Dairy Foods: Cheese I

T38 Sensory and microbiological properties of cheddar cheese made with different fat content. M. A. Drake[1], C. J. Brighton[2], D. J. McMahon[2], and J. R. Broadbent*[2], [1]*North Carolina State University*, *Raleigh*, [2]*Utah State University*, *Logan*.

Production of high quality lowfat (< 6% fat) Cheddar cheese is a current industry goal in the U.S., but critical information of how fat reduction, and corresponding compositional changes in lowfat cheese such as lower salt-in-moisture content, influences sensory and microbiological properties is lacking. Specific knowledge of how fat reduction influences these properties could lead to identification of methods to enhance or minimize formation of specific flavors. Our objective was to characterize sensory and microbiological differences in Cheddar cheeses containing 32 (full), 16 (reduced), or 5 % (lowfat) fat (wet wt). Cheeses were manufactured in duplicate with a single-strain Lactococcus lactis starter culture and ripened at 8°C. After 2 wks, 3 mo, 6 mo and 9 mo, the cheeses were evaluated by a trained sensory panel using an established flavor language and sampled for starter and nonstarter lactic acid bacteria (NSLAB). Sensory results were evaluated by univariate and multivariate analyses to document the influence of fat reduction and ripening time on flavor. Cheeses with 5 % fat were characterized by a lack of milkfat flavor across ripening. Additionally, these cheeses lacked sulfur and brothy flavor development after 6 and 9 mo ripening compared to reduced and full fat cheeses and were instead distinguished by whey flavor and burnt flavors. Microbiological data also showed some interesting trends. First, starter populations remained stable out to 3 mo in lowfat and reduced fat cheeses before showing any decline, but in full fat cheese generally declined by at least 2 orders of magnitude by 3 mo. Additionally, NSLAB levels in low fat cheese exceeded 10^6 by 6 wks, but populations in reduced or full fat cheese did not attain that level even after 6 mo. These results provide greater insight into the problems, and potential solutions, related to manufacture of high-quality lowfat Cheddar cheese.

Key Words: Lowfat Cheese, Cheese Flavor, Cheese Microbiology

T39 Comparison of Hispanic cheeses from US and country of origin manufacturers. L. A. Jiménez-Maroto*, A. López-Hernández, and S. A. Rankin, *University of Wisconsin*, *Madison*.

US-made Hispanic cheeses are routinely criticized by ethnic consumers for a lack of authenticity when compared to cheeses manufactured in the countries of origin. In order to authenticate and characterize such deficiencies several assessments were conducted including microbial testing, sensory profiles, chemical composition, and functional character. Commercial samples of three different types of Hispanic cheeses (fresh, pasta filata, aged) were acquired from domestic (n=44) and country of origin (n=40) manufacturers. Proximate analysis of the cheeses was conducted using standard methods. A modified melt-flow apparatus was employed to ascertain the melt character. Quantitative descriptive analyses (QDA) of cheese flavor, texture, and appearance were conducted by thirteen trained panelists and the results analyzed using principal component analysis (PCA). None of the samples tested positive for the presence of food pathogens. Cheeses from non-US manufacturers had lower salt, higher pH and moisture, similar lipid and protein content, and often contained many non-traditional ingredients including vegetable oil, caseinates, nonfat dry milk, modified starch, stabilizers, and preservatives. Melt character of pasta filata and fresh cheeses were consistent between US-made and foreign Hispanic cheeses, but aged cheeses varied dramatically in melting character. Cheese color, shape, and packaging varied for all types of cheeses comparing domestic and country of origin manufacturers. The most significant flavor attribute differences between cheeses were salt, bitter, buttery, cowy, milkfat, oxidized, unclean and rancid notes. These results provide some level of understanding of the differences between cheeses made in the US and those made in their countries of origin. Knowledge of these differences will allow manufacturers to improve the perceived authenticity of products in the US market.

Key Words: Hispanic Cheese, Sensory Profile, Melt Character

T40 Evaluation of mineral compositions in reduced-fat and full-fat caprine milks and their Cheddar-type cheeses. W. Nouira*, T. H. Terrill, and Y. W. Park, *Fort Valley State University*, *Fort Valley, GA*.

Reduced fat dairy products have been increasingly popular among consumers. Although characteristics of reduced fat bovine milk products have been studied, mineral compositions of such products have little been reported, especially in caprine milk products. Two lots each of reduced-fat (RF) and full-fat (FF) Cheddar-type caprine cheeses were manufactured to evaluate 20 major and trace mineral compositions. The cheeses were made at the University dairy plant using bulk milk from Saanen, Alpine, and Nubian goat herd. RF cheeses were made using cream separated goat milk by a separator (Model PG-57, Hoegger Suppl. Co., Fayetteville, GA). Minerals of milks and cheeses were quantitated by an Inductively Coupled Plasma Optical Emissions Spectrometer (Thermo Jarrel Ash Enviro 36, Worchester, MA), using argon as the carrier gas and the EPA method 6010. The maximum fat reduction in caprine cheeses was only 21.4%, from 28 % to 22% (FF vs. RF). Mean major mineral contents (ppm, wet basis) of the RF and FF milks were: Ca 1004, 1128; P 834, 945; K 1198, 1102; Mg 114, 132; and Na 456, 509, while mean trace mineral contents (ppm) of the two treated milks were: Fe 0.786, 0.892; Mn 0.038, 0.075; Cu 6.25, 6.24; and Zn 6.94, 7.24, respectively. For the corresponding RF and FF goat cheeses, the mean major mineral (ppm) were: Ca 9242, 8662; P 6011, 5613; K 1300, 1173; Mg 569, 527; Na 3105, 3035, while mean trace mineral (ppm) were: Fe 13.34, 14.45; Mn 0.559, 0.913; Cu 22.03, 24.06; Zn 38.54, 44.22, respectively. There were no differences in major mineral levels between RF and FF cheeses. However, Ca:P ratio of both RF and FF cheeses were greater than those of milks (1.53 vs. 1.20), indicating Ca was retained more than P in cheese compared to the original milk. Cu and Zn contents of milk and cheeses were higher than those of other reports. Mo content of FF cheese was greater than RF cheese, suggesting that fat globule membrane-bound xanthine oxidase was higher in FF than RF cheeses.

