Dairy Foods: Forum on Cheese Ripening

156 Combined abstract for forum on cheese ripening symposium presentations. W. J. Harper*[1], M. Johnson[2], J. Broadbent[3], J. Lucey[2], and M. Drake[4], [1]*The Ohio State University*, *Columbus*, [2]*University of Wisconsin*, *Madison,*, [3]*Utah State University*, *Logan,*, [4]*North Carolina State University*, *Raleigh*.

Organizer: Jim Harper, The Ohio State University, Columbus

This symposium is a forum to provide a broader discussion on this specific topic of interest-Cheese Ripening. The five participants will be discussion facilitators. This format will allow greater audience participation than normally occurs in the traditional symposium format.

Discussion facilitators and the various topics are:

a. Jim Harper, The Ohio State University, Columbus-Cheese Ripening -A Historical Perspective

b. Mark Johnson, University of Wisconsin, Madison-Milk and the Cheese Maker

c. Jeff Broadbent, Utah State University, Logan -Microbiology and Biochemistry

d. John Lucey, University of Wisconsin, Madison-Chemistry and Physical Properties

e. MaryAnne Drake, North Carolina State University, Raleigh-Flavor

f. Open Discussion with Audience Participation for the remainder of the time

Key Words: Cheese Ripening, Milk and Cheese Making, Changes during Ripening

Graduate Student Competition: National ADSA Dairy Foods

157 Identification of genes associated with *Mycobacterium avium* subsp. *paratuberculosis* entry into cultured bovine epithelial cells. D. Patel*, L. Meunier-Goddik, and L. E. Bermudez, *Oregon State University*, *Corvallis*.

Mycobacterium avium subsp. *paratuberculosis* (MAP) is the etiologic agent of Johne's disease (JD) in ruminants. The intestinal tract is believed to be an important route of MAP infection, but MAP genes with role in the invasion of intestinal epithelial cells are mostly unknown. The objective of this investigation was to create and screen the signature-tagged mutagenesis (STM) based MAP transposon library for invasion-associated genes. A mixed tag plasmid pYJ that contains transposon Tn *5367* and a kanamycin-resistance gene as a selectable marker was used for STM library. From 33 signature-tagged clones, a library of total 1980 mutants was constructed. Invasion assays were carried out for individual clones and efficiency of invasion was calculated as percentage of inoculated bacteria that entered MDBK cells after 2 h contact time compared with the wild type bacteria screened under the same conditions. Screening of 600 mutants identified clones 2C12, 2δ5, 2δ6 and 2D1 with impaired ability to enter MDBK epithelial cells ($p < 0.01$). The genes flanking transposon insertion site were identified by nucleotide sequence analysis using transposon primers. The gene sequence analysis based on BLAST program of National Center for Biotechnology resulted in the identification of mycobacterial cell entry (*mce1*D) operon, oxidoreductase operon, NADH-ubiquinone-oxidoreductase (*nuo*L), and a potassium transporter (*trk*A) as invasion-associated genes for MAP entry into MDBK epithelial cells. The cross genome comparison of identified genes suggests that role of *mce1*D in invasion may be due to its direct participation in epithelial cell entry. The role of *nuo*L and *trk*A in invasion may be through sensor response resulting in upregulation of invasion-associated genes. The role of oxidoreductase may be through catalytic protein folding influencing secretion of virulence factors. The identification of invasion-associated genes will be useful for characterizing bacterial factors associated with the MAP infection of bovine host.

Key Words: Invasion-Associated Genes, Johne's Disease, *Mycobacterium avium* Subsp. *paratuberculosis*

158 Flavor profiles of full fat, reduced fat and cheese fat made from aged Cheddar with the fat removed using a novel process. M. Carunchia Whetstine*[1], M. Drake[1], B. Nelson[2], and D. Barbano[2], [1]*North Carolina State University*, *Raleigh*, [2]*Cornell University*, *Ithaca, NY*.

Many consumers are concerned with fat intake. However, reduced fat cheeses may lack robust flavors. The objectives of this study were to characterize the flavors found in full fat cheese, cheese fat and reduced fat cheese made from aged Cheddar using a novel process to remove the fat (JDS 87:841). Two aged cheeses (12 months and 42 months) were selected, and the fat was removed using the novel fat removal process. Full fat cheeses, corresponding reduced fat cheeses and cheese fats were then analyzed using descriptive sensory and instrumental analysis. Cheeses were extracted with diethyl ether, followed by isolation of volatile material by high vacuum distillation. Volatile extracts were analyzed using gas chromatography-olfactometry (GCO) with aroma extract dilution analysis (AEDA). Selected compounds were quantified. The 12 month cheese was characterized by fruity and sulfur notes, while the 42 month old cheese was characterized by a spicy brothy flavor. Reduced fat cheeses had very similar flavor profiles to corresponding full fat cheeses. Sensory profiles of the cheese fats were characterized by low intensities of the prominent flavors found in the full fat cheeses. Instrumental analysis revealed similar trends. Consistent with sensory analysis, there were lower concentrations and log3FD factors for most compounds in the cheese fats compared to both the reduced and full fat cheeses, regardless of compound polarity. This study demonstrates that when fat is removed from aged Cheddar cheese, most of the flavor and flavor compounds remain in the cheese and are not removed with the fat.

