individuals. This new recombinant was tested for antibody production against the T-dependent antigen, bovine RBC (BRBC). Fifty-one progeny segregating for *R13R13* (n = 10), *R13B17* (n = 26), and *B17B17* (n = 15) genotypes were produced by a single *R13B17* male mated to five *R13B17* dams. One mL of 2.5% bovine BRBC was injected intravenously into all genotypes at 4 and 11 weeks of age to stimulate primary and secondary immune responses, respectively. Blood samples were collected 7 days post-injection. Serum total and mercaptoethanol (ME)-resistant antibodies against BRBC were measured by microtiter methods. Titers were expressed as the $\log_2$ of the reciprocal of the highest dilution giving visible agglutination. The least squares ANOVA used to evaluate all primary and secondary antibody titers included hatch and *B* genotype as main effects. Significant means were separated by Fisher's Protected LSD at *P* < 0.05. *R13R13* chickens had significantly lower primary total and ME-resistant antibodies than did the *R13B17* and *B17B17* genotypes. Secondary total and ME-resistant antibodies were significantly lower in *R13R13* chickens compared with *R13B17* but not *B17B17* chickens. Gene differences generated through recombination impacted the antibody response of *R13* compared with *B17*. Secondary antibody titers were not substantially higher than the primary titers suggesting that the memory response had waned in the 7 week interval between injections.

Key Words: Immunity, Recombination, Antibody

Graduate Student Paper Competition: National ADSA Dairy Foods Division

73   Use of HTST pasteurization combined with other nonthermal processes to improve fluid milk shelf life. Z. P. Caplan* and D. M. Barbano, *Cornell University*, *Ithaca, NY*.

Our objective was to develop a process using minimum HTST pasteurization in combination with other nonthermal processes to achieve 60 to 90 days of fluid milk shelf life at 6°C. Microfiltration of raw skim milk and different methods of reducing the total bacteria count of milk fat sources for production of 2% milk were evaluated. Microfiltration (MF) and HTST pasteurization were used to reduce total bacteria, spores, and coliforms in 2% milk made from MF skim milk and various milk fat sources. Raw skim milk was microfiltered at 51°C using a Tetra Alcross M7 Pilot Plant equipped with a ceramic Membralox membrane (pore size: 1.4 micron). MF skim milk plus 3 different milk fat sources were heated to 51°C, and pumped, by weight, into separate containers of MF skim milk to create different 2% milks. These milks were compared to a MF skim milk control without fat added. Each 2% milk was homogenized at 500/2500 psi before undergoing HTST processing (73°C, 15 sec). Total bacteria counts of raw and pasteurized MF skim milks, and pasteurized 2% milks, were determined with most probable number and standard plate count (SPC) methods. Average (n=4) raw skim milk SPC was reduced from 1690 cfu/mL to 0.13 cfu/mL by MF, and further reduced to 0.08 cfu/mL by HTST processing, demonstrating an average 4.3 log reduction from the raw skim milk count due to the combination of MF and HTST. The SPC for all of the pasteurized 2% milks averaged <100 cfu/mL. The pasteurized MF skim milk and pasteurized 2% milks were then stored at 6°C, and the SPC was determined weekly over a 90 d period using a Foss Bactoscan™ FC. Different fat sources did not have a large impact on shelf life. Across 3 replicates, 9 of 9 one liter containers of the pasteurized MF skim milk, and 23 of 27 one liter containers of the pasteurized 2% milks, remained below 20,000 cfu/mL at 70 d. Minimum HTST pasteurization combined with other nonthermal processes was used to successfully extend refrigerated fluid milk shelf life beyond 60 d at 6°C.

Key Words: Microfiltration, Shelf Life, HTST

74   Manufacture of pasteurized process cheese spread from milk concentrated by microfiltration. H. Somni*, V. V. Mistry, K. Muthukumarappan, and K. R. Nauth, *Midwest Dairy Foods Research Center, South Dakota State University*, *Brookings*.