Key Words: Reduced-Fat, Goat Milk Cheese, Mineral Composition

T41 The effect of aging on low, reduced, and full fat cheddar cheese on texture. N. R. Rogers*, M. A. Drake, and E. A. Foegeding, *North Carolina State University*, *Raleigh*.

There is a desire to produce low fat cheese with textural and flavor properties similar to full fat cheeses. Towards that end, a systematic study of textural and flavor changes was initiated. This report will address the changes in textural properties. Cheddar cheeses with full (32%) reduced (16%) or low (6%) fat were prepared and aged at 8°C for 9 months at Utah State University. The cheeses were sampled initially at 2 weeks, followed by points at 3, 6, and 9 months. At each time point, cheeses were assessed by a trained texture panel as well as rheological tests that determined fracture properties at three different strain rates, creep/recovery tests, stress sweeps to determine the linear viscoelastic region, and a pressure sensitive tack test using a dental composite probe.

At the initial time point, the low fat cheeses and full fat cheeses were very similar in texture, with the low fat cheeses being slightly more deformable and cohesive ($p<0.05$). As the cheeses aged, the low fat cheeses lost firmness but maintained their springy texture. The full fat samples also had decreased firmness, but unlike the low fat samples, lost their springiness. Chewdown sensory properties, such as smoothness and cohesiveness, increased in all cheeses with aging; however, the changes in these properties were much greater in full fat as compared to low fat cheeses. During storage, the greatest differences across all cheeses were seen in the first 3 months. Changes over 3 to 9 months were in a similar direction but at a slower rate. The rheological tests conducted also showed that the low fat cheeses were more elastic and deformable than the full fat. Also, similar relative magnitudes and rates of changes were seen in the instrumental analysis as in the sensory.

Low fat Cheddar cheese started out with a similar texture to full fat cheeses; however, within the first three months, changes occurred that resulted in distinctively different textures for low fat and full fat cheeses.

Key Words: Lowfat, Cheese, Rheology

T42 Survey of the fatty acid profile including *cis*-9, *trans*-11 conjugated linoleic acid of some Oklahoma cow cheeses. G. Davila El Rassi* and V. Banskalieva, *Oklahoma State University*, *Stillwater*.

Although Oklahoma cheeses (OKCh) are very well accepted by consumers, no information concerning their fatty acid composition (FAC) was available. The objective of this survey was to study the FAC, particularly the content of the beneficial *cis*-9, *trans*-11 conjugated fatty acid (CLA) of OKCh and to compare to some non-OKCh. Fifteen OKCh, Christian: Cheddar Raw Milk and Cheddar Cowboy; Hardesty: Cheddar, Mozzarella and Pepper Jack; Lovera: Caciocavallo; Swan Brothers: Mozzarella Part Skim Milk, Colby Pasteurized Milk, Colby Raw Milk, Sharp Cheddar Pasteurized Milk (SCPM), Sharp Cheddar Raw Milk, Mild Cheddar Pasteurized Milk, Mild Cheddar Raw Milk (MCRM) and Cheddar Hot Pepper Pasteurized Milk; Watonga: Long Horn, and nine non-OKCh: Munster, Baby Swiss, Colby Jack (CJ), Parmigiano Reggiano, Mild Brick, White Cheddar, Sharp Cheddar, Extra Sharp Cheddar and Medium Cheddar were included in this study. The average percentage of saturated (SFA) and monounsaturated fatty acids was not different between non-OKCh and OkCh. In non-OKCh the percentage of cholesterol raising SFA was between 36 and 49%, whereas in OKCh it was between 31 and 42%. The n-6 PUFA/n-3 PUFA ratio varied between 2.1-4.6 and 2.8-5.0, respectively for non-OKCh and OKCh. The proportions of CLA ranged between 0.49 and 0.63% for non-OKCh, whereas in OKCh the proportions of CLA ranged betwee 0.64% (four cheeses) to 0.83 -1.23% (eleven cheeses). The CLA content in the OKCh was between 4.1 and 11mg/g lipid; the lowest - in Hardesty (4.1-4.8 mg/g lipid) and the highest - in SCPM, MCRM and the two Christian (9.6, 10 and 10.7-11, mg/g lipid, respectively). In non-OKCh the average content of CLA was 5.14 (mg/g lipid), with extreme values for Muenster and CJ (0.96 and 8.6 mg/g lipid). Across all studied cheeses, a linear positive relationship between *trans*-11 C18:1 and *cis*-9, *trans*-11 CLA was found. The data obtained show that the FAC and CLA contents of OKCh were in the same range or even better than some of the non-OKCh.

