
DAIRY FOODS: TECHNICAL SESSION 1: CHEESE / YOGURT

0989 (M067) Physicochemical and sensory characteristics of processed cheese manufactured from goat's milk fed diet supplemented with sunflower seed or sunflower oil. A. G. Mohamed^{*1}, T. A. Morsy², and S. Kholif², ¹National Research Center, Cairo, Egypt, ²National Research Center, Cairo, Egypt.

Oilseed lipids are important sources of unsaturated lipids. Among oilseeds, linseed, soybeans, and sunflower seed are used both in farms and experimental work. Moreover, the enhancement of unsaturated fatty acids and conjugated linoleic acid (CLA) in milk products is important for human health. The aim of this work was to improve the fatty acid profile of processed cheese by using milk from goats fed with different supplements, namely, sunflower seed or sunflower oil. Fifteen lactating Damascus goats, in early lactation, were divided into three groups using complete randomized design for a 90-d experimental period. The treatments were: 1) control ration consisted of concentrate feed mixture: bersem clover (1:1 dry matter bases); 2) control +50 g/head/d sunflower seed; and 3) control +20 mL/head/d sunflower oil. Pooled milk from each treatment was used in the manufacture of processed cheese. It was manufactured by using cheese base that was prepared by acidifying goats' milk with diluted lactic acid until coagulation. Cheese samples were stored at 7°C for 3 mo. The results demonstrated that experimental additives increased ($P < 0.05$) the total unsaturated fatty acids and CLA in the processed cheese. In all additives decreased ($P < 0.05$) the total saturated fatty acids and omega 6:omega 3 ratio and increased ($P < 0.05$) the polyunsaturated fatty acids contents of the processed cheese fat. Processed cheese flavors, color, and physical properties such as melting index, oil separation, and penetrometer reading were not significantly affected by the experimental treatments. It can be concluded that sunflower seed or sunflower oil addition to lactating goats ration increased the nutritive value of processed cheese.

Key Words: goat's milk, processed cheese, fatty acids profile.

0990 (M068) Fatty acid profile of sheep cheeses that are commercialized in Chile. E. Vargas-Bello-Pérez*, C. Ugalde, P. Toro-Mujica, R. Vera, and C. Aguilar, *Pontificia Universidad Católica de Chile, Santiago, Chile.*

The fatty acid (FA) content of sheep cheeses is an important characteristic for consumers due to its role in human health. In Chile, there is an incipient internal market for sheep cheeses due to the fact that the demand for these cheeses is not widespread;

however, its production is expected to be increased in the forthcoming years. The present study was performed to characterize the FA profile of sheep cheeses that are commercialized in Chile. Thirty-two sheep cheeses were collected from supermarkets of five different cities from which 21 were Chilean and 11 imported from Europe (Spain and France). Results showed that C10:0, C14:0, C16:0, C18:0, C18:1 t11, and C18:1c9 represented around 78% of the total FA profile detected in cheeses. Short-chain (C4:0-C6:0) and medium-chain (C8:0-12:0) FA content was lower in Chilean cheeses than European. Saturated, monounsaturated and polyunsaturated FA contents did not differ between cheeses. The n6:n3 ratio was lower in Chilean cheeses than European (2.8 and 5.9). The atherogenicity index was not different between cheeses; however, the thrombogenic index was lower in Chilean cheeses (2.7) than European (2.9). The results indicated that the FA profile of Chilean cheeses was desirable from a human standpoint.

Key Words: cheese, fatty acids, thrombogenic index

0991 (M069) Investigating the impact of distiller's dried grains with solubles on the quality of milk and Swiss cheese. V. Manimanna Sankarlal*, E. D. Testroet, and S. Clark, *Iowa State University, Ames.*

Late blowing in Swiss cheese, a result of unwanted gas production during ripening, is unacceptable to consumers, is impossible to slice, and causes economic loss to manufacturers. Cheese processors have raised concerns that feeding distiller's dried grains with soluble DDGS to cows leads to this defect, in part because of *Clostridium tyrobutyricum*. In this study, the effect of feeding DDGS on composition and quality of milk and Swiss cheese was studied. Thirty healthy mid-lactation ISU Dairy Farm Holstein cows were assigned randomly to one of three dietary treatment groups (10 cows per treatment group): 1) total mixed ration (TMR) with no DDGS; 2) TMR with 10% substitution with DDGS; and 3) TMR with 20% DDGS. One complete milking from all cows within a treatment was collected and pooled for cheese-making trials, twice within each of 3-mo-long treatment periods. Additionally, individual milk samples from three milkings of a day were collected weekly, and proximate analysis was performed on pooled individual milk samples. Cheese milk was filtered, standardized to 0.88 fat:protein, and pasteurized before addition of starter cultures and coagulant. Curds were cut, fore-worked, worked, and post-worked according to a baby Swiss cheese recipe, followed by pressing and brining (10°C, 12 h). The 3.5 kg blocks were vacuum packed and allowed to ripen (10°C, 7 d; then 22°C, 21 d), then cooled (4°C, 60 d). The milk and DDGS were analyzed for *C. tyrobutyricum* using selective media. After incubation up to 48 h in modified RCM lactate medium, tubes containing DDGS did not show gas formation, whereas most of the tubes containing milk showed gas formation, which indicates that DDGS were not the source of *C. tyrobutyricum*. Milk fat content decreased as % DDGS in diet increased ($P < 0.05$). Sol-

