133 Low fat cheese opportunities. J. Montel*, *Dairy Management Inc.*, *Rosemont, IL*.

With over 90% household penetration, cheese is enjoyed by virtually everyone; consumed in everything from pizzas to cheeseburgers, salads and cheese snacks. Cheese is everywhere, both in home and away-from-home. In 2006, per capita consumption of cheese reached an all-time high of 32.4 pounds.

Today food choices are driven by three needs: convenience, taste and health & nutrition. In fact, health is the #1 driver of the food industry world wide. Consumers have certain health needs, whether that is less fat, less calories, less cholesterol or less sugar.

Even though consumers demand fat reduction, they are not willing to sacrifice taste or functionality in the foods they eat. In fact, a recent consumer survey recorded 86% of consumers stating taste as having an impact on their decision to buy foods and beverages. In other words, they want it all - both taste and less fat.

Since 2002, manufacturers have introduced 223 new low/no/reduced fat cheese items in the marketplace - the second highest segment of new product introductions in the cheese category. Despite these efforts low fat and fat free cheese account for only 2% of sales.

How big of an opportunity is good tasting, functional low/reduced fat cheese for the industry? Recent research found that 49% of consumers are interested in purchasing a "great tasting cheese with half the fat". In addition, DMI funded custom research with TNS (a well regarded research company) to quantify the sales opportunity for a great tasting reduced fat cheese with "cheese restrictors" consumers who love the taste of cheese but restrict their consumption because of fat concerns. They would significantly increase consumption of cheese with great tasting low fat cheese products.

In addition to retail opportunities, the foodservice channel offers significant volume especially in the schools channel where cheese could be at risk due to the implementation of wellness policies and the recent Institute of Medicine (IOM) guidelines. Cheese as an ingredient in pizza, sandwiches/burgers and a la carte represent cheese volume that the industry cannot afford to lose. Opportunities also exist within commercial foodservice as operators look to improve the nutritional profiles of menu items as well as create new good-tasting reduced fat menu items.

134 The impact of fat content on flavor of cheddar cheese. M. A. Drake*, *North Carolina State University*, *Raleigh*.

Consumer emphasis on health and nutrition is driving increased demand for nutritious and lower-fat foods. Despite previous studies on reduced fat cheese, information is critically lacking in understanding the flavor and flavor chemistry of reduced and low fat Cheddar cheeses and how they differs from their full fat counterparts. The objectives of this study were to characterize the flavor and flavor chemistry of low fat, reduced fat and full fat Cheddar cheeses. Cheddar cheeses with 32, 16, or 5 % fat 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, cheeses were evaluated by sensory and instrumental volatile analyses. Flavor and volatile components of low fat Cheddar cheeses were distinct from full fat cheeses. Decreases in fat content resulted in decreases in milkfat flavor, higher whey flavor and a decrease in the rate of aged cheese flavor development compared to full fat cheeses. 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. Differences between the flavor of low fat and full fat Cheddar cheeses are due to differences in the biochemistry and are not solely a result of differences in volatile flavor compound release.

Key Words: Cheddar Cheese, Flavor, Low Fat

135 Effect of composition on the microbial ecology of low fat cheese. J. R. Broadbent*, *Utah State University*, *Logan*.

The absence of desirable flavor in reduced fat and low fat natural Cheddar cheeses limits consumer acceptability of these products. Flavor development in bacterial-ripened cheeses like Cheddar is largely a biochemical process that is driven by microbiological activity in the ripening curd. Although knowledge of the relationship between cheese bacteria and flavor development has advanced significantly in recent years, critical information is still lacking on how fat reduction, and corresponding compositional changes in low fat cheese such as lower salt-in-moisture content, influence the microbiology of cheese. Specific knowledge of how fat reduction influences the microbial ecology of cheese could lead to the identification of methods to enhance flavor development in low fat products. The objective of this work was to characterize microbiological differences in Cheddar cheeses containing 32 (full), 16 (reduced), or 5 % (lowfat) fat (wet wt). Cheeses were manufactured in duplicate at 3 locations 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 sampled for starter and nonstarter lactic acid bacteria (NSLAB), and DNA was collected from cheese and cells for analysis by denaturing gradient gel electrophoresis (DGGE) of 16S rDNA fragments. Microbiological data showed interesting differences between cheeses made with different fat contents at all 3 sites. First, starter populations remained stable out to 3 mo in low fat 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 most reduced or full fat cheese did not attain that level even after 3-6 mo. DGGE studies are still ongoing, but results to date suggest the NSLAB fraction of all cheeses includes *Lactobacillus curvatus*, but several other species of bacteria have also been identified. A more complete understanding of the relationship between fat content and cheese microbiology should provide greater insight into the problems, and potential solutions, related to flavor development in lowfat Cheddar cheese.