Key Words: Cheese, Fatty Acid, *cis*-9, *trans*-11 CLA

T43 Mapping consumer preferences for mild cheddar cheese. S. L. Drake*[1], P. D. Gerard[2], and M. A. Drake[1], [1]*North Carolina State University*, *Raleigh*, [2]*Clemson University*, *Clemson, SC*.

Cheese consumption in the United States has tripled in the past thirty years with Cheddar cheese accounting for 4.5 kg per capita in 2005. Flavor is an important factor in consumer selection of cheeses. Mild Cheddar cheese is the classification used to describe Cheddar cheese that is not aged extensively and has a “mild” flavor. In contrast Cheddar cheese labeled as “sharp” is expected to have a stronger flavor and may be more aged. However, there is no legal definition or age limit for Cheddar cheese to be labeled mild, medium, or sharp, nor are the flavor profiles or flavor expectations of these cheeses specifically defined. Little research has focused specifically on mild Cheddar cheese flavor, but studies with Cheddar cheeses suggest that a diverse array of flavors and flavor intensities may be preferred by consumers. The objectives of this research were to document the distinct flavor profiles among commercially labeled mild Cheddar cheeses, and to determine if diverse consumer segments existed for these mild Cheddar cheese flavors. Descriptive sensory profiles of a representative array of mild-labeled Cheddar cheeses (n =22) were determined using a trained sensory panel and an established cheese flavor sensory language. Nine representative Cheddar cheeses were selected for consumer testing. Consumers (n = 215) assessed the cheeses for overall liking and other consumer liking attributes. External preference mapping, cluster analysis and discriminant analysis were conducted on the collected data. Mild Cheddar cheeses were diverse in flavor with many displaying flavors typically associated with more age (sulfur, brothy, nutty flavors). Four distinct consumer clusters were identified. The key drivers of liking for mild Cheddar cheese were: color, cooked/milky, whey and brothy flavors and sour taste. An orange color was preferred by three of the four consumer segments. Mild Cheddar cheese acceptance varies among consumers but consumers have distinct preferences for specific flavor profiles and color. These results can help manufacturers understand consumer preferences for mild Cheddar cheese.

Key Words: Cheddar Cheese, Consumer Preferences, Mapping

T44 Manufacture of cheddar cheese with added sodium gluconate. C. Phadungath*[1] and L. E. Metzger[2], [1]*University of Minnesota*, *St Paul*, [2]*South Dakota State University*, *Brookings*.

During the aging process of hard-type cheese especially Cheddar cheese, small white spots that can be seen often without magnification, can appear within and on the surface of cheese between two and six months of aging. The crystals have previously been identified as calcium lactate crystals (CLC). One approach to preventing CLC is to add sodium gluconate to the cheese during salting. Sodium gluconate increases the solubility of calcium and/or lactate in the cheese serum phase. The objective of this study was to determine the manufacture and composition of Cheddar cheeses with different levels of sodium gluconate addition. Six Cheddar cheeses with two levels of salting (2 and 2.5%) and three sodium gluconate addition levels (0, 0.5 and 1%) were manufactured. All cheeses were made using a stirred-curd procedure and replicated three times. Two salting rates were obtained by dividing cheese curd (at pH 5.6) into two equal-weight halves; each half was salted with 2 and 2.5% (by weight of cheese curd) sodium chloride. In order to obtain six treatments, each of the salted halves was separated into three equal-weight batches and mixed with 0 (control), 0.5, and 1.0% sodium gluconate, respectively. After sodium gluconate addition, the curds were hooped, pressed for 16 hour, vacuum-sealed in polyethylene bags, and transferred to a ripening room at 6 to 8°C. After 1 week of storage, compositional analyses (pH, moisture, salt, fat and protein) and gluconic acid concentration were determined. Mean pH, moisture, salt, fat and protein content of the cheeses ranged from 5.06 to 5.32, 36.98 to 38.15%, 1.65 to 2.13%, 30.96 to 32.98%, and 25.6 to 26.1%, respectively. At both salting levels, the pH and moisture contents were significantly ($p<0.5$) increased in the treatments with added sodium gluconate. The concentration of gluconic acid in the low salt treatments was 0.26 and 0.61% for the 0.5 and 1.0% addition level, respectively, whereas the concentration in the high salt levels was 0.32 and 0.51%, respectively.

Key Words: Cheddar Cheese, Calcium Lactate Crystals, Sodium Gluconate

T45 Changes in residual sugar and water-soluble organic acids during ripening of Cheddar cheese with added sodium gluconate. C. Phadungath*[1] and L. E. Metzger[2], [1]*University of Minnesota*, *St Paul*, [2]*South Dakota State University*, *Brookings*.

During Cheddar cheese ripening, lactose is converted to glucose and galactose or galactose-6-phosphate by starter and non-starter lactic acid bacteria. These sugars are primarily converted into lactic acid during the manufacturing process. However, under stressed condition (low pH and high salt) present during cheese ripening, bacteria utilize alternative pathways, which can result in formation of various organic acids. The objective of this study was to determine if the level and type of residual sugar and organic acids produced during ripening was impacted by sodium gluconate addition to Cheddar cheeses. Six cheeses with two salting rates (2 and 2.5%) and three sodium gluconate addition levels (0, 0.5 and 1%) were manufactured. The cheeses were analyzed for residual sugar (lactose) and water-soluble organic acids (acetic, butanoic, citric, formic, gluconic, lactic, orotic, propanoic, and uric) at 1-week, 3-month and 6-month of ripening by using a cation-exchange-column HPLC externally equipped with a refractive index detector . The organic acids were detected using the UV detector set at 210 and 285 nm, and the refractive index was used for quantification of carbohydrates. The results indicated that at 1-week of ripening, Cheddar cheeses with a higher concentration of gluconic acid had significantly lower concentration of lactic acid ($p<0.05$), but significantly higher concentration of lactose ($p<0.05$), while there was no differences ($p>0.05$) in acetic, butanoic, citric, formic, orotic, propanoic and uric acids among treatments at all ripening times. The concentrations of butanoic and propanoic acids gradually increased over time ($p<0.05$) in all treatments, whereas the concentrations of orotic acid and lactose gradually decreased over time ($p<0.05$). Minor changes in the levels of acetic, citric, formic, lactic, and uric were also observed throughout ripening in all treatments.

