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SURFACE ROUGHNESS AND PACKAGING TIGHTNESS AFFECT CALCIUM LACTATE CRYSTALLIZATION ON CHEDDAR CHEESE

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Calcium lactate crystals that sometimes form on Cheddar cheese surfaces are a significant expense to manufacturers. Researchers have identified several postmanufacture conditions such as storage temperature and packaging tightness that contribute to crystal formation. Anecdotal reports suggest that physical characteristics at the cheese surface, such as roughness, cracks, and irregularities, may also affect crystallization. The aim of this study was to evaluate the combined effects of surface roughness and packaging tightness on crystal formation in smoked Cheddar cheese. Four 20-mm-thick cross-section slices were cut perpendicular to the long axis of a retail block (~300 g) of smoked Cheddar cheese using a wire cutting device. One cut surface of each slice was lightly etched with a cheese grater to create a rough, grooved surface; the opposite cut surface was left undisturbed (smooth). The 4 slices were vacuum packaged at 1, 10, 50, and 90 kPa (very tight, moderately tight, loose, very loose, respectively) and stored at 1°C. Digital images were taken at 1, 4, and 8 wk following the first appearance of crystals. The area occupied by crystals and number of discrete crystal regions (DCR) were quantified by image analysis. The experiment was conducted in triplicate. Effects of storage time, packaging tightness, surface roughness, and their interactions were evaluated by repeated-measures ANOVA. Surface roughness, packaging tightness, storage time, and their 2-way interactions significantly affected crystal area and DCR number. Extremely heavy crystallization occurred on both rough and smooth surfaces when slices were packaged loosely or very loosely and on rough surfaces with moderately tight packaging. In contrast, the combination of rough surface plus very tight packaging resulted in dramatic decreases in crystal area and DCR number. The combination of smooth surface plus very tight packaging virtually eliminated crystal formation, presumably by eliminating available sites for nucleation. Cut-and-wrap operations may significantly influence the crystallization behavior of Cheddar cheeses that are saturated with respect to calcium lactate and thus predisposed to form crystals

EVALUATION OF DAIRY POWDER PRODUCTS IMPLICATES THERMOPHILIC SPOREFORMERS AS THE PRIMARY ORGANISMS OF INTEREST

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Dairy powders (e.g., sweet whey, nonfat dry milk, acid whey, and whey protein concentrate-80) are of economic interest to the dairy industry. Customers have set strict tolerances (<500 to <1,000/g) for thermophilic and mesophilic spores in dairy powders; therefore, understanding proliferation and survival of sporeforming organisms within dairy powder processing plants is necessary to control and reduce sporeformer counts. Raw, work-in-process, and finished product samples were collected from 4 dairy powder processing facilities in the northeastern United States over a 1-yr period. Two separate spore treatments: (1) 80°C for 12 min (to detect sporeformers) and (2) 100°C for 30 min (to detect highly heat resistant sporeformers) were applied to samples before microbiological analyses. Raw material, work-in-process, and finished product samples were analyzed for thermophilic, mesophilic, and psychrotolerant sporeformers, with 77.5, 71.0, and 4.6% of samples being positive for those organisms, respectively. Work-in-process and finished product samples were also analyzed for highly heat resistant thermophilic and mesophilic sporeformers, with 63.7 and 42.6% of samples being positive, respectively. Sporeformer prevalence and counts varied considerably by product and plant; sweet whey and nonfat dry milk showed a higher prevalence of thermophilic and mesophilic sporeformers compared with acid whey and whey protein concentrate-80. Unlike previous reports, they found limited evidence for increased spore counts toward the end of processing runs. The data provides important insights into spore contamination patterns associated with production of different types of dairy powders and support that thermophilic sporeformers are the primary organism of concern in dairy powders.

SHORT COMMUNICATION: NORBIXIN AND BIXIN PARTITIONING IN CHEDDAR CHEESE AND WHEY

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The objective was to determine norbixin partitioning in cheese and whey from full-fat and fat-free Cheddar cheese and to determine the viability of bixin, the nonpolar form of norbixin, as an alternative Cheddar cheese colorant. Full-fat and fat-free Cheddar cheeses and wheys were manufactured from colored pasteurized milk. Three norbixin (4% wt/vol) levels (7.5, 15, and 30 mL of annatto/454 kg of milk) were used for full-fat Cheddar cheese manufacture, and 1 norbixin level was evaluated in fat-free Cheddar cheese (15 mL of annatto/454 kg of milk). For bixin incorporation, pasteurized whole milk was cooled to 55°C, and then 60 mL of bixin/454 kg of milk (3.8% wt/vol bixin) was added and the milk homogenized (single stage, 8 MPa). Milk with no colorant and milk with norbixin at 15 mL/454 kg of milk were processed analogously as controls. No difference was found between the norbixin partition levels of full-fat and fat-free cheese and whey (cheese mean: 79%, whey: 11.2%). In contrast to norbixin recovery (9.3% in whey, 80% in cheese), 1.3% of added bixin to cheese milk was recovered in the homogenized, unseparated cheese whey, concurrent with higher recoveries of bixin in cheese (94.5%). These results indicate that fat content has no effect on norbixin binding or entrapment in Cheddar cheese and that bixin may be a viable alternative colorant to norbixin in the dairy industry.