Key Words: Reduced Fat Cheese, GC/O, Flavor Partitioning

159 Development and application of an image analysis method to quantify calcium lactate crystals on cheddar cheese. P. Rajbhandari* and P. Kindstedt, *University of Vermont*, *Burlington*.

Calcium lactate crystals that form white specks or haze on

the surface of cheese constitute a significant quality problem for producers of Cheddar cheese. Subjective methods to evaluate crystal coverage of cheese surfaces have been reported previously, but objective methods are currently lacking. The goals of this research were to develop and evaluate an objective method to measure the area occupied by calcium lactate crystals on surfaces of naturally smoked Cheddar cheese samples using digital photography and image analysis. Coefficients of variation ranged from 1.19 to 4.7% for 5 replicate analyses of 3 different cheese surfaces that ranged from ca. 2 to 49% of total surface area occupied by crystals. Thus, results showed a high degree of repeatability for the 3 cheese surfaces, which ranged from very slight and geometrically simple to very heavy and geometrically complex crystal coverage.The method underestimated total area occupied by crystals on the 3 surfaces by 0.3 to 4.8% unless the faint crystal regions that went undetected during initial thresholding were manually segmented and quantified. The wet weight of crystal substance collected per unit of surface area from 20 different cheese samples increased exponentially as the percentage of total surface area occupied by crystals increased. These data were consistent with subjective observations that crystal regions appeared to grow vertically as well as horizontally as they expanded to occupy greater surface area. Image analysis was well suited for evaluating

changes in crystal coverage during cheese aging because measurements were made nondestructively and with minimal disruption to the cheese. The area occupied by crystals on 6 different surfaces from 3 different cheese samples increased linearly (R^2 = .94 to .99) during storage at 4° C for up to 33 wk. However, the rates of increase differed significantly among the 3 cheese samples. Image analysis may serve as a useful tool to quantitatively evaluate the effects of factors such as cheese composition, packaging conditions, storage temperature, etc. on rate of crystal growth and time of crystal appearance during storage.

Key Words: Cheese, Calcium Lactate, Crystals

160 Effect of formulation and manufacturing parameters on process cheese food functionality- I. tri-sodium citrate. S. K. Garimella Purna*, A. Pollard, and L. E. Metzger, *University of Minnesota*, *St. Paul*.

The objective of this study was to utilize a rapid visco

analyzer (RVA) to study the effect of natural cheese age, tri-sodium citrate (TSC) concentration and mixing speed on

process cheese food (PCF) functionality. In this study three replicates of natural cheese were manufactured, and at 2, 4, 6, 12 and 18 weeks of ripening a portion of each cheese was subjected to six different PCF manufacturing treatments. These treatments were factorial combinations of TSC at three levels (i.e. 2.0, 2.5 and 3.0%) and two mixing speeds (450 rpm and 1050 rpm). Functional properties of PCF evaluated included manufacturing properties (apparent viscosity after manufacture (VAM)); un-melted textural properties (firmness); melted cheese flow properties (hot apparent viscosity (HAV)); and cheese thickening during cooling (time at 5000cP (T5)). All four parameters (VAM, firmness, HAV and T5) were significantly ($p < 0.05$) affected by natural cheese age and mixing speed. The VAM, HAV and firmness decreased as cheese age increased, whereas T5 values increased as cheese age increased. Similarly VAM, HAV and firmness values increased due to an increase in mixing speed, whereas T5 values decreased due to increased mixing speed. The VAM, HAV and T5 also significantly ($p < 0.05$) increased as the concentration of TSC increased, whereas firmness was not significantly ($p > 0.05$) affected by concentration of TSC. The age and mixing rate interaction was significant ($p < 0.05$) for VAM and firmness, whereas the age and concentration of TSC interaction was significant ($p < 0.05$) for VAM and HAV. It was also observed that mixing speed and concentration of TSC interaction was significant ($p < 0.05$) for firmness and HAV, whereas the three-way interaction term between age, mixing speed and concentration of TSC was significant ($p < 0.05$) for HAV. The results demonstrate that, natural cheese age, mixing speed during manufacture and concentration of TSC have a significant impact on process cheese functionality.