ids nonfat, protein, and lactose content of milk of cows fed 10 and 20% DDGS were only slightly higher than from control diet. After ripening (> 60 d), baby Swiss cheese had typical propionic acid Swiss cheese aroma. Regardless of diet treatment, pinholes, slits, and cracks were seen throughout most cheeses. DDGS feeding increased the amount of long-chain unsaturated fatty acids and decreased short-chain and most medium-chain fatty acids. Although feeding cows DDGS modified milk composition and subsequent cheese composition, DDGS alone should not be blamed as a source for *C. tyrobutyricum* for late blowing in Swiss cheese.

Key Words: *C. tyrobutyricum*, Swiss cheese

0992 (M070) Evaluation of unidentified structural features in hard, aged cheeses and soft, washed rind cheeses by powder X-ray diffractometry.

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Hard, aged cheeses and soft, washed rind cheeses sometimes develop structural features that can be detected visually and texturally by mouthfeel, but which are incompletely characterized. The objectives of this research were to evaluate visible spherical features embedded within the bodies of aged Parmigiano Reggiano and Gouda cheeses, and granular features at the surfaces of three artisanal washed rind cheeses using powder X-ray diffractometry (PXRD). All cheese samples were purchased from local retail sources. Discolored spherical features up to ca. 5mm in diameter, which were readily visible against the darker cheese matrix, were extricated from the matrix of Parmigiano Reggiano and Gouda cheeses, defatted in acetone, ground to a powder, and analyzed by PXRD. Samples of the cheese matrix that surrounded the spheres were also prepared similarly and analyzed by PXRD for comparison. Granular features at the surface of washed rind cheeses were scraped off, defatted in acetone, ground, and analyzed by PXRD. The resulting X-ray diffraction patterns were compared with those in a database of over 1 million known crystals to establish crystal identities. The discolored spherical features from both Parmigiano Reggiano and Gouda cheeses diffracted X-rays in a manner characteristic of leucine; however, the surrounding cheese matrix did not diffract X-rays. The formation of numerous large (5-mm diameter) crystalline leucine entities may have important implications for the rheological properties of Parmigiano Reggiano and Gouda cheeses, which warrant further study. The washed rind cheeses exhibited surface grittiness that was perceptible in the mouth. Surface scrapings from three different washed rind cheese varieties yielded X-ray diffraction patterns that were all unique from one another. Two cheeses produced diffraction patterns that could not be identified, whereas the third displayed the presence of calcite crystals. None of the surface scrapings contained appreciable quantities of previously documented cheese crystals such as brushite, tyrosine, or calcium

lactate. Due to the outward migration of calcium in washed rind cheeses, it is possible that the unidentified diffraction patterns represent crystalline calcium salts in novel forms that have not been documented. Based on anecdotal reports from cheesemakers and cheese mongers, we hypothesize that these surface crystals are responsible for distinctive visual and mouthfeel characteristics that appeal to consumers of artisanal washed rind cheeses.

Key Words: cheese, crystal, X-ray

0993 (M071) Quality of milk and Minas fresh cheese of pasture cows supplemented with licuri cake.

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This study aimed to determine the best level of licuri cake for the diets of pasture dairy cows. This was done by evaluating the quality of milk and Minas frescal cheese. Eight crossbreed cows were distributed in four Latin square simultaneously, on the Farm of Federal University of Bahia (UFBA), Brazil, in August to October 2012. The concentrated feeding consisted of soybean meal, ground corn, mineral salt, ammonia, urea, and licuri cake at 0, 20, 40, and 60% dry matter. Contents of fat, protein, lactose, total solids and solids not fat in milk and cheese were not affected ($P > 0.05$) by licuri cake in the diet (Table 0993). The decrease in the yields of components in the milk is related to the low energy content of the diet and low intake of dry matter. Furthermore, the amounts of fat and protein vary according to race, climate, management, and other factors. The percentage of milk fat had lower values in cows that had given birth at a younger age. In the summer months, the fat content (3.41 to 3.49%) was lower than in the winter months (around 3.7%).