Key Words: Cheddar Cheese, Organic Acids, Cheese Ripening

T46 Flavor chemistry of cheddar cheeses with varying fat contents. R. E. Miracle*[1], D. J. McMahon[2], and M. A. Drake[1], [1]*North Carolina State University*, *Raleigh*, [2]*Utah State University*, *Logan*.

A current industry goal is to produce a 75 to 80 % fat reduced Cheddar cheese that is tasty and appealing to consumers. Despite previous studies on reduced fat cheese, information is critically lacking in understanding the flavor chemistry of reduced and low fat Cheddar cheeses and how it differs from its full fat counterpart. Specific knowledge of the nature of these differences could lead to identification of methods to enhance or minimize formation of specific key flavor compounds. The objective of this study was to characterize volatile compound changes with fat reduction in Cheddar cheeses. Cheddar cheeses with 5, 16, or 32% fat (wet weight) were manufactured in triplicate with a single strain starter culture and ripened for 2 weeks, 3 mo, 6 mo and 9 mo. At each timepoint, volatile components were extracted by solid phase microextraction (SPME) and by solvent assisted flavor evaporation (SAFE) followed by gas chromatography mass spectrometry (GC-MS) for compound identification. Gas chromatography-olfactometry (GC-O) with aroma extract dilution analysis (AEDA) was also applied to identify aroma-active volatile components. More than 45 aroma-active compounds were characterized in the cheeses by GC-O. Free fatty acids (butyric, hexanoic, nonanoic, and decanoic), furaneol, sotolon and saturated hydrocarbons were present at higher concentrations in low fat cheeses compared to full fat Cheddar cheeses while lactones (gamma nonalactone, gamma decalactone, delta decalactone) were predominant in full fat cheeses. The volatile components of low fat Cheddar cheeses were distinct from full fat cheeses.

Key Words: Cheese Flavor, Flavor Chemistry, Low Fat

T47 Development of cholesterol-reduced block type process cheese made by crosslinked β-cyclodextrin. S. Y. Kim, E. K. Hong, and H. S. Kwak*, *Sejong University*, *Seoul, Korea*.

The present study was carried out to examine the physicochemical and sensory properties in cholesterol-reduced block type process cheese made by crosslinked β-cyclodextrin (β-CD). For process cheese manufacture, 82% of aged Cheddar cheese, 10% butter, 3% emulsifying salts, 5% skim milk powder and 10% water were added in the cooker. The raw materials were heated at 85°C with a rotary agitation of 500 rpm for 3 min. The composition of process cheese treated by crosslinked β-CD was similar to the control and cholesterol removal reached 91.0%. No significant difference was found in total short-chain free fatty acids between groups. All color values were significantly lower in cholesterol-reduced process cheese than those in the control. All rheological properties except brittleness in the cholesterol-reduced process cheese were not significantly different from those in the control. Most of sensory properties were similar between cholesterol-reduced and the control cheeses. In the cholesterol-reduced process cheese, yellowness was significantly lower, while crumbly texture was significantly higher compared with the control. The overall acceptability score of cholesterol-reduced cheese was significantly higher than that of the control. Based on these results, no profound difference was found in most physicochemical and sensory properties between cholesterol-reduced block type process cheese and the control. Therefore, this study may suggest the possibility to develop the cholesterol-reduced block type process cheese using crosslinked β-CD.

Key Words: Block Type Process Cheese, Crosslinked β-cyclodextrin, Cholesterol Removal

T48 Physicochemical and rheological characterization of cream cheese made from freeze-dried milk powder. S. H. Kim, S. Lee, and H. S. Kwak*, *Sejong University, Seoul, Korea*.

Cream cheese was produced from freeze-dried milk powder milk (FDMP) through a continuous multi-stage process and its physicochemical and rheological properties were characterized. The composition of the FDMP cream cheese was 56.03% moisture, 33.12% fat, and 7.97% protein which was comparable to that of the commercial cream cheese made from raw milk. A slight increase in specific gravity was observed in the FDMP cream cheese while there was no significant difference in color between the samples made from FDMP and raw milk. Furthermore, the viscoelastic properties of FDMP cream cheese were investigated by using dynamic shear measurements. When a strain sweep test was preformed at a fixed frequency of 1Hz, the cream cheese sample exhibited the linear viscoelasticity within a strain of 0.005%. In a frequency sweep test, both storage (elastic) and loss (viscous) moduli increased with increasing frequency, showing weak gel-like behaviors. Also, the viscoelastic properties of FDMP cream cheese exhibited temperature-dependence. Even, the storage moduli measured at 5°C were almost an order of magnitude higher that those at 25°C. Thus, the results indicated that the FDMP cream cheese had similar composition and physicochemical properties to the cream cheese made from raw milk. In addition, it was shown to rheologically behave like a weak-gel.