THE EFFECT OF ACIDIFICATION OF LIQUID WHEY PROTEIN CONCENTRATE ON THE FLAVOR OF SPRAY-DRIED POWDER

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The objective of this study was to determine the effect of preacidification of liquid ultrafiltered whey protein concentrate (WPC) before spray drying on flavor of dried WPC. Two experiments were performed to achieve the objective. In both experiments, Cheddar cheese whey was manufactured, fat-separated, pasteurized, bleached (250 mg/kg of hydrogen peroxide), and ultrafiltered (UF) to obtain liquid WPC that was 13% solids (wt/wt) and 80% protein on a solids basis. In experiment 1, the liquid retentate was then acidified using a blend of phosphoric and citric acids to the following pH values: no acidification (control; pH 6.5), pH 5.5, or pH 3.5. The UF permeate was used to normalize the protein concentration of each treatment. The retentates were then spray dried. In experiment 2, 150 μg/kg of deuterated hexanal (D_{12}-hexanal) was added to each treatment, followed by acidification and spray drying. Both experiments were replicated 3 times. Flavor properties of the spray-dried WPC were evaluated by sensory and instrumental analyses in experiment 1 and by instrumental analysis in experiment 2. Preacidification to pH 3.5 resulted in decreased cardboard flavor and aroma intensities and an increase in soapy flavor, with decreased concentrations of hexanal, heptanal, nonanal, decanal, dimethyl disulfide, and dimethyl trisulfide compared with spray drying at pH 6.5 or 5.5. Adjustment to pH 5.5 before spray drying increased cabbage flavor and increased concentrations of nonanal at evaluation pH values of 3.5 and 5.5 and dimethyl trisulfide at all evaluation pH values. In general, the flavor effects of preacidification were consistent regardless of the pH to which the solutions were adjusted after spray drying. Preacidification to pH 3.5 increased recovery of D_{12}-hexanal in liquid WPC and decreased recovery of D_{12}-hexanal in the resulting powder when evaluated at pH 6.5 or 5.5. These results demonstrate that acidification of liquid WPC80 to pH 3.5 before spray drying decreases off-flavors in spray-dried WPC and suggest that the mechanism for off-flavor reduction is the decreased protein interactions with volatile compounds at low pH in liquid WPC or the increased interactions between protein and volatile compounds in the resulting powder.

CALCIUM RELEASE FROM MILK CONCENTRATED BY ULTRAFILTRATION AND DIAFILTRATION

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The present work studied the solubilization of Ca during acidification in milk concentrated by ultrafiltration (UF) and diafiltration (DF). The effect of heating milk at 80°C for 15 min was also evaluated. In addition to measuring buffering capacity, the amount of Ca released as a function of pH was determined. The area of the maximum peak in buffering capacity observed at pH ~5.1, related to the presence of colloidal Ca phosphate, was significantly affected by casein volume fraction but did not increase proportionally with casein concentration. In addition, a lower buffering capacity and less solubilized Ca were measured in 2× DF milk compared with 2× UF milk. Heat treatment did not change the buffering capacity or Ca release in 1× and 2× concentrated milk. On the other hand, at a higher volume fraction (4×), more Ca was present in the soluble phase in heated 4× UF and DF milk compared with unheated milk. This is the first comprehensive study on the effect of concentration, distinguishing the effect of UF from that of DF, before and after heating, on Ca solubilization.

THE ROLE OF SODIUM IN THE SALTY TASTE OF PERMEATE

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The objective was to determine the sensory and compositional properties of permeates and to determine if elements other than sodium contribute to the salty taste of permeate. Eighteen whey (n = 14) and reduced-lactose (n = 4) permeates were obtained in duplicate from commercial facilities. Proximate analyses, specific mineral content, and nonprotein nitrogen were determined. Organic acids and nucleotides were extracted followed by HPLC. Aromatic volatiles were evaluated by gas chromatography-mass spectrometry. Descriptive analysis of permeates and model solutions was conducted using a trained sensory panel. Whey permeates were characterized by cooked/milky and brothy flavors, sweet taste, and low salty taste. Permeates with lactose removed were distinctly salty. The organic acids with the highest concentration in permeates were lactic and citric acids. Volatiles included aldehydes, sulfur-containing compounds, and diacetyl. Sensory tests with sodium chloride solutions confirmed that the salty taste of reduced-lactose permeates was not solely due to the sodium present. Permeate models were created with NaCl, KCl, lactic acid, citric acid, hippuric acid, uric acid, orotic acid, and urea; in addition to NaCl, KCl, lactic acid, and orotic acid were contributors to the salty taste.