Key Words: Lowfat Cheese, Cheese Microbiology, Nonstarter Bacteria

136 Effect of composition on the microbial metabolism of low fat cheese. J. Steele*, *University of Wisconsin*, *Madison*.

Low-fat cheeses differ significantly from that of their correspondent full fat varieties with regard to flavor. If we are to understand these

flavor differences, an understanding of how changes in cheese composition influences the structure and metabolism of the cheese microbiota is essential. Changes in chemical attributes during ripening such as simple and modified carbohydrates, organic acids, nucleic acids, serine-phosphate (free and bound), and glycoproteins; as well as starter culture enzyme activities: general aminopeptidase activity (AP), X-prolyl dipeptidyl aminopeptidase (PAP) and post-prolyl endopeptidase (PEP) were studied in cheeses made at 3 different dairy plants. Cheddar cheeses made with full, reduced and low fat content as well as the inclusion of a washing step in the making of the full fat cheeses were chemically analyzed. An HPLC method for the extraction and analysis of trace level carbohydrates was developed. Carbohydrate profile shows that as fat levels decreased, the levels of lactose and galactosamine and D-Lactate increased, however, only slight decreases of enzyme activities (PAP and PEP) were observed. Soluble nitrogen had no apparent change as fat content was decreased. The effect of the wash step decreased the levels of lactose, galactosamine and glucosamine from the available energy sources in cheese, yet only slight increases in heterofermentative products were observed, suggesting that the washing step did not remove all the energy sources available for the starter and non-starter bacteria present in these cheeses. Overall, this research demonstrates that the carbohydrates present to support microbial growth and metabolism differ in Cheddar cheese in a fat-dependant manner. These changes may influence the structure and metabolism of the cheese microbiota and hence cheese flavor.

Key Words: Low Fat Cheddar Cheese, Energy Sources, Microbiota

137 Impact of fat content on cheese texture. E. A. Foegeding*, *North Carolina State University*, *Raleigh*.

Fat is a key component in cheese as it impacts flavor and texture. However, there is a desire to produce reduced fat foods as a way to lower overall caloric intake. Therefore, the ultimate goal is to manufacture a cheese with a reduced level of fat while maintaining a desirable level of flavor and texture. A common problem in low fat cheeses is that the texture becomes rubbery with minimal breakdown during chewing. This implies that a basic understanding of what regulates the rheological and fracture properties of cheese microstructure may shed some light on how texture can be improved. There are two models that may explain the microstructural basis of texture. A filled gel model predicts that texture is based on the amount of filler particle, if the filler particle interacts or does not interact with the gel network, and the relative ratio of the network and filler particle rigidities. In this model, the casein gel network surrounds the fat particles. An alternative model is that of a closely packed system. In this model, protein particles are tightly packed with lipid particles. It is also possible to view cheese as starting out as a filled gel then being converted to a closely packed particle system when moisture is removed during manufacturing. Cheddar cheeses were manufactured containing 32%, 16% or 6% fat, and aged for 9 months. Sensory texture and fracture/rheological properties were determined initially at 2 weeks, then at 3, 6, and 9 months. The results from this investigation on cheddar cheese, along with published investigations on other cheeses, will be discussed based on filled gel and closely packed particles models.

Key Words: Cheese, Texture, Low Fat

138 Effect of fat reduction on the functional properties of slice on slice process cheese. L. E. Metzger*[1], S. Chandran[1], C. R. Daubert[2], M. Yurgec[2], and S. Ramsey[2], [1]*South Dakota State University*, *Brookings*, [2]*North Carolina State University*, *Raleigh*.

A common form of process cheese called slice on slice (SOS) is manufactured using a chill roll or chill belt which forms and cools the molten cheese into a thin sheet; then cuts and stacks the slices into a loaf. As a result of machineability issues, low fat process cheese is not produced using a SOS manufacturing process. The objective of this research was to characterize the effect of fat reduction on the functional properties of SOS process cheese. Four process cheese formulations were developed including: full fat (30% fat); 25% reduced fat (22.5% fat); 50 % reduced fat (15% fat); and low fat (6.00% fat). Each formulation utilized the same skim milk natural cheese (1.4% fat) as the primary ingredient. Each formulation also contained 12% aged Cheddar cheese, was standardized to 2.2% salt, and was standardized to the appropriate fat content with butter oil. Each formulation was prepared on a small scale using a rapid visco analyzer to determine their cooked apparent viscosity. The cooked apparent viscosity of each formulation was similar and ranged from 3,149 to 3,328cP. Each formulation was then prepared in a Stephan Universal Cooker on a larger scale (1,500 g) and the rheological properties of each formulation were evaluated. Rheological analysis included: small deformation, compression, torsion, and tack. Rheological analysis demonstrated that the torsion stress, compression stress, tack extension, and tack energy significantly ($P < .05$) increased as the fat content decreased. These results demonstrate that fat reduction impacts the functionality of SOS process cheese. Subsequent research will evaluate the effect of formulation modifications on the functionality of SOS process cheese.

