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COMPARISON OF THE BEHAVIOR OF TWO NANOFILTRATION MEMBRANES FOR SWEET WHEY DEMINERALIZATION

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Nanofiltration is a process used to separate mineral salts from lactose, having previously removed the proteins by ultrafiltration. Both proteins and lactose can be used as raw materials to prepare a variety of products. In this paper, we studied the feasibility of demineralizing sweet whey obtained from the cheese industry of the Comunidad Valenciana (Spain) using membrane technologies. The NF200 membrane showed the highest volumetric flux and solute rejection values, whereas the DS-5 DL membrane showed the lowest values. The volumetric fluxes obtained with the NF200 and DS-5 DL membranes in these experiments with the ultra-filtered whey demonstrated significant differences between membranes. Concerning solute rejection, the highest values were obtained using the NF200 membrane. The chosen parameter to evaluate the demineralization capability was solute flux. In this way, the values obtained for chloride ion were 9.90 and 32.42 g/ (m2·h) for the NF200 and DS-5 DL membranes, respectively, with the highest demineralization rates being achieved with the DS-5 DL membrane.

EVALUATING MID-INFRARED SPECTROSCOPY AS A NEW TECHNIQUE FOR PREDICTING SENSORY TEXTURE ATTRIBUTES OF PROCESSED CHEESE

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The objective was to investigate the potential application of mid-infrared spectroscopy for determination of selected sensory attributes in a range of experimentally manufactured processed cheese samples. This study also evaluates mid-infrared spectroscopy against other recently proposed techniques for predicting sensory texture attributes. Processed cheeses (n = 32) of varying compositions were manufactured on a pilot scale. After 2 and 4 wk of storage at 4°C, mid-infrared spectra (640 to 4,000 cm–1) were recorded and samples were scored on a scale of 0 to 100 for 9 attributes using descriptive sensory analysis. Models were developed by partial least squares regression using raw and pretreated spectra. The mouth-coating and mass-forming models were improved by using a reduced spectral range (930 to 1,767 cm–1). The remaining attributes were most successfully modeled using a combined range (930 to 1,767 cm–1 and 2,839 to 4,000 cm–1). The root mean square errors of cross-validation for the models were 7.4 (firmness; range 65.3), 4.6 (rubbery; range 41.7), 7.1 (creamy; range 60.9), 5.1 (chewy; range 43.3), 5.2 (mouth-coating; range 37.4), 5.3 (fragmentable; range 51.0), 7.4 (melting; range 69.3), and

3.1 (mass-forming; range 23.6). These models had a good practical utility. Model accuracy ranged from approximate quantitative predictions to excellent predictions (range error ratio = 9.6). In general, the models compared favorably with previously reported instrumental texture models and near-infrared models, although the creamy, chewy, and melting models were slightly weaker than the previously reported near-infrared models. We concluded that mid-infrared spectroscopy could be successfully used for the nondestructive and objective assessment of processed cheese sensory quality.

EFFECT OF NATURAL CHEESE CHARACTERISTICS ON PROCESS CHEESE PROPERTIES

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The objective was to evaluate the effect of natural cheese characteristics on the chemical and functional properties of process cheese. Three replicates of 8 natural (Cheddar) cheeses with 2 levels of calcium and phosphorus, residual lactose, and salt-to-moisture ratio (S/M) were manufactured. After 2 mo of ripening, each of the 8 natural cheeses was converted to 8 process cheese foods that were balanced for their composition, including moisture, fat, salt, and total protein. In addition to the standard compositional analysis (moisture, fat, salt, and total protein), the chemical properties (pH, total Ca, total P, and intact casein) and the functional properties [texture profile analysis (TPA), modified Schreiber melt test, dynamic stress rheometry, and rapid visco analysis] of the process cheese foods were determined. Natural cheese Ca and P, as well as S/M, significantly increased total Ca and P, pH, and intact casein in the process cheese food. Natural cheese Ca and P and S/M also significantly affected the final functional properties of the process cheese food. With the increase in natural cheese Ca and P and S/M, there was a significant increase in the TPA-hardness and the viscous properties of process cheese food, whereas the meltability of the process cheese food significantly decreased. Consequently, natural cheese characteristics such as Ca and P and S/M have a significant influence on the chemical and the final functional properties of process cheese.