The objective was to replace base cheese in pasteurized process cheese (PC) spread making with microfiltered (MF) milk. Earlier studies focused on PC manufacture from ultrafiltered (UF) milk. With microfiltration, milk proteins are fractionated and offer unique opportunities in process cheese making. Raw skim milk was microfiltered using 0.1μm membrane to approximately 5.7X casein concentration (MFC). Casein in the MFC was 95, 94 and 77% of true protein, total protein and total solids, respectively. MFC was used to substitute base Swiss cheese in PC spread formulations at 33% (T1), 66% (T2) and 100% (T3) by weight of cheese. Total solids, fat, and salt were targeted to 59, 21.5, and 1.5%, respectively, and pH at 5.75. Control (C) was made from Swiss cheese without any substitution. Swiss cheese flavor concentrate was added at 0, 0, 1.85 and 3.5 % levels to C, T1, T2 and T3, respectively. The cheese spread was pasteurized at 71°C for 2 min. The treatments were replicated three times using a randomized block design. Cheeses were analyzed for composition, sensory and rheological properties. Spreadability was measured as percent increase in area after 2.5 and 5.0 min at 25°C. Means were compared using PROC GLM procedure of SAS at p=0.05. With increase in the level of MFC in the spreads, total protein decreased and minerals increased significantly. Control differed from treatments and had minimum viscosity. The bulk and elastic moduli differed for the treatments but did not correlate to level of MFC. A panel of seven expert judges rated T1 above C and the difference was significant for overall flavor, body and texture, and overall acceptability on 1-9 scale (9-liked most and 1-extreme dislike). Substitution of base Swiss cheese with MFC significantly affected rheological properties of the PC spread. This could be because of differences in the protein and minerals levels within the treatments. Thus, microfiltration offers opportunities for developing spreads with consistency and acceptable quality.

Key Words: Microfiltration, Process Cheese Spread

75   Effect of different stabilizers on the textural and rheological properties of cream cheese. M. Brighenti*[1], S. Govindasamy-Lucey[2], J. J. Jaeggi[2], M. E. Johnson[2], and J. A. Lucey[1], [1]*University of Wisconsin*, *Madison*, [2]*Wisconsin Center for Dairy Research*, *Madison, WI*.

Stabilizers are added during cream cheese manufacture to help prevent syneresis during storage. The objective of this study was to determine the impact of different stabilizers on the texture and rheology of cream

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cheese. Cream cheeses were manufactured with 0.33% of xanthan gum, locust bean gum or guar gum, and a combination (CBN) of these three stabilizers (0.11% of each). The rheological properties of solutions of these gums, under conditions similar to the aqueous phase of cream cheese (0.6% gum, 1.8% NaCl and pH 5.00), were also tested. Dynamic small amplitude rheological properties were measured during heating from 5 to 80°C at 1°C/min and cooling at the same rate and the parameters measured were storage modulus (SM) and loss tangent (LT). Hardness was determined by texture profile analysis (TPA). A trained sensory panel used spectrum descriptive analysis to determine firmness, stickiness, and spreadability. Lower LT values (indicating higher elasticity) were observed in several regions of the heating and cooling curves for the CBN cream cheeses compared to the cream cheeses manufactured with the individual gums. The CBN cream cheeses gave significantly ($P<0.01$) higher hardness values than the cream cheeses manufactured with the individual gums. A similar trend was observed for firmness and spreadability obtained from sensory analyses while stickiness gave the opposite trend. Due to small differences in the moisture contents of the experimental cream cheeses further replicates will be performed. Rheological tests on the CBN solutions also indicated that they had higher SM values than the individual gums. Differences were also observed among the solutions containing individual gums with locust bean gum solutions having the lowest SM followed by guar gum and xanthan. The higher hardness and lower LT values observed for the CBN cheese samples could be due to the synergistic interaction that exists between xanthan and the galactomannans present in guar gum and locust bean gum. This study shows that the stabilizers used in cream cheese manufacture impacted the texture and rheology of cream cheese.

Key Words: Texture, Cream Cheese, Stabilizers

76   Effect of stabilizers on fat agglomeration and melting resistance of ice cream. I. Herlambang*[1], W. J. Harper[1], and B. W. Tharp[2], [1]*The Ohio State University*, *Columbus*, [2]*Tharp's Food Technology*, *Wayne, PA*.

Hydrocolloid stabilizers are commonly used in ice cream to improve smoothness of body, increase melting resistance and maintain stability during storage. Fat network is one essential element in development of ice cream infrastructure. The mechanism in which the stabilizers affect the fat agglomeration is not yet well understood.