Key Words: Cream Cheese, Freeze-Dried Powder Milk, Rheology

T49 Effects of manufacturing parameters on the chemical, functional, and rheological properties of Queso Chihuahua. D. L. Van Hekken*, M. H. Tunick, R. Kwoczak, J. J. Shieh, and P. M. Tomasula, *USDA-ARS, ERRC, Wyndmoor, PA*.

The quality variations noted among Queso Chihuahua, a semi-hard cheese made in northern Mexico traditionally from raw milk, are due to the diverse manufacturing conditions used to make the cheese, the compositional and microbiological differences in the cheesemilk, and heat treatment (raw versus pasteurized). In this study, we examined the effects of manufacturing parameters on the chemical, functional, and rheological properties of Queso Chihuahua made with pasteurized milk in order to identify the processing steps that result in cheese with properties similar to that of the traditionally made raw milk cheese. Based on the results of our earlier survey of manufacturing protocols and quality traits of Queso Chihuahua made in Mexico, we manufactured 36 2-kg blocks of cheeses using different cooking temperatures (32, 38, or 44°C), pH at the time of drain (6.0 or 6.3), and overnight pressing pressures (0.96 or 1.9 kPa). Temperature during the cooking step and pressure used in overnight pressing significantly influenced the moisture, protein, salt, and ash content of the cheese as well as the hardness, chewiness, and shear stress, strain and rigidity at the point of fracture. Pressing pressure affected lactose content of the cheese and its viscoelastic properties while cooking temperature impacted the pH of the final cheese. All cheeses had excellent melt properties. Queso Chihuahua cheeses made with pasteurized milk and cooked at 38°C, drained of whey at either pH 6.3 or 6.0, and pressed overnight at 1.9 kPa, were the closest in compositional, functional, and rheological properties to the raw-milk cheeses. This study demonstrates that through careful selection of manufacturing conditions cheese makers will be able to develop pasteurized versions of Queso Chihuahua that mimic the traditionally-made cheeses.

Key Words: Cheese, Queso, Manufacture

T50 Characterization of organic acid and carbohydrate profiles of commercial Swiss cheese samples. H. Zhang* and L. E. Metzger, *South Dakota State University, Brookings*.

The objective of this study was to characterize the profiles of organic acids and carbohydrates in Swiss cheese. Ten commercial Swiss cheese samples from five companies were collected from local grocery stores (Brookings, SD). Cheese samples were extracted with 0.013N H_2SO_4 at 65°C using a high-shear mixer-homogenizer. A high performance liquid chromatograph method with a photodiode array detector set at 210 and 285nm and refractive index detection was employed to simultaneously analyze short-chain, water soluble organic acids and carbohydrates in the cheese samples. Rezex ROA-organic acid H^+ column (300 × 7mm, 8 μm, Phenomenex) was used for the separation and isocratic elution was achieved using a mobile phase of 0.013N H_2SO_4 aqueous solution at a flow rate of 0.6 mL per minute. Lactic, acetic, propanoic, butanoic, citric, pyruvic, succinic acid, isovaleric (3-methylbutanoic) acid, and glycerin were detected in all ten Swiss cheese samples. However, their concentrations (g/100g cheese) were varied; the respective ranges for the compounds mentioned above were 0.0506-0.1479, 0.0272-0.1877, 0.0160-1.4185, 0.1804-0.3208, 0.4848-1.5903, 0.0553-0.1476, 0.0259-0.1072, 0.1394-0.5071, and 0.3694-0.8980. Galactose was detected in nine of the ten samples, and samples that had a higher concentration of galactose also had a higher concentration of pyruvic acid. Lactose was detected in five samples and the concentrations ranged from 0.0304 to 0.0958. Formic acid and 2-methylbutanoic acid were only detected in three samples and their concentrations ranged from 0.1065 to 0.1669 and from 0.1095 to 0.1445 respectively. These results and the well-documented organoleptic diversity of Swiss cheese warranty further investigation to determine the association between flavor attributes and organic acid and carbohydrate profiles as well as their relationship to consumer preferences of Swiss cheese.

Key Words: Swiss Cheese, Organic Acids, HPLC

T51 Surface roughness affects the formation of calcium lactate crystals on Cheddar cheese. P. Rajbhandari*, C. Ogg, and P. S. Kindstedt, *University of Vermont, Burlington*.

Calcium lactate crystals that sometimes form on Cheddar cheese surfaces are a significant expense to manufacturers. Previous researchers have identified several ost-manufacture 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. Four 25 mm-thick cross-section specimens were cut perpendicular to the long axis of a retail block (ca. 300 g) of smoked Cheddar cheese using a wire cutting device. One cut surface of each specimen was lightly scored with a cheese grater to create a rough, grooved surface; the opposite cut surface was left undisturbed (smooth). The four specimens were vacuum packaged at 10, 100, 500, 900 mbar (extremely tight to extremely loose, respectively) and stored at 1°C. Digital images were taken 1, 4 and 8wk following the first appearance of crystals. 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 two-way interactions significantly affected crystal area and DCR number. Extremely heavy crystallization occurred on both rough and smooth surfaces when packaged loosely (500 and 900 mbar), and on rough surfaces with slightly loose packaging (100 mbar). In contrast, the combination of rough surface plus very tight packaging (10 mbar) resulted in dramatic decrease in crystal area and DCR number. The combination of smooth surface plus very tight packaging virtually eliminated crystal formation by eliminating available sites for nucleation. The data suggest that the cut-and-wrap step in commercial Cheddar cheese production is a critical control point for crystal formation.