FILTRATION OF MILK FAT GLOBULE MEMBRANE FRAGMENTS FROM ACID BUTTERMILK CHEESE WHEY

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The proteins and polar lipids present in milk fat globule membrane (MFGM) fragments are gaining attention for their technological and nutritional properties. These MFGM fragments are preferentially enriched in side streams of the dairy industry, like butter serum, buttermilk, and whey. The objective of this study was to recover MFGM fragments from whey by tangential filtration techniques. Acid buttermilk cheese whey was chosen as a source for purification by tangential membrane filtration because it is relatively rich in MFGM-fragments and because casein micelles are absent. Polyethersulfone and cellulose acetate membranes of different pore sizes were evaluated on polar lipid and MFGM-protein retention upon filtration at 40°C. All fractions were analyzed for dry matter, ash, lipids, proteins, reducing sugars, polar lipid content by HPLC, and for the presence of MFGM proteins by sodium dodecyl sul-

fate-PAGE. A fouling coefficient was calculated. It was found that a thermocalcic aggregation whey pretreatment was very effective in the clarification of the whey, but resulted in low permeate fluxes and high retention of ash and whey proteins. By means of an experimental design, the influence of pH and temperature on the fouling and the retention of polar lipids (and thus MFGM fragments), proteins, and total lipids upon microfiltration with 0.15 µM cellulose acetate membrane was investigated. All models were highly significant, and no outliers were observed. By increasing the pH from 4.6 to 7.5, polar lipid retention at 50°C increased from 64 to 98%, whereas fouling of the filtration membrane was minimized. A 3-step diafiltration of acid whey under these conditions resulted in a polar lipid concentration of 6.79 g/100 g of dry matter. As such, this study shows that tangential filtration techniques are suited for the purification of MFGM fragments.

SURVEY OF SALTY AND SWEET WHEY COMPOSITION FROM VARIOUS CHEESE PLANTS IN WISCONSIN

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Salty whey is currently underutilized in the dairy industry because of its high salt content and increased processing and disposal costs. Salty whey accounts for 2 to 5% of the total whey generated during Cheddar and other dry-salted cheese manufacture. Because relatively little information is available on salty whey, this study was conducted to determine the range of compositional components in salty whey from commercial cheese plants. Gross compositional differences in percent protein, salt, solids, and fat between sweet whey and salty whey from various dry-salted cheeses from 8 commercial plants were determined. Differences between individual whey protein compositions were determined using sodium dodecyl sulfate-PAGE. Average total solids, fat, and salt content were significantly greater in the salty whey compared with the corresponding sweet whey. True protein was reduced in salty whey although great variability existed among samples. Individual whey proteins identified included lactoferrin (Lf), BSA, immunoglobulin G, ß-lactoglobulin, and á-lactalbumin. Salty whey showed an increase in Lf content and a decrease in á-lactalbumin and ß-lactoglobulin content when compared with sweet whey. Salty whey may be a source of Lf, potentially increasing its value to whey processors. However, the compositional assessments showed that commercial salty whey is a highly variable waste stream.

PROTEOLYSIS IN MOZZARELLA CHEESES MANUFACTURED BY DIFFERENT INDUSTRIAL PROCESSES

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The objective was to investigate the influence of stretching temperature, fat content, and time of brining on proteolysis during ripening of Mozzarella cheeses. Seventeen cheese-making experiments (batches) were carried out on an industrial scale on successive days, following the standard procedure with some modifications. Fat content of cheese milk, temperature at the stretching step, and time of brining varied from one batch to another as required by the experimental design, outlined by a surface response model. Proteolysis was assessed during ripening of samples, which was prolonged for at least 3 mo, by means of

electrophoresis, nitrogen fractions, and soluble peptide mapping. The amount of soluble nitrogen at pH 4.6 was not significantly different in cheeses obtained by diverse procedures, but it increased during ripening of all samples. This result was coincident with the breakdown of ás1- and ß-caseins evidenced by electrophoresis, which reached similar extents at late stages of ripening, regardless of the cheese-making process. Multivariate analysis on soluble peptide profiles obtained by liquid chromatography also detected sample grouping according to ripening time, but did not evidence any separation caused by the cheese-making technology. We concluded that the changes in the cheese-making process assayed in this work were insufficient to produce significant differences in proteolysis of the cheeses. Ripening time had more influence on proteolysis of Mozzarella cheeses than any other assayed variable.

INNOVATIVE ACTIVE PACKAGING SYSTEMS TO PROLONG THE SHELF LIFE OF MOZZARELLA CHEESE

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J. of Dairy Sci. 90(5): 2126. 2007.

In this work the effectiveness of different antimicrobial packaging systems on the microbial quality decay kinetics during storage of Mozzarella cheese was evaluated. Lemon extract, at 3 different concentrations, was used as active agent, in combination with brine and with a gel solution made of sodium alginate. Shelf life tests were run at 15°C to simulate thermal abuse. The cell load of spoilage and dairy functional microorganisms were monitored at regular time intervals during storage. By fitting the experimental data through a modified version of the Gompertz equation, the shelf life of dairy products packaged in the different systems was calculated. Results show an increase in the shelf life of all active packaged Mozzarella cheeses, confirming that the investigated substance may exert an inhibitory effect on the microorganisms responsible for spoilage phenomena without affecting the functional microbiota of the product.