Key Words: Process Cheese, Functionality

161 Effect of calcium and moisture on rheological and melting properties of Mozzarella. C. Udayarajan*[1], D. S. Horne[2], and J. Lucey[1], [1]*University of Wisconsin*, *Madison*, [2]*Charis Food Research*, *Ayr, Scotland*.

The objective of this study was to evaluate how possible interactions between total calcium, moisture and age influence the rheological and melting properties of Mozzarella. Four types of low fat Mozzarella cheeses (~ 15% FDM) with low calcium-high moisture, low calcium-low moisture, high calcium-high moisture and high calcium-low moisture levels were manufactured and stored at 4°C for 28 d. Low and high calcium cheeses had total calcium contents ranging from 25-27 and 33-35 mg Ca/g protein, respectively. Moisture contents of low and high moisture cheeses were 45-46% and 49-50%, respectively. Fourier transform mechanical spectroscopy was used for rheological analysis over a frequency range of 0.08-4 Hz, while samples were heated from 10 to 90°C at 1°C/min. Melting properties like extent of flow and melt area were analyzed using UW Melt profiler and Schreiber test, respectively. Storage Modulus (G′) increased with frequency for all cheeses. Moisture had a significant effect on G′ values at 20, 40 and 60°C, whereas calcium had an effect on G′ values at higher temperatures, e.g. 60 and 80°C. G′ values decreased with an increase in moisture and decrease in calcium content. G′ values at 60 and 80°C decreased with increased ripening. During heating all cheeses exhibited a maximum in loss tangent (MaxLT) and the MaxLT value increased with decrease in calcium and increase in ripening. Extent of flow and melt area increased as calcium content decreased. There was a significant correlation between MaxLT and melting properties. It is likely that changes in insoluble calcium content and proteolysis contributed to the ripening effects. In high moisture cheeses the less dense protein network resulted in weaker protein interactions, which contributed to the increase in MaxLT and improved melt parameters. In high calcium cheeses, the strong calcium-protein interactions retarded rheological (e.g. MaxLT value) and melt properties and these interactions seemed to have relatively more impact at high temperatures (i.e. during melting).

Acknowledgements: Dairy Management Inc.

Key Words: Rheology, Mozzarella

162 Variations in the *trans* and CLA content of Ontario milk fat. H. Thomsen*[1], M. Hernandez[2], A. Hill[1], and J. Kramer[2], [1]*University of Guelph*, *Guelph, Ontario, Canada*, [2]*Agriculture and Agri-Food Canada, Food Research Program*, *Guelph, Ontario, Canada*.

A survey was conducted to determine seasonal and regional

variations in fatty acid (FA) composition of Ontario bovine milk. The province was divided into five regions - north, south, east, west, and central - with 10 farms from each region and each season. Herd milk samples were preserved with Bronopol, stored at 2-4^{O}C, and shipped overnight. Total lipids were extracted, methylated with sodium methoxide, and analyzed by gas chromatography using a 100m CP Sil 88 capillary column. The data reported is from the spring (reported at AOCS 2004), summer, and fall 2003. The saturated fatty acids (SFAs) ranged from 61.3-70.5%, the *trans* 18:1 from 2.2-4.9% and 11t-18:1 from 0.58- 3.28%. The total CLA content ranged from 0.35-1.07% and the 9c11t-CLA (including 7c9t-CLA) from 0.24-0.94%: in both cases, the summer fat contained the greatest quantities. The long chain n-3 PUFA ranged from 0.08-0.96%. The north had the highest means for SFA: 68.29% (spring), 67.1% (summer), and 69.98% (fall), highest 11t-18: 1 - 1.4% (spring) and 3.28% (fall). It also had the highest amounts of total CLA: 0.88% (spring), 1.07% (summer), and 1.01% (fall) as well as 9c11t-CLA: 0.74% (spring), 0.94% (summer), and 0.86% (fall). Great seasonal and regional variability was also observed for the n-3 PUFA; the north had the highest during the spring (0.15%) whereas the east had the highest quantities for both summer and fall (0.76% and 0.96% respectively). The five regions have variances in the composition of their dietary sources (not analyzed), which is reflected in the FA composition of the milk. The north uses higher amounts of grass and forage, the east higher amounts of corn products, and the central and west regions more soybean based products. A correlation exists between 11t-18:1 and 9c11t-CLA, but not between 9c11t-CLA and 18:2n-6 or 18:3n-3. Further studies are ongoing to assess the FA composition of the 2003 winter milk for the five regions as well as breed differences.

Acknowledgements: Dr. Z. Deng

Key Words: CLA, Fatty Acid Composition, Seasonal and Regional Variability