T52 Influence of native casein concentrates on process cheese texture. P. Salunke* and L. E. Metzger, *South Dakota State University*, *Brookings*.

Milk Protein Concentrate (MPC) produced with an ultrafiltration based process is commonly used in process cheese product formulations. However, the use of MPC can result in various texture defects including a soft body and restricted melting characteristics. These texture defects are believed to be related to the substantial amount of the whey proteins present in MPC. Recently, Native Casein Concentrate (NCC) produced in a microfiltration based process has been developed. NCC is similar to MPC except a portion of the whey protein is removed. The objective of the current study was to determine the impact of NCC on the texture of process cheese. Three replicates of process cheese product formulations were produced from three different batches of NCC and MPC. Each formulation was standardized to 25.0 % fat, 1.89% salt, 44.0% moisture and 17.0% protein. In each formulation the MPC or NCC utilized contributed 10.5% protein. Other ingredients in the formulation included water, butter, cheddar cheese, deproteinised whey, salt, lactic acid, disodium phosphate and sodium citrate. Each formulation was manufactured in Rapid Visco Analyzer (RVA). In the RVA the blend of ingredients was mixed at 1000 rpm and heated to 95°C in two minutes. Subsequently the cheese was mixed at 160 rpm for a minute. The cheese was then transferred to electroplated copper molds and cooled overnight at 4°C. After cooling five samples of each formulation were evaluated using Texture Profile Analysis (TPA) at 25°C. The hardness, springiness, gumminess and chewiness of the process cheese product were significantly increased with the NCC formulation. The mean value of the three NCC replicates was 5002g, 0.124, 728g, 92g.sec whereas the mean values for the MPC replicates was 3319g, 0.085, 488g, 42g.sec respectively for hardness, springiness, gumminess, chewiness. The results demonstrate that the texture of process cheese products can be modified with the use of NCC.

Key Words: Process Cheese, Native Casein Concentrate, Rheology

T53 The effect of culture combinations on swiss cheese flavor quality. N. A. Kocaoglu-Vurma*[1], A. Eliardi[1], M. A. Drake[2], L. E. Rodriguez-Saona[1], and W. J. Harper[1], [1]*The Ohio State University*, *Columbus*, [2]*North Carolina State University*, *Raleigh*.

Propionibacterium freudenrechii is mainly responsible for eye formation and also is a major contributor to the flavor of Swiss cheese. *Lactobacillus helveticus*, in turn, influence the growth and fermentation products of Propionibacteria. A better understanding of the effect of such interactions between different strains of the starter cultures on commercial product quality is useful for industrial culture selection. The objective of this study was to evaluate the effect of culture combinations on the quality of Swiss cheese manufactured under commercial conditions.

Cheeses were produced by four commercial Swiss cheese manufacturers using two different culture combinations. Cultures consisted of the same *P. freundenreichii* and *Streptococcus thermophilus* strains, but varied in the type of *Lactobacillus helveticus* strain (LSA and LSB). Cheese samples were evaluated right out of warm room, at 4 months, and 7 months after the manufacture for bacterial counts, and mid-infrared (MIR; 4000-700 cm^{-1}) spectroscopy. The cheeses were also profiled by a trained sensory panel at 7 months after manufacture. At the end of warm room, there were no differences in Propionibacteria, and *S. thermophilus* counts, however total *Lactobacillus* counts were approximately 1 log CFU/g lower in cheeses manufactured with *L. helveticus* LSA. The infrared analysis allowed classification of samples by manufacturer, and culture combinations. The wavenumber 1122 cm^{-1}, corresponding to S-O vibration modes, was shown to give the highest discrimination when samples were classified by manufacturer. For cheeses produced by a single company, the wavenumbers 1330-1377 cm^{-1} contributed highest to the discrimination of cheese samples by culture combination. The sensory descriptors, vinegar, dried fruit, and cabbage received higher scores when *L. helveticus* LSA was used. The attributes fresh fruit, butyric, and metallic were not detected in any of the samples. The study of culture interactions under commercial manufacturing conditions provides a basis for the selection of starter strains for industrial applications, as the product quality is determined by both the starter cultures and manufacturing conditions.

Key Words: Swiss Cheese, Spectroscopy

T54 Iodine content in sheep and goat cheese produced in Sardinia (Italy). G. Pulina*[1,3], F. Aghini-Lombardi[2], M. Frigeri[2], G. Battacone[1], R. Rubattu[1], G. Garzella[2], L. Grasso[2], and A. Nudda[1], [1]*University of Sassari*, *Sassari, Italy*, [2]*University of Pisa*, *Pisa, Italy*, [3]*AGRIS Sardegna, Olmedo Loc. Bonassai*, *Sassari, Italy*.

Iodine deficiency disorders have been described in several surveys conducted in European countries. Dairy products could be a valuable source to increase iodine intake in human diet. The aim of this study was to evaluate the iodine content in sheep and goat cheese produced in the Sardinia region (Italy). Cheese samples (n. 23 and n. 49 from sheep and goat milk, respectively) from 9 dairies located in different areas of Sardinia were collected at different months of production (from December to July). Iodine concentration of cheese was determined, after alkaline mineralization, using the Sandell-Kolthoff reaction.