USE OF WHEY PERMEATE FOR CULTIVATING GANODERMA LUCIDUM MYCELIA

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J. of Dairy Sci. 90(5): 2141. 2007.

A novel approach to utilizing whey permeate, the cultivation of mycelia of the edible mushroom Ganoderma lucidum, is introduced. The major objective of this research was to use whey permeate as an alternative growth medium for the cultivation of mycelia of edible mushroom G. lucidum and to find an optimum condition for solid-state cultivation. Response surface analysis was applied to determine the combination of substrate concentration (25 to 45 g of lactose/L), pH (3.5 to 5.5), and temperature (25 to 35°C) resulting in a maximal mycelial growth. The radial extension rates, estimated by measuring the diameters of growing colonies on the Petri dishes, were used as the growth of the mycelia at different conditions. In the model, pH and temperature significantly affected mycelial growth, but lactose concentration did not. The condition predicted to maximize the radial extension rate of 17.6 ± 0.4 mm/d was determined to be pH 4.4 and temperature 29.4°C. Therefore, the results suggest that whey permeate could be utilized as a growth substrate for the cultivation of mycelia from the edible mushroom G. lucidum, enhancing the use of this by-product by the cheese manufacturing industry.

FACTORS REGULATING CHEESE SHREDDABILITY

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Two sets of cheeses were evaluated to determine factors that affect shred quality. The first set of cheeses was made up of 3 commercial cheeses, Monterey Jack, Mozzarella, and process. The second set of cheeses was made up of 3 Mozzarella cheeses with varying levels of protein and fat at a constant moisture content. A shred distribution of long shreds, short shreds, and fines was obtained by shredding blocks of cheese in a food processor. A probe tack test was used to directly measure adhesion of the cheese to a stainless-steel surface. Surface energy was determined based on the contact angles of standard liquids, and rheological characterization was done by a creep and recovery test. Creep and recovery data were used to calculate the maximum and initial compliance and retardation time. Shredding defects of fines and adhesion to the blade were observed in commercial cheeses. Mozzarella did not adhere to the blade but did produce the most fines. Both Monterey Jack and process cheeses adhered to the blade and produced fines. Furthermore, adherence to the blade was correlated positively with tack energy and negatively with retardation time. Mozzarella cheese, with the highest fat and lowest protein contents, produced the most fines but showed little adherence to the blade, even though tack energy increased with fat content. Surface energy was not correlated with shredding defects in either group of cheese. Rheological properties and tack energy appeared to be the key factors involved in shredding defects.

FIVE TIPS FOR MAINTAINING TOP PRESSURE NOZZLE PERFORMANCE IN YOUR SPRAY DRYER

S. G. Gibson
Powder & Bulk Engineering 21(4): 23. 2007.

Is your spray-drying production rate lower than it should be? Does your spray-dried powder fail to consistently meet your product specs? These problems may indicate that your atomizer isn't operating as it should. Concentrating on one of the most common atomizers — the pressure nozzle — this article gives five tips for maintaining the nozzle's top performance and improving your spray dryer's operation.

EFFECT OF IRON SATURATION ON THE RECOVERY OF LACTOFERRIN IN RENNET WHEY COMING FROM HEAT-TREATED SKIM MILK

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This study aimed to determine the effect of thermal treatments on the recovery of lactoferrin in whey coming from rennet-coagulated skim milk. The impact of lactoferrin iron saturation was also assessed using skim milk spiked with different lactoferrin iron forms. The recovery of lactoferrin in the rennet whey fraction was determined by reverse-phase HPLC. One- and 2-dimensional sodium dodecyl sulfate PAGE analyses were performed on rennet curds to characterize the protein interactions involving lactoferrin in heated milk. The extent of lactoferrin recovered in the whey fraction was found to reduce as the heating temperature increased. The binding of iron by lactoferrin improved its thermal stability

and its recovery in the whey fraction. Poly-acrylamide gel electrophoresis results showed that the association of lactoferrin in the unheated milk rennet curd involved noncovalent interactions, whereas upon heating, lactoferrin also interacted via an intermolecular disulfide link. Depending on the severity of the heat treatment, lactoferrin aggregates with Cys-containing proteins (ß-lactoglobulin, á-lactalbumin, ás2-casein, and κ-casein) occurred by intermolecular thiol/disulfide exchange reactions. These noncovalent and covalent interactions explained the lower recovery of lactoferrin in heated milk.

