and crystallized at 70% RH. The delay before crystallization depends on the contents of ß-LG and starch in the formulations. A mathematical model was proposed to predict crystallization time (delay) at 70% RH. For the formulation containing 50% lactose, 25% ß-LG, and 25% starch, lactose was still amorphous after 42 h at 70% RH, whereas pure amorphous lactose crystallized after approximately 70 min. Calculated and experimental results of adsorbed moisture from the formulations were compared. Adsorbed water of formulation containing lactose could not be calculated from moisture sorption properties of each component at a given RH because ß-LG and gelatinized starch prevented lactose crystal growth.

ENZYMATIC HYDROLYSIS OF HEATED WHEY: IRON-BINDING ABILITY OF PEPTIDES AND ANTIGENIC PROTEIN FRACTIONS

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This study evaluated the influence of various enzymes on the hydrolysis of whey protein concentrate (WPC) to reduce its antigenic fractions and to quantify the peptides having iron-binding ability in its hydrolysates. Heated (for 10 min at 100°C) WPC (2% protein solution) was incubated with 2% each of Alcalase, Flavourzyme, papain, and trypsin for 30, 60, 90, 120, 150, 180, and 240 min at 50°C. The highest hydrolysis of WPC was observed after 240 min of incubation with Alcalase (12.4%), followed by Flavourzyme (12.0%), trypsin (10.4%), and papain (8.53%). The nonprotein nitrogen contents of WPC hydrolysate followed the hydrolytic pattern of whey. The major antigenic fractions (ß-lactoglobulin) in WPC were degraded within 60 min of its incubation with Alcalase, Flavourzyme, or papain. Chromatograms of enzymatic hydrolysates of heated WPC also indicated complete degradation of ß-

lactoglobulin, α-lactalbumin, and BSA. The highest iron solubility was noticed in hydrolysates derived with Alcalase (95%), followed by those produced with trypsin (90%), papain (87%), and Flavourzyme (81%). Eluted fraction 1 (F-1) and fraction 2 (F-2) were the respective peaks for the 0.25 and 0.5 M NaCl chromatographic step gradient for analysis of hydrolysates. Iron-binding ability was noticeably higher in F-1 than in F-2 of all hydrolysates of WPC. The highest iron contents in F-1 were observed in WPC hydrolysates derived with Alcalase (0.2 mg/kg), followed by hydrolysates derived with Flavourzyme (0.14 mg/kg), trypsin (0.14 mg/kg), and papain (0.08 mg/kg). Iron concentrations in the F-2 fraction of all enzymatic hydrolysates of WPC were low and ranged from 0.03 to 0.05 mg/kg. Fraction 1 may describe a new class of iron chelates based on the reaction of $FeSO4 \cdot 7H2O$ with a mixture of peptides obtained by the enzymatic hydrolysis of WPC. The chromatogram of Alcalase F-1 indicated numerous small peaks of shorter wavelengths, which probably indicated a variety of new peptides with greater ability to bind with iron. Alcalase F-1 had higher Ala (18.38%), Lys (17.97%), and Phe (16.58%) concentrations, whereas the presence of Pro, Gly, and Tyr was not detected. Alcalase was more effective than other enzymes at producing a hydrolysate for the separation of iron-binding peptides derived from WPC.

PEPTIC AND TRYPTIC HYDROLYSIS OF NATIVE AND HEATED WHEY PROTEIN TO REDUCE ITS ANTIGENICITY

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This study examined the effects of enzymes on the production and antigenicity of native and heated whey protein concentrate (WPC) hydrolysates. Native and heated (10 min at 100°C) WPC (2% protein solution) were incubated at 50°C for 30, 60, 90, and 120 min with 0.1, 0.5, and 1% pepsin and then with 0.1, 0.5, and 1% trypsin on a protein-equivalent basis. A greater degree of hydrolysis was achieved and greater nonprotein nitrogen concentrations were obtained in heated WPC than in native WPC at all incubation times. Hydrolysis of WPC was increased with an increasing level of enzymes and higher incubation times. The highest hydrolysis (25.23%) was observed in heated WPC incubated with 1% pepsin and then with 1% trypsin for 120 min. High molecular weight bands, such as BSA, were completely eliminated from sodium dodecyl sulfate-PAGE of both native and heated WPC hydrolysates produced with pepsin for the 30-min incubation. The α-lactalbumin in native WPC was slightly degraded when incubated with 0.1% pepsin and then with 0.1% trypsin; however, it was almost completely hydrolyzed within 60 min of incubation with 0.5% pepsin and then with 0.5% trypsin. Incubation of native WPC with 1% pepsin and then with 1% trypsin for 30 min completely removed the BSA and α-lactalbumin. The ß-lactoglobulin in native WPC was not affected by the pepsin and trypsin treatments. The ß-lactoglobulin in heated WPC was partially hydrolyzed by the 0.1 and 0.5% pepsin and trypsin treatments and was completely degraded by the 1% pepsin and trypsin treatment. Antigenicity reversibly mimicked the hydrolysis of WPC and the removal of ß-lactoglobulin from hydrolysates. Antigenicity in heated and native WPC was reduced with an increasing level of enzymes. A low antigenic response was observed in heated WPC compared with native WPC. The lowest antigenicity was observed when heated WPC was incubated with 1% pepsin and then with 1% trypsin. These results suggested that incubation of heated WPC with 1% pepsin and then with 1% trypsin was the most effective for produc-

ing low-antigenic hydrolysates by WPC hydrolysis and obtaining low molecular weight small peptides. Further research is warranted to identify the low molecular weight small peptides in the WPC hydrolysates produced by pepsin and trypsin, which may enhance the use of whey.

PRELIMINARY STUDY OF ULTRASONIC STRUCTURAL QUALITY CONTROL OF SWISS-TYPE CHEESE

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There is demand for a new nondestructive cheese-structure analysis method for Swiss-type cheese. Such a method would provide the cheese-making industry the means to enhance process control and quality assurance. This paper presents a feasibility study on ultrasonic monitoring of the structural quality of Swiss cheese by using a single-transducer 2-MHz longitudinal mode pulse-echo setup. A volumetric ultrasonic image of a cheese sample featuring gas holes (cheese-eyes) and defects (cracks) in the scan area is presented. The image is compared with an optical reference image constructed from dissection images of the same sample. The results show that the ultrasonic method is capable of monitoring the gas-solid structure of the cheese during the ripening process. Moreover, the method can be used to detect and to characterize cheese-eyes and cracks in ripened cheese. Industrial application demands were taken into account when conducting the measurements.