The first objective of this study was to examine the particle size distribution and melting properties of ice creams varying in emulsifiers and gums. Eight commercial ice creams were analyzed for particle size and melting properties. Another objective of the study was to understand the effect of carboxymethyl cellulose (CMC) on fat agglomeration during freezing in the presence and absence of an emulsifier. Ice cream mix was formulated to contain 10% milk fat, 10% milk solids-not-fat, 12% sucrose, 6% corn syrup solids, and 0.15% CMC. The formulations also included mixes with and without 0.15% mono-and di-glycerides (MDG). Fat aggregation was indicated by D[4.3] and % particles above 10 μm as measured by a Malvern Mastersizer. Melting rate was defined as the amount of drip loss divided by melting time. The commercial ice cream analysis showed that ice cream with egg yolks (EY) without any stabilizers had no fat aggregates. Particle size distributions varied between ice cream brands. Ice creams with MDG or those with gums in addition to EY showed an increased aggregation. Ice cream without stabilizer, which also had no fat aggregates, melted at the fastest rate. Gums decreased the melting

rate and the melting properties were independent from particle size. Ice cream with only CMC showed the highest amount of fat aggregates and highest resistance to melting. The effect was followed by ice cream made with both CMC and MDG, and only MDG. The amount of fat aggregates was highly correlated to the melting resistance of the ice creams. Ice cream with most melting resistance had greater amount of fat aggregates. The results indicated that stabilizers in ice cream affected fat agglomeration by somewhat modifying the fat structure. These results are useful to better understand the functionality of stabilizers in ice cream.

Key Words: Fat Agglomeration, Stabilizers, Ice Cream

77   Optical measurement of curd shrinkage during cheese manufacturing. C. C. Fagan*[2,1], M Castillo[1], C. P. O'Donnell[2], D. J. O'Callaghan[3], and F A Payne[1], [1]*University of Kentucky*, *Lexington*, [2]*University College Dublin*, *Ireland*, [3]*Moorepark, Teagasc, Cork, Ireland*.

There is currently a drive towards continuous monitoring and automation in the cheese processing industry. Control of the process through real time analysis of critical quality parameters can improve product quality and consistency. Full automation of the manufacturing process is dependent on developing technologies for monitoring critical unit operations such as syneresis. The objective of this study was to determine if the response of an optical sensor detecting light backscatter in a laboratory scale cheese vat was related to physicochemical changes occurring in the curd and whey mixture during syneresis. A three-factor (coagulation temperature, calcium chloride addition level, cutting time), randomized, central composite design comprising 20 runs was carried out in triplicate. A prototype sensor collected scattered light during coagulation and syneresis which was conducted through a fibre optic cable to a miniature spectrometer. Upon cutting the gel, stirring commenced and samples of curd and whey were removed at 10 min intervals up to 85 min after cutting and analyzed for moisture and fat. The sensor output during syneresis at each sampling point was shown to have a significant relationship with curd moisture and whey fat content ($P < 0.001$). The rate of change of the optical sensor response was also significantly ($P < 0.01$) correlated with the kinetic rate constants for changes in curd moisture and whey fat content during syneresis. In conclusion, these results showed that light backscatter measured during syneresis was sensitive to physicochemical changes resulting from curd shrinkage and provided information required for curd moisture content control. This optical technique has the potential to be developed as a unique sensor for monitoring syneresis, providing a key enabling technology for improving process control during cheese manufacture.

Key Words: Light Backscatter, Syneresis, Curd Shrinkage

78   Impact of different curd-washing methods on the insoluble Ca content and rheological properties of Colby cheese. M.-R. Lee*[1], M. E. Johnson[2], S. Govindasamy-Lucey[2], J. Jaeggi[2], and J. A. Lucey[1], [1]*University of Wisconsin*, *Madison*, [2]*Center for Dairy Research*, *Madison, WI*.

A curd-washing step is used in the manufacture of some cheese varieties (e.g. Colby) to decrease the residual lactose content and to reduce the formation of lactic acid during ripening. Curd washing

may also alter the levels of Ca, which may influence cheese rheology. The objective of this study was to investigate the impact of different washing methods on the Ca equilibrium and rheological properties of Colby cheese. Four different methods of curd-washing were performed including batch washing (BW) where water (10°C) was added to the vat, with and without stirring, where curds were in contact with water for 5 min. The other method used was continuous washing (CW), with or without stirring, where curds were rinsed with continuously running water for ~15 min and water was allowed to drain immediately. The rate of acid development during manufacturing was similar in all 4 treatments. The insoluble (INSOL) Ca content of cheese was measured by cheese juice method and rheological properties were measured by small amplitude oscillatory rheology. The levels of lactose in cheese at 1 d were significantly ($P<0.05$) higher in both CW cheeses (0.08%) than in both BW cheeses (0.02%). The levels of lactic acid at 2 and 12 wk were significantly ($P<0.05$) higher in both types of CW cheese compared with both BW cheeses. The INSOL Ca content of all cheeses decreased during the first 4 wk and this occurred concomitantly with an increase in cheese pH from 5.1 to 5.4. The INSOL Ca content of cheese during ripening was significantly ($P<0.01$) affected by washing method but not by stirring. The INSOL Ca content of BW cheeses was significantly higher ($P<0.05$) than that of CW cheeses at all time points during the first mo. At 1 d and 1 wk of ripening the maximum loss tangent values during heating of cheese were significantly higher ($P<0.05$) in CW cheeses compared to BW cheeses. In conclusion, different curd washing methods had a significant impact on the levels of lactose, lactic acid, INSOL Ca and meltability of Colby-type cheese during ripening.