The iodine concentration averaged 23.02 μg/100 g (ranging from 8.03 to 52.84 μg/100 g) in sheep cheese and 21.71 μg/100 g (ranging from 10.57 to 73.95 μg/100 g) in goat cheese. The iodine content did not differ between sheep and goat cheese ($P = 0.73$).

The iodine concentration was significantly influenced by season. In both species the highest iodine concentration was found in cheese produced during winter months (26.33 and 38.90 μg/100 g in sheep and goats, respectively) compared to spring months (21.13 and 14.23 μg/100 g in sheep and goats, respectively) and summer months (20.61 and 17.42 μg/100 g in sheep and goats, respectively). A significant effect of the different dairies on iodine concentration has been observed ($P<0.01$).

In conclusion, these preliminary results suggest that the iodine concentration in cheese from sheep and goats milk: a) did not differ between the two species; b) varied markedly with season, being higher in winter; and c) was too poor to provide an adequate iodine intake, even if dairy

products are second only to fish as suppliers of iodine in human diet.
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Key Words: Iodine, Cheese, Sheep and Goat

T55 Three-dimensional microscopy using stereoscopy applied to scanning electron microscopy imagery. M. Caccamo*[1], G. Impoco[2], L. Tuminello[1], and G. Licitra[1,3], [1]*CoRFiLaC, Regione Siciliana*, *Ragusa, Italy*, [2]*IPLAB, Catania University*, *Catania, Italy*, [3]*D.A.C.P.A., Catania University*, *Catania, Italy*.

Scanning electron microscopy (SEM) is a powerful tool to study cheese microstructure. Although providing high resolution digital scanning, SEM flattens the 3D scanned surface and therefore does not allow direct in-depth measurements. Stereoscopy mimics the features of the human visual system by reconstructing 3D information from 2D images. Recovering depth is based on the parallax between corresponding points in different images. These algorithms and the underlying equations have been tailored to optical cameras, but are also valid for SEM imagery, the SEM image formation being approximately the same as that of a thin lens. Two kinds of cheese texture, pressed and pasta filata, were analyzed using stereoscopy. Several SEM images of each sample were taken with a small displacement (0.03mm vertically, 0.04mm horizontally) at 1000× magnification. Scans were automatically aligned, such that the structures in small overlapping areas matched between different images. 3D models of the scanned surface were generated using a software that mimics human binocular vision. Results were not satisfactory mostly due to sensor noise and to the lack of well-recognizable objects in the scene. Two experiments were designed to improve the quality of the 3D models: i) displacement with respect to the specimen plane, and ii) tilting of the specimen mount. In the first experiment, the specimen mount was displaced and a series of overlapping images was acquired. We used small displacements to correlate corresponding images and large displacements for 3D reconstruction to enlarge the parallax effect. This choice improved the output 3D models. Displacement values given by the SEM device and needed for reconstruction were not accurate enough. Values were corrected via software to obtain robust metric measurements. The second experiment employed only tilting of the specimen mount. A small angle was preferred to avoid losing track of the surface features. Both methods yielded better results than arbitrary specimen orientation. Reconstructed 3D surfaces showed the possibility to perform direct metric measurements of the surface of the specimen.

Key Words: Electron Microscopy, Microstructure, Stereoscopy

T56 Prediction of curd moisture content by near infrared light scattering over a range of stirring speed and cutting intensity during cheese-making. M. J. Mateo*[1], D. J. O'Callaghan[1], C. D. Everard[1], C. P. O'Donnell[2], C. C. Fagan[2], M. Castillo[3], and F. A. Payne[3], [1]*Moorepark Food Research Centre, Teagasc*, *Fermoy, Cork Ireland*, [2]*University College of Dublin*, *Dublin, Ireland*, [3]*University of Kentucky*, *Lexington*.

Every cheese has a specification regarding its optimum content of moisture which relates to the final quality of cheese. This crucial parameter determines the shelf-life of the cheese. If the moisture content is higher than the standard the cheese will be more perishable and will be less acceptable to the consumer. On the other hand, cheeses having less moisture than the standard are more costly to produce. An online fiber-optic light backscatter sensor is being investigated for better control of curd moisture content. The aim of this study was to evaluate light backscatter at 980 nm during syneresis to improve the prediction of curd moisture content under the influence of two experimental variables namely stirring speed and cutting intensity.
The experiment was performed using three stirring speeds (10, 16 and 22 rpm) and three gel cutting intensities (4.2, 8.3 and 12.5 total revolutions), with three replicates (n = 27). The trials were carried out using recombined whole milk in an 11 L double-O cheese vat, in which the light backscatter sensor was installed. The milk was coagulated under constant conditions at pH 6.5 and 32°C. Samples for determining curd moisture content were taken from the cheese vat at 10 min intervals up to t = 75 min.
A linear model was developed for predicting Mc with five significant ($P < 0.001$) distinct terms, i.e. light backscatter ratio, time after cutting, stirring speed, milk fat content and cutting intensity (SEy = 1.10 g/100g, $R^2 = 0.83$).
These results showed the potential of the light backscatter syneresis sensor technology to predict curd moisture content changes during syneresis in the cheese vat under a wide range of stirring speeds and cutting intensities, but in-plant calibration would be required to take account of technological factors.

Key Words: Curd Moisture Content, Light Scattering, Prediction

T57 Effect of various starches on the properties of a processed Swiss-type cheese product. M. C. M. Soledad* and W. J. Harper, *The Ohio State University*, *Columbus*.