REMOVAL OF MILK FAT GLOBULES FROM WHEY PROTEIN CONCENTRATE 34% TO PREPARE CLEAR AND HEAT-STABLE PROTEIN DISPERSIONS

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Whey protein concentrates (WPC) are low-cost protein ingredients, but their application in transparent ready-to-drink beverages is limited due to turbidity caused by fat globules and heat instability. In this work, fat globules were removed from WPC 34% (WPC-34) to prepare heat-stable ingredients via the Maillard reaction. The removal of fat globules by acid precipitation and centrifugation was observed to be the most complete at pH 4.0, and the loss of protein was caused by micrometer-sized fat globules and protein aggregates. Spray-dried powder prepared from the transparent supernatant was glycated at 130°C for 20 and 30 min or 60°C for 24 and 48 h. The 2 groups of samples had comparable heat stability and degree of glycation, evaluated by free amino content and analytical ultracentrifugation, but high-temperature, short-time treatment reduced the color formation during glycation. Therefore, WPC-34 can be processed for application in transparent beverages.

EFFECT OF MICROPARTICULATED WHEY PROTEINS ON MILK COAGULATION PROPERTIES

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The objective was to assess the effect of MWP on MCP; namely, rennet coagulation time (RCT), curd-firming time, and curd firmness 30 min after rennet addition. Six concentrations of MWP (vol/vol; 1.5, 3.0, 4.5, 6.0, 7.5, and 9.0%) were added to 3 bulk milk samples (collected and analyzed during 3 d), and a sample without MWP was used as control. Within each day of analysis, 6 replicates of MCP for each treatment were obtained, changing the position of the treatment in the rack. For control samples, 2 replicates per day were performed. In addition to MCP, WP fractions were measured on each treatment during the 3 d of analysis. Milk coagulation properties were measured on 144 samples by using a Formagraph (Foss Electric, Hillerød, Denmark). Increasing the amount of MWP added to milk led to a longer RCT. In particular, significant differences were found between RCT of the control samples (13.5 min) and RCT of samples with 3.0% (14.6 min) or more MWP. A similar trend was observed for curd-firming time, which was shortest in the control samples and longest in samples with 9.0% MWP (21.4 min). No significant differences were detected for curd firmness at 30 min across concentrations of MWP. Adjustments in cheese processing should be made when recycling MWP, in particular during the coagulation process, by prolonging the time of rennet activity before cutting the curd.

CHANGES IN THE PHYSICAL PROPERTIES, SOLUBILITY, AND HEAT STABILITY OF MILK PROTEIN CONCENTRATES PREPARED FROM PARTIALLY ACIDIFIED MILK

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The objective was to investigate the effects of acidification of milk by glucono-δ-lactone (GDL) before ultrafiltration (UF) on the composition, physical properties, solubility, and thermal stability (after reconstitution) of MPC powders. The MPC samples were manufactured in duplicate, either by UF (65% protein, MPC65) or by UF followed by diafiltration (80% protein, MPC80), using pasteurized skim milk, at either the native milk pH (~pH 6.6) or at pH 6.0 after addition of GDL, followed by spray drying. Samples of different treatments were reconstituted at 5% (wt/wt) protein to compare their solubility and thermal stability. Powders were tested in duplicate for basic composition, calcium content, reconstitutability, particle size, particle density, and microstructure. Acidification of milk did not have any significant effect on the proximate composition, particle size, particle density, or surface morphology of the MPC powders; however, the total calcium content of MPC80 decreased significantly with acidification (from 1.84 ± 0.03 to 1.59 ± 0.03 g/100 g of powder). Calcium-depleted MPC80 powders were also more soluble than the control powders. Diafiltered dispersions were significantly less heat stable (at 120°C) than UF samples when dissolved at 5% solids. The present work contributes to a better understanding of the differences in MPC commonly observed during processing.

THE DISTRIBUTION OF FAT IN DRIED DAIRY PARTICLES DETERMINES FLAVOR RELEASE AND FLAVOR STABILITY

C.W. Park & M.A. Drake
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Dried dairy ingredients are utilized in various food and beverage applications for their nutritional, functional, and sensory properties. Dried dairy ingredients include milk powders of varying fat content and heat treatment and buttermilk powder, along with both milk and whey proteins of varying protein contents. The flavor of these ingredients is the most important characteristic that determines consumer acceptance of the ingredient applications. Lipid oxidation is the main mechanism for off-flavor development in dried dairy ingredients. The effects of various unit operations on the flavor of dried dairy ingredients have been investigated. Recent research documented that increased surface free fat in spray dried WPC80 was associated with increased lipid oxidation and off-flavors. Surface free fat in spray-dried products is fat on the surface of the powder that is not emulsified. The most common emulsifiers present in dried dairy ingredients are proteins and phospholipids. Currently, only an association between surface free fat and lipid oxidation has been presented. The link between surface free fat in dried dairy ingredients and flavor and flavor stability has not been investigated. In this review, some hypotheses for the role of surface free fat on the flavor of dried dairy ingredients are presented along with proposed mechanisms.