Key Words: INSOL Ca, Curd Washing, Cheese Meltability

79   Preference mapping of commercial strawberry drinkable yogurt among African-American, Caucasian and Hispanic consumers. J. L. Thompson*, K. Lopetcharat, and M. A. Drake, *North Carolina State University*, *Raleigh*.

The drinkable yogurt marketplace is a competitive and growing category in the dairy industry. Drinkable yogurts vary widely in flavor, variety, texture, and other sensory properties. Understanding these sensory differences is critical for understanding the product and ultimately consumer preference. Little is known about differences in preference among Caucasian, African-American, and Hispanic consumers within the United States. The objective of this study was to identify and define the sensory characteristics of commercial drinkable yogurts and identify consumer preferences among Caucasian, African-American, and Hispanic consumers in the United States. Focus groups with each ethnic group (3 groups/ethnicity) were conducted to gain insight into perceptions of drinkable yogurts. A descriptive sensory language was developed to document the sensory properties (visual, flavor, and mouthfeel) of strawberry drinkable yogurts. Thirteen commercial products (strawberry flavor) were evaluated by a trained panel using the sensory language. Five representative yogurts were chosen for consumer testing by African-American (n=83), Caucasian (n=88) and Hispanic (n=88) consumers. Univariate and multivariate analyses were conducted to identify differences in product liking among the consumer groups. Drinkable yogurts were differentiated by descriptive analysis in visual, flavor and mouthfeel attributes (p<0.001). Three distinct clusters of consumers were identified and ethnic membership within the clusters was distinct (p<0.05). Key drivers for all three consumer clusters were natural fruit flavor and sweet taste. The impact of changes in these attributes on liking differentiated two of the three consumer clusters while the third consumer cluster was characterized by these attributes along with other fruit flavors, artificial sweetener, and color intensity as key drivers. Acceptability varied widely among consumers and consumer ethnicities and drinkable yogurts with specific flavor and physical properties could be marketed to specific target market segments.

Key Words: Drinkable Yogurts, Preference Mapping, Sensory Analysis

80   Classification of cheddar cheese based on flavor quality using Fourier transform infrared spectroscopy. A. Subramanian*, J.W. Harper, and L.E. Rodriguez-Saona, *The Ohio State University*, *Columbus*.

Flavor quality of cheddar cheese significantly influences its acceptance and price. Cheese flavor is directly affected by the changes that occur during maturation. Cheese flavor is currently determined using trained sensory panels. This process is time consuming and very expensive. Hence there is a need for rapid and simple instrumental methods. Fourier transform Infrared (FT-IR) spectroscopy, which monitors the light absorbing properties of chemical compounds, combined with an efficient sample preparation method, can be used as a rapid, inexpensive, and sensitive method to analyze cheese flavor. The objective of this research was to develop a sample preparation method and FT-IR technique to rapidly predict flavor quality of cheddar cheese. Fifteen cheddar cheese samples obtained from a local manufacturer were ground into powders using liquid nitrogen. The water-soluble compounds from the cheese powder, without interfering compounds such as fat and protein, were extracted using water and organic solvents. Aliquots (10 µL) of the extract were placed onto a FT-IR sample crystal, dried and scanned in the spectrometer (4000 to 700 cm^{-1}). The spectra were matched with the flavor quality to build multivariate classification models. The developed extraction method yielded extracts, whose FT-IR spectra were highly consistent within each sample and distinct from other samples. The multivariate model showed a 3D plot in which all the 15 cheese samples formed well separated clusters. The orientation of the clusters in 3D space correlated well with the cheese flavor. All the cheese samples could be classified based on their flavor quality attributes (fermented, unclean, low flavor, sour, good cheddar, etc.). The discrimination of the samples was due to organic and fatty acids and their esters (1500 to 900 cm^{-1}), which are known to contribute significantly to cheese flavor. The total analysis time, including the sample preparation time, was less than 20 min per cheese sample. This technique can be a rapid, inexpensive, high-throughput and simple tool to the cheese industry for predicting the flavor quality of cheese.

Key Words: Cheddar Cheese, Flavor, Infrared Spectroscopy