Key Words: byproduct, supplement, ruminant nutrition

Table 0993. Fat content, crude protein, lactose in milk and cheese, and total solids (TS) solid not fat (SNF) in milk from cows on pasture supplemented with licuri cake

Variable	Levels of Licuri cake (% DM)				SEM1	P-Value	
	0	20	40	60		Linear	Quadratic
Fat (%)	2,22	2,31	2,38	2,77	0306	00696	04645
Protein (%)	3,11	3,11	3,11	3,09	0060	08501	09560
Lactose (%)	4,63	4,63	4,64	4,62	0042	09256	08643
TS (%)	10,92	11,00	11,07	11,44	0296	00802	04745
SNF (%)	8,69	8,68	8,68	8,67	0082	08567	09655
Minas freshcheese							
Fat (%)	17,20	18,22	19,12	18,41	0298	01835	02528
Protein (%)	23,64	27,33	22,96	23,55	0058	03821	01973
pH	6,45	6,40	6,47	6,40	0754	06322	07385
Humidity (%)	59,94	57,19	58,78	57,86	0054	01544	02123

¹ SEM = standard error of mean. The cheeses were, on average, 18.2% fat and 58.4% moisture. Cheeses of this study can be classified as lean and high humidity. The licuri cake included in the concentrate until 60% of cows grazing did not alter the parameters of milk quality and frescal cheese.

0994 (M072) Microbial stress responses and gene expression during aging of cation-substituted full fat cheddar cheese. B. Ganesan*, S. Muruganandam, and D. J. McMahon, *Western Dairy Center, Utah State University, Logan*

Sodium replacement is a potential alternative to direct Na reduction in foods, wherein an equally salty cheese will attract consumers without the risk of high sodium intake. However bacteria in Cheddar cheese responsible for cheese flavor development may experience a different form of stress and respond differently when Na is, for example, substituted by K. We are yet to understand how salt change is likely to alter flavor formation in cheddar cheese. We proposed to study whether bacteria continue to experience NaCl stress even with Na reduction or with use of different NaCl mixtures with less Na in full fat cheddar cheese containing different fat levels. We investigated how starter bacteria respond to stress from different NaCl combinations during aging of cheddar cheese. To study starter bacterial stress, gene expression studies were done by qPCR targeting six known NaCl stress-related genes (three induced, three repressed by NaCl stress, based on literature) for starter lactococcal subspecies in cheeses with different NaCl combinations. Five cation combinations with different levels of Na replacement— 100% Na (control with 2.2% total salt), 75:25 and 50:50 Na:K, 50:40:10 of Na:K:Ca, and low sodium (0.7% total salt)— were chosen for the analyses. Starter lactococci survived well in response to stress, with initial variations post salting due to cations diminished over aging ($P < 0.05$). Initial responses of the dual enolase genes of lactococci matched known responses from other studies, with *enoA* being induced more by high NaCl and *enoB* repressed by high NaCl ($P < 0.05$), respectively. Expression of *dnaK*, which encodes a molecular chaperone and is known to be induced immediately with acid and NaCl stresses, steadily plateaued and remained high ($> 10^6$ copies) throughout 6 mo of aging. Initial stress response to other cations varied between the six genes, with only the cheese substituted with 50:40:10 of Na:K:Ca exhibiting lower transcript induction ($P < 0.05$) of all stress response genes. This indicates that Ca even at low levels plays a role in mitigating lactococcal stress. Notably, RNA extracted for gene expression directly from cheeses was devoid of any cross-contaminating genomic DNA, which confirmed that only transcripts were detected. The presence of detectable mRNA even after 6 mo of cheddar cheese aging confirms that lactococci are still physiologically active independent of their exhibiting growth on media plates. This study presents a novel perspective on cation-controlled gene expression through cheese aging.

Key Words: lactococci, cation substitution, gene expression

0995 (M073) Characteristics of yogurt manufactured using reconstituted yogurt cultured milk powder compared to yogurt powder. L. Song^{*1}, and K. J. Aryana², ¹*Louisiana State University, Baton Rouge*, ²*Louisiana State University Agricultural Center, Baton Rouge*.