THERMOCALCIC AGGREGATION OF MILK FAT GLOBULE MEMBRANE FRAGMENTS FROM ACID BUTTERMILK CHEESE WHEY

R. Rombaut and K. Dewettinck
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Fragments originating from the milk fat globule membrane (MFGM), which is rich in polar lipids and membrane-specific proteins, are gaining interest for their functional and nutritional properties. Acid buttermilk cheese whey was used as a source for MFGM purification, because its MFGM content is more than 5 times higher than that of standard rennet whey. Because polar lipids are the main constituent of the MFGM and only occur in membranous structures, the polar lipid content was taken as a parameter for the total MFGM fragment content. The process of thermocalcic aggregation was evaluated on its recovery of MFGM fragments in the pellet. This method, originally intended for whey clarification and defatting, is a combination of calcium addition, a pH increase, and a thermal treatment. The influence of pH (6.5 to 8), temperature (40 to 70°C), and calcium concentration (0.1 to 0.24 g/100 g) on the pellet mass and dry matter (DM) content and on recovery of protein and polar lipids (and thus indirectly on MFGM fragments) was investigated by means of a response surface Box-Behnken orthogonal design. Reduced quadratic models were fit to the experimental data and were found to be highly significant. No outliers were observed. The recovery of MFGM fragments was found to be highly dependent on the pH, and less dependent on temperature and calcium addition. Next to MFGM proteins, whey proteins were also found to be involved in the formation of aggregates. Optimal conditions were found at 55°C, pH 7.7, and 0.205 g of calcium/L of whey. Under these conditions, 91.0% of the whey polar lipids were recovered in a firm and compact pellet of only 7.86% of the original whey mass, with a polar lipid concentration of 8.34% on pellet DM. Washing with water and centrifugation of the pellet was successful because after one washing step, virtually all sugars were removed, whereas 75.9% of the whey polar lipids could still be recovered. As such, the polar lipid content of the washed pellet increased to 10.70% on a DM basis. However, a second washing step resulted in serious losses of MFGM material.

EFFECT OF TYPE OF CONCENTRATED SWEET CREAM BUTTERMILK ON THE MANUFACTURE, YIELD, AND FUNCTIONALITY OF PIZZA CHEESE

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Sweet cream buttermilk (SCB) is a rich source of phospholipids (PL). Most SCB is sold in a concentrated form. This study was conducted to determine if different concentration processes could affect the

behavior of SCB as an ingredient in cheese. Sweet cream buttermilk was concentrated by 3 methods: cold (< 7 ° C) UF, cold reverse osmosis (RO), and evaporation (EVAP). A washed, stirred-curd pizza cheese was manufactured using the 3 different types of concentrated SCB as an ingredient in standardized milk. Cheesemilks of casein:fat ratio of 1.0 and final casein content ~2.7% were obtained by blending ultrafiltered (UF)-SCB retentate (19.9% solids), RO-SCB retentate (21.9% solids), or EVAP-SCB retentate (36.6% solids) with partially skimmed milk (11.2% solids) and cream (34.6% fat). Control milk (11.0% solids) was standardized by blending partially skimmed milk with cream. Cheese functionality was assessed using dynamic low-amplitude oscillatory rheology, UW Meltprofiler (degree of flow after heating to 60 ° C), and performance of cheese on pizza. Initial trials with SCB-fortified cheeses resulted in ~4 to 5% higher moisture (51 to 52%) than control cheese (~47%). In subsequent trials, procedures were altered to obtain similar moisture content in all cheeses. Fat recoveries were significantly lower in RO- and EVAP-SCB cheeses than in control or UF-SCB cheeses. Nitrogen recoveries were not significantly different but tended to be slightly lower in control cheeses than the various SCB cheeses. Total PL recovered in SCB cheeses (~32 to 36%) were lower than control (~41%), even though SCB is high in PL. From the rheology test, the loss tangent curves at temperatures > 40 ° C increased as cheese aged up to a month and were significantly lower in SCB cheeses than the control, indicating lower meltability. Degree of flow in all the cheeses was similar regardless of the treatment used, and as cheese ripened, it increased for all cheeses. Trichloroacetic acid-soluble N levels were similar in the control and SCB-fortified cheese. On baked pizza, cheese made from milk fortified with UF-SCB tended to have the lowest amount of free oil, but flavor attributes of all cheeses were similar. Addition of concentrated SCB to standardize cheesemilk for pizza cheese did not adversely affect functional properties of cheese but increased cheese moisture without changes in manufacturing procedure.