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FORTIFICATION OF CHEDDAR CHEESE WITH VITAMIN D DOES NOT AFFECT CHEESE FLAVOR PERCEPTION

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Currently, dietary guidelines for vitamin D consumption are under review, considering new information that >50% of the US population is vitamin D deficient, and may lead to a recommendation of a higher dietary intake of this vitamin. Vitamin D fortification of cheese aims to improve the current availability of fortified dairy foods beyond liquid milk. However, cheese is susceptible to undesirable flavor changes during long-term cheese ripening, and cheese bacteria and enzymes may degrade added vitamins. To test the retention of vitamin D₃ in Cheddar cheese curd, cheese milk was fortified initially during manufacture at a level of 150 IU/serving, using commercial sources that contained vitamin D₃ in powder, oil, or emulsion form, with and without homogenization of the fortified milk. When fortification was done directly to the cheese milk, we found that more than 80% vitamin D₃ was retained in cheese curd, irrespective of homogenization or form of fortification. Further, Cheddar cheese was fortified with the emulsion form of vitamin D₃ directly in cheese milk at 200 and 400 IU/serving to test stability and flavor changes. Vitamin D₃ fortified in this manner was stable for up to 9 mo in Cheddar cheese. Consumer acceptance and descriptive analysis of flavor profiles of cheese were also conducted and showed that vitamin D₃ fortified cheeses were equally liked by consumers, and cheese taste and flavor remained unaltered with vitamin D₃ addition even after aging for 9 mo.

STANDARDIZATION OF MILK USING COLD ULTRAFILTRATION RETENTATES FOR THE MANUFACTURE OF SWISS CHEESE: EFFECT OF ALTERING COAGULATION CONDITIONS ON YIELD AND CHEESE QUALITY

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Fortification of cheesemilk with membrane retentates is often practiced by cheesemakers to increase yield. However, the higher casein (CN) content

can alter coagulation characteristics, which may affect cheese yield and quality. The objective of this study was to evaluate the effect of using ultrafiltration (UF) retentates that were processed at low temperatures on the properties of Swiss cheese. Because of the faster clotting observed with fortified milks, we also investigated the effects of altering the coagulation conditions by reducing the renneting temperature (from 32.2 to 28.3°C) and allowing a longer renneting time before cutting (i.e., giving an extra 5 min). Milks with elevated total solids (TS; +13.4%) were made by blending whole milk retentates (26.5% TS, 7.7% CN, 11.5% fat) obtained by cold (<7°C) UF with part skim milk (11.4% TS, 2.5% CN, 2.6% fat) to obtain milk with CN:fat ratio of approximately 0.87. Control cheeses were made from part-skim milk (11.5% TS, 2.5% CN, 2.8% fat). Three types of UF fortified cheeses were manufactured by altering the renneting temperature and renneting time: high renneting temperature = 32.2°C (UFHT), low renneting temperature = 28.3°C (UFLT), and a low renneting temperature (28.3°C) plus longer cutting time (+5 min compared to UFLT; UFLTL). Cutting times, as selected by a Wisconsin licensed cheesemaker, were approximately 21, 31, 35, and 32 min for UFHT, UFLT, UFLTL, and control milks, respectively. Storage moduli of gels at cutting were lower for the UFHT and UFLT samples compared with UFLTL or control. Yield stress values of gels from the UF-fortified milks were higher than those of control milks, and decreasing the renneting temperature reduced the yield stress values. Increasing the cutting time for the gels made from the UF-fortified milks resulted in an increase in yield stress values. Yield strain values were significantly lower in gels made from control or UFLTL milks compared with gels made from UFHT or UFLT milks. Cheese composition did not differ except for fat content, which was lower in the control compared with the UF-fortified cheeses. No residual lactose or galactose remained in the cheeses after 2 mo of ripening. Fat recoveries were similar in control, UFHT, and UFLTL but lower in UFLT cheeses. Significantly higher N recoveries were obtained in the UF-fortified cheeses compared with control cheese. Because of higher fat and CN contents, cheese yield was significantly higher in UF-fortified cheeses (~11.0 to 11.2%) compared with control cheese (~8.5%). A significant reduction was observed in volume of whey produced from cheese made from UF-fortified milk and in these wheys, the protein was a higher proportion of the solids. During ripening, the pH values and 12% trichloroacetic acid-soluble N levels were similar for all cheeses. No differences were observed in the sensory properties of the cheeses. The use of UF retentates improved cheese yield with no significant effect on ripening or sensory quality. The faster coagulation and gel firming can be decreased by altering the renneting conditions.