The study explores the possibility of using starch as an ingredient in processed cheese products. Starches are versatile food ingredients which open opportunities for cost and fat reduction, and, control of textural and melting properties. The study aimed to evaluate the effect of various starches on the properties of a processed Swiss-type cheese product and differentiate them based on flavor profile. A Stephan UMC5 processed cheese maker was used to prepare the samples composed of natural Swiss cheese, water, starch, disodium phosphate, lactic acid, and trisodium citrate. Eight starches were compared with a control (without starch), consisting of four native starches, namely: waxy corn, potato, tapioca, and wheat; and, four modified starches, namely: acid-modified dent corn, instant waxy corn, blend of hydroxypropylated and oxidized potato, and thin-boiling potato. Samples were evaluated for texture (texture profile analysis, TPA) and melting behavior (modified Schreiber test). TPA results suggest that starch addition may significantly increase hardness and chewiness. The control had an average hardness value of 385g whereas, 800-2200g for those made with various starches. The average chewiness value of the control was 187 whereas, 440-1400 for those made with various starches. Modified Schreiber test results suggest that starch addition may significantly reduce the spread during melting. The average increase in cheese disc circumference of the control was 122mm whereas those made with the various starches were in the range of 50-100mm. Fourier transform infrared spectrometry coupled with multivariate analysis was used to differentiate the samples based on water-soluble flavor compound profile which provided information on possible differences in ingredient interaction based on the starch used. This study may contribute to the formulation of processed cheese products and elucidate the effect of varying the type of starch on its properties.

Key Words: Starch, Processed Cheese, Texture

T58 Influence of comminuting curd on curd particle size, moisture content and cohesiveness of 50%-reduced fat cheddar cheese.
D. J. McMahon* and C. Brothersen, *Utah State University*, *Logan*.

Comminuting cheese curd can be used as a tool for incorporating value-added ingredients into cheese without adversely affecting the whey generated during cheesemaking. Such a reduction in curd particle size does, however, change the physical properties of the cheese and expulsion of whey during pressing. We investigated the influence of comminuting reduced fat cheddar cheese curd on particle size, moisture retention during pressing, and cohesiveness of the resultant cheese. A 50%-reduced fat cheddar cheese was made using a stirred curd method and after salting, 30-lb batches of curd were comminuted in a bowl chopper for 15, 30 or 45 s. Samples of comminuted curd were mixed with an anti-caking agent and passed through a sieve stack with openings from 12.5 to 1 mm. Other portions of the curd were placed in round plastic hoops and pressed at either 35 or 70 kPa for 2, 4, 8 or 20 h. Cheeses were then vacuumed packaged and stored at 6°C and texture profile analysis performed at 1, 3, 6, 10, 15, 30 and 60 d. Non-comminuted curd had a broad size distribution of 1 to 9.5 mm with most of the curd particles being collected on the 2, 4 and 6.3 mm mesh sieves. Chopping for 15 s reduced the particle size to 1 to 4 mm (most of curd being collected on the 2 mm mesh sieve). Further chopping reduced particle size to 1 to 2 mm. Whey expulsion during pressing was retarded in comminuted cheese curd and after 20 h the experimental cheeses contained more moisture (49.1%) than the control cheese (47.4%). After pressing (d 1) the control cheese had 49% cohesiveness while cheeses made from comminuted curd had only 30% cohesiveness. During storage, cohesiveness increased for all cheeses; to 68% by d 15 for the control cheese, while the experimental cheeses initially decreased through d 5 before increasing to 41 to 50% by d 30. Thus, comminuted curd particle knitting is delayed during the initial storage period, but increases proportionally during storage. This may be an advantage in reduced fat cheeses that have a tendency to be more rubbery than full fat cheeses.

Key Words: Cheese, Curd Size, Cohesiveness

T59 Preparation of low fat fresh panela type cheese with ω-3 fatty acid.
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Fresh panela cheese is a product with a high consumption in Mexico, thus it is desirable to improve its nutritional value. In addition, the ω-3 fatty acids have demonstrated benefits to the human health. The docosahexaenoic acid (DHA) is a component of the ω-3 fatty acids and it is important during the fetal development, childhood, and the adult age. However, this component is limited in some foods. Therefore, the objective of this work was to produce a fresh low fat cheese added with DHA and to evaluate its physical-chemical, microbiological and sensory properties.
Panela was elaborated with fat milk concentrations of 1.5 and 2.5 % and 30, 45, and 60 mg/30 g Martek DHA™, respectively. For each treatment, a control cheese was used. Moisture, ash, protein, and fat contents were evaluated. The retention level of DHA was measured by means of gas chromatography. A microbiological test was conducted in order to monitor for the presence of *Salmonella*, *Staphylococcus aureus*, and total coliforms. Additionally, a triangular test with a trained panel was established for the sensory analysis.
Results showed that the addition of DHA did not affect significantly the physical-chemical composition of the cheese when compared with the control product ($P<0.05$). A retention level of DHA of 3.4165 to 5.4706 mg/g fat was obtained for all the treatments. However, the product elaborated with 1.5% fat milk and the addition of 45 mg of DHA gave an average retention of 5.4706 mg/g fat, thus this treatment was judged as the best option for the enrichment process. The microbiological analysis according to the NOM-121-SSA1-1994 satisfied the sanitary quality. The sensory evaluation demonstrated that cheese with added DHA did not produce odd flavors.
This research demonstrated that there is an alternative to consume a cheese with a high nutritive value and a methodological base for developing new products.

Key Words: Cheese, ω-3 Fatty Acid, Low Fat