Key Words: Process Cheese, Low Fat

139 Advances in nonfat/lowfat process cheese for melting and ingredient use. J. A. Lucey*, *University of Wisconsin*, *Madison*.

In recent work at the University of Wisconsin, we have investigated various approaches to improving the melting and baking properties of lowfat/nonfat process cheese (PC). We have developed a novel approach to solve some of the critically important defects in lowfat/nonfat cheese. These defects include poor color, excessively hard or sticky texture, scorching during baking and surface skin formation. The first critical step is to manufacture a skim curd cheese base that has suitable properties for process cheesemaking. One method is to use direct acidification of skim milk to pH 5.6 with a calcium chelating agent, such as citric acid. This base could be used for process cheesemaking the same day of manufacture or stored and used within a few weeks to produce a softer, more meltable PC performance. In our method, we do not use any phosphate or citrate salts to chelate calcium. The acidification of base with citric acid is sufficient to reduce the crosslinking of caseins in curd formed by calcium phosphate. High concentrations (>0.5%) of traditional emulsifiers, such as mono- or diglycerides, are added to alter casein interactions. This produces a nonfat (or lowfat if the glycerides are included in the estimation of total fat) PC that has a white color and slices easily. The slices are not sticky. The cheese shreds easily, melts and flows during baking, maintains a white color during heating and after cooling and is bland in flavor. Another important benefit is this

product can be classified as a low sodium cheese as the only sodium that is added is what is added as a salt (preservative) in the base. This approach can also be used for lowfat natural cheese (e.g. Mozzarella) as the Nutrition Labeling and Education Act (NLEA) (21CFR 130.10) allows the addition of nonstandard ingredients to improve the texture of lowfat versions as long of the cheese is nutritional equivalent to the standard version. These novel approaches are very promising for producing lowfat or nonfat cheeses that have excellent functional properties for ingredient use.

Key Words: Lowfat Cheese, Process Cheese, Functionality

140 A novel technology for making lowfat cheese. N. Y. Farkye* and M. Arnold, *California Polytechnic State University*, *San Luis Obispo*.

Low fat Cheddar cheese containing less than 6% fat was manufactured by combining pre-determined portions of ripened full fat or reduced-fat Cheddar and/or enzyme-modified cheese with freshly made nonfat Cheddar cheese using novel mixing and stuffing technologies to produce a uniform product. Under normal conditions, mixing two streams of curds results in uneven distribution and mottled appearance of finished cheese. This technique results in cheese with a uniform appearance. Pasteurized and pre-acidified nonfat milk was used to make Cheddar-type cheese using commercial mesophilic lactic starter and Chymax™ as coagulant. After coagulation and cutting, the curd was cooked to the desired firmness and whey drained. The curd was mixed with pre-chopped ripened cheese or enzyme-modified cheese to provide flavor, then salted. Ingredients to help hold moisture may be added. Salted curds were pressed in Wilson-style cheese hoops for block cheese or stuffed into casings for logs. Both methods of curd treatment produced acceptable cheese. Finished cheese had characteristic flavor of the ripened cheese used in blend.

Key Words: Lowfat Cheese, Blending

141 Alternative manufacturing protocols for low fat cheese. M. Johnson*, *University of Wisconsin*, *Madison*.

Manufacturing protocols for cheese are often dictated by time and cost of manufacture. How the cheese will be used and shelf-life requirements also impact how the cheese should be made. Consequently, manufacturing methods that produce a cheese suitable for one application may not produce a cheese that fulfills the requirements for another. In addition, natural cheese used directly as a snack food, referred to as “table cheese”, is often made differently than a cheese that will be used as an ingredient. Cheese making technologies for low fat cheese have generally fallen into two categories; firstly, substantial acidification of the milk prior to rennet addition followed by either whey dilution or curd rinsing with cold water and secondly, limited acidification prior to rennet addition and limited water addition or curd rinsing. Major differences in both body and flavor characteristics can result depending upon which method is used. Slight modifications to both manufacturing methods include milk or cream homogenization, high pasteurization temperatures and addition of fat mimetics or whey protein aggregates. To reduce the cost of manufacture, standardization of milk through use of concentrated milk solids is commonly practiced and has introduced additional challenges but has also provided opportunities. This presentation will describe the preliminary results on the use of different acidulants, and characteristics of low fat cheese made without use of acidulants. A combination of lactic acid and citric as an acidulant enhanced softening and smoothness of body compared to just lactic acid but a curd rinse may be necessary to prevent making a cheese with excessively low pH. Cheese made using a non-wash method was prone to excessive acidity. However, the body and flavor of this cheese may be better for certain applications compared to a wash-curd cheese.

Key Words: Low Fat Cheese, Manufacturing Protocol, Body