PHYSICAL PROPERTIES, MOLECULAR STRUCTURES, AND PROTEIN QUALITY OF TEXTURIZED WHEY PROTEIN ISOLATE: EFFECT OF EXTRUSION MOISTURE CONTENT

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To explore the complex relationship between processing conditions and functional and nutritional properties of food products containing whey protein isolate (WPI), we investigated the effect of extrusion texturization at various temperatures (50, 75, and 100°C) and varying moisture levels of the feed (20, 30, 40, and 50%) on changes in the composition, molecular structure, and protein quality of the extrudates. Bradford assay methods were used to determine protein solubility of the extruded WPI as a function of changing level of moisture. Protein compositional changes as a function of extrusion conditions were quantitatively characterized and analyzed by sodium dodecyl sulfate-PAGE and reversed-phase-HPLC techniques. We showed that at a given temperature, increasing the extrusion moisture content resulted in a slight increase in the overall protein water solubility (at 50 and 75°C), averaging approximately 5% per 10% increase in moisture content. A reduction in b-lactoglobulin content was observed at 50°C with increasing moisture content, indicative of the sensitive nature of b-lactoglobulin to extrusion treatment, whereas the amount of α -lactalbumin remained unchanged at all moisture contents used at a set temperature. The protein quality of the extruded WPI, determined chemically by available sulfhydryl and primary and secondary amines, remained relatively unchanged as a function of moisture level. Circular dichroism and intrinsic tryptophan fluorescence spectroscopic studies revealed considerable structural changes, both at the secondary structural level and the tertiary contacts as a function of increasing temperature, and higher moisture levels can slightly preserve secondary structures but not the tertiary contacts of the protein molecules. Atomic force microscopy provided direct visualization of the fine difference of the protein particles caused by changing extrusion moisture contents, which is in close agreement with the results obtained using other techniques in this work.

IMPROVEMENT IN MELTING AND BAKING PROPERTIES OF LOW-FAT MOZZARELLA CHEESE

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Low-fat cheeses dehydrate too quickly when baked in a forced air convection oven, preventing proper melting on a pizza. To overcome this problem,

low-fat Mozzarella cheese was developed in which fat is released onto the cheese surface during baking to prevent excessive dehydration. Low-fat Mozzarella cheese curd was made with target fat contents of 15, 30, 45, and 60 g/kg using direct acidification of the milk to pH 5.9 before renneting. The 4 portions of cheese curd were comminuted and then mixed with sufficient glucono- δ -lactone and melted butter (45, 30, 15, or 0 g/kg, respectively), then pressed into blocks to produce low-fat Mozzarella cheese with about 6% fat and pH 5.2. The cheeses were analyzed after 15, 30, 60, and 120 d of storage at 5°C for melting characteristics, texture, free oil content, dehydration performance, and stretch when baked on a pizza at 250°C for 6 min in a convection oven. Cheeses made with added butter had higher stretchability compared with the control cheese. Melting characteristics also improved in contrast to the control cheese, which remained in the form of shreds during baking and lacked proper melting. The cheeses made with added butter had higher free oil content, which correlated (R^2 is greater than 0.92) to the amount of butterfat added, and less hardness and gumminess compared with the control low fat cheese.

MILK PROCESSED BY PULSED ELECTRIC FIELDS: EVALUATION OF MICROBIAL QUALITY, PHYSICOCHEMICAL CHARACTERISTICS, AND SELECTED NUTRIENTS AT DIFFERENT STORAGE CONDITIONS

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Pulsed electric fields (PEF) technology was used to pasteurize raw milk under selected treatments. Processing conditions were: temperature 20, 30, and 40 °C, electric field 30.76 to 53.84 kV/cm, and pulse numbers 12, 24, and 30 for skim milk (SM), and 12, 21, and 30 for whole milk (WM) (2 μ s pulse width, monopolar). Physicochemical parameters (pH, electrical conductivity, density, color, solids nonfat [SNF]) and composition (protein and fat content) were measured after processing. Shelf life of SM and WM was assessed after processing at 46.15 kV/cm, combined with temperature (20 to 60 °C) and 30 pulses. Mesophilic and psychrophilic loads and pH were evaluated during storage at 4 and 21 °C. Results showed minor variations in physicochemical properties after processing. There was an interesting trend in SM in SNF, which decreased as treatment became stronger; similar behavior was observed for fat and protein, showing a 0.18% and 0.17% decrease, respectively, under the strongest conditions. Protein and fat content decreased in WM samples treated at 40 °C, showing a decrease in protein (0.11%), and an even higher decrease in fat content. During storage, PEF-treated milk samples showed higher stability

at 4 °C with minor variations in pH; after 33 d, pH was higher than 6. However samples at 21 °C showed faster spoilage and pH dropped to 4 after 5 d. Growth of mesophilic bacteria was delayed in both milks after PEF processing, showing a 6- and 7-log cycles for SM and WM, respectively, after day 25 (4 °C); however, psychrophilic bacteria grew faster in both cases.

EFFECTS OF STARTER CULTURE AND STORAGE ON THE FLAVOR OF LIQUID WHEY

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The primary off flavors in dried whey proteins have been attributed to lipid oxidation products. A deeper understanding of lipid oxidation in fluid whey is crucial to understand how to minimize off flavors in dried whey protein. The objectives of this study were to further elucidate the role of storage and starter cultures as sources of lipid oxidation in whey. Fluid Cheddar, Mozzarella, and rennet-set wheys were manufactured from skim and whole milk. Liquid wheys and milks were evaluated by descriptive sensory and volatile instrumental analysis within 2 h of manufacture and following storage for 3 d at 4 °C. Culture type greatly influenced the oxidative stability of liquid whey, with Cheddar and Mozzarella whey differing not only in sensory profile, but also in volatile compounds. The type of starter culture (Mozzarella compared with Cheddar) had more influence on flavor than the set type (acid compared with culture). Milks had lower relative abundances of volatile free fatty acids than their liquid whey counterparts. Volatile lipid oxidation products in wheys were higher than in their respective milks, but oxidation in both milks and wheys increased with storage time. Wheys from Cheddar starters displayed more oxidation products than wheys from Mozzarella starters. Starter media did not have an effect on the flavor or oxidative stability of liquid whey, however, culture strain influenced lipid oxidation of fluid whey.

EXPANDED FUNCTIONALITY OF MODIFIED WHEY PROTEIN DISPERSIONS AFTER TRANSGLUTAMINASE CATALYSIS

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The functionality of whey dispersions, prepared with a modified whey protein concentrate (mWPC) ingredient, was significantly altered after cross-linking with microbial transglutaminase (TGase) upon pH adjust-

ment to 8. Test TGase-mWPC solutions, pH 8, gelled faster than control mWPC dispersions, as measured in real time; whereas, the gelling temperature of pretreated TGase-mWPC samples (37 °C, 2.5 h) increased from 67.8 to 74.8 °C with a minimal change in gel strength. Prolonged prior incubation with the enzyme (37 °C, 20 h) raised the gel strength in both control mWPC and TGase-mWPC dispersions, though these values were approximately 2.7 times lower in TGase-mWPC samples. Furthermore, the gelling temperature was raised by 9 °C after extensive polymerization. The water holding capacity was not impacted by enzymatic processing while emulsions prepared with TGase-mWPC dispersions proved very stable with no evidence of phase separation during storage at room temperature for 1 mo. Moreover, the apparent viscosity of TGase-mWPC emulsions exhibited a 10-fold increase compared to nonenzyme-treated mWPC samples. The particle size was nearly 11 µm in covalently linked TGase-mWPC test fractions compared with 8 µm in nonpolymerized mWPC dispersions. Ultimately, the functional characteristics of TGase-mWPC ingredients may be designed to deliver superior performance, especially with regard to improving heat and emulsion stability.

RELATIONSHIP BETWEEN FUNCTIONAL PROPERTIES AND AGGREGATION CHANGES OF WHEY PROTEIN INDUCED BY HIGH PRESSURE MICROFLUIDIZATION

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Aggregation changes of whey protein induced by high-pressure microfluidization (HPM) treatment have been investigated in relation with their functional properties. Whey protein was treated with HPM under pressure from 40 to 160 MPa. Functional properties (solubility, foaming, and emulsifying properties) of whey protein concentrate (WPC) ultrafiltered from fluid whey were evaluated. The results showed significant modifications in the solubility (30% to 59%) and foaming properties (20% to 65%) of WPC with increasing pressure. However, emulsifying property of WPC treated at different pressures was significantly worse than untreated sample. To better understand the mechanism of the modification by HPM, the HPM-induced aggregation changes were examined using particle size distribution, scanning electron microscopy, and hydrophobicity. It was indicated that HPM induced 2 kinds of aggregation changes on WPC: deaggregation and reaggregation of WPC, which resulted in the changes of functional properties of WPC modified by HPM.

EFFECTS OF BUTTERMILK POWDERS ON EMULSIFICATION PROPERTIES AND ACID TOLERANCE OF CREAM*K. Ihara, H. Ochi, H. Saito and K. Iwatsuki**J. of Food Sci. 76(2): C265. 2011.*

Emulsifying properties and acid tolerance are 2 of the most important characteristics of cream. The effects of the buttermilk component, especially its phospholipids, on the emulsifying properties and acid tolerance of cream were investigated in this study. Two buttermilks with differing phospholipid contents and skimmed milk were used to evaluate the effects of phospholipids on the aforementioned parameters. The mean diameter of fat globules and the cream viscosity were used as indicators of emulsifying properties. Acid tolerance was evaluated by studying the effect of citric acid on the maximum viscosity of cream. This was tested by adding 400 μ L of 10% (w/w) citric acid solution to cream every minute and simultaneously measuring pH and viscosity. In 45% and 40% fat cream systems, buttermilk, and especially that with higher phospholipid content, improved the emulsifying properties and acid tolerance of the cream. The components of buttermilk could alter the properties of the surface of fat globules, thereby altering the emulsification properties of the cream. However, neither of the tested buttermilks affected the emulsifying properties and acid tolerance of lower-fat (35% and 30%) cream systems. Emulsifying components exist in proportionately larger amounts in lower-fat creams, which could render the emulsifying properties resistant to change. The number of fat globules may also influence acid-induced changes in viscosity. The addition of phospholipids or lysophospholipids did not improve the acid tolerance of creams, a finding that may be attributable to the formation of complexes of phospholipids and protein.