For the manufacture of commercial yogurt powder the yogurt has to go through drying process which substantially lowers the yogurt culture counts, so the potential health benefits of the yogurt culture bacteria are diminished or lost. Also, on reconstitution, commercial yogurt powder does not taste like yogurt, it is sour and off-flavored. The objective was to enumerate *Streptococcus thermophilus* and *Lactobacillus bulgaricus* of reconstituted yogurt cultured milk powder and reconstituted commercial yogurt powder up to 8 wk and to elucidate their physicochemical and sensory characteristics. Commercial yogurt powder (CYP) was the control and yogurt-cultured milk powder (YCMP) was the treatment. Freeze-dried yogurt starter culture (*Lactobacillus bulgaricus* and *Streptococcus thermophilus* at ratio 1:1) was added to milk powder at 10^7 cfu/g on reconstitution. Microbial and physicochemical characteristics of the reconstituted CYP and YCMP were analyzed daily for the first week and then weekly for a period of 8 wk (at 1, 2, 3, 4, 5, 6, 7, 14, 21, 28, 35, 42, 49, and 56 d) after reconstitution. Three replications of each treatment were conducted. Sensory consumer testing of CYP and YCMP on reconstitution was conducted with 100 consumers of yogurt. Data were analyzed by PROC GLM of SAS. YCMP had 5 log cfu/ml higher counts of *Streptococcus thermophilus* compared to the control (CYP) at 56 d. Also, *Lactobacillus bulgaricus* counts of YCMP at 28 d was 6.55 log cfu/ml and at 56 d was 5.35 log cfu/ml while the CYP at 28 d onward had no counts. YCMP also had significantly higher apparent viscosity, pH, appearance, sensory color, aroma, taste, thickness, overall liking, consumer acceptability and purchase intent compared to CYP. YCMP had better overall characteristics than CYP.

Key Words: yogurt, powder, reconstituted

0996 (M074) Impacts of different types of exopolysaccharides on the physical and rheological properties of yogurts. U. Pachekrepapal^{*1}, J. A. Lucey², and D. S. Horne², ¹*Dep. of Food Science, University of Wisconsin–Madison, Madison*, ²*Wisconsin Center for Dairy Research, Madison*.

Exopolysaccharides (EPS) produced by some starter cultures are often used to modify yogurt texture. Our goal was to study the impact of different EPSs on yogurt properties. Reconstituted skim milk was inoculated with eight strains of *S. thermophilus*; ST1-UWM (non-EPS producer used as a control) and seven EPS producing strains. Due to the different acid producing ability of each strain, milks were supplemented with different amounts of peptone, and the inoculation rates were var-

ied to achieve a similar acidification rate for all strains. Milks were fermented at 40°C until pH 4.6 was reached. Small amplitude oscillatory rheology was performed to monitor yogurt gel formation. Gel permeability and whey separation were determined. Microstructure of the yogurt gels was studied using fluorescence microscopy. EPS from each strain were isolated for molar mass determination using size exclusion chromatography– multi-angle laser light scattering (SEC-MALLS), and for repeating unit structure determination using nuclear magnetic resonance spectroscopy (NMR-spectroscopy). Gelation pH of each yogurt was significantly different. The yogurt made from the control strain had significantly lower gelation pH (pH ~ 5.10) than yogurts made from EPS-producing strains (pH ~ 5.17 to 5.29). Storage modulus (G') of the control gel at pH 4.6 ($G' \sim 97$ Pa) was significantly lower than the other yogurts made from EPS-producers ($G' \sim 151$ to 191 Pa) except the yogurt made from ST-143 strain ($G' \sim 67$ Pa). Permeability and whey separation of each yogurt were significantly different with the control yogurt having higher permeability and whey separation than other yogurt gels. The microstructure of the control yogurt showed finer and smaller pore sizes compared to other gels. The yields of EPS produced from each strain varied between 34 and 95 mg dry material/L, with ST-143 being the highest EPS producer. The molar mass of the isolated EPS ranged from 0.13×10^6 to 1.74×10^6 g/mol. The structures of the repeating units showed that all EPS were different in terms of sugar compositions, linkages and conformations. Since all samples had similar milk composition, heat treatment, and rate of acidification, this study shows that EPS produced during yogurt fermentation modifies the gelation mechanism and physical properties of the yogurt gels.

Key Words: EPS, yogurt, rheology

0997 (M075) Substituting KCl for NaCl in fresh queso fresco. D. L. Van Hekken^{*1}, D. X. Ren^{1,2}, and M. H. Tunick¹, ¹USDA, ARS, ERRC, Dairy & Functional Foods Research Unit, Wyndmoor, PA, ²Institute of Dairy Science, College of Animal Science, Zhejiang University, Hangzhou, P.R., China.

Reducing the sodium level in cheese is challenging when a signature salty flavor is expected, such as in high-moisture Queso Fresco (QF). Fresh starter-free QF was fine milled and dry salted at different levels of NaCl and KCl to obtain total NaCl levels of 1.5 to 2.0%. The treatments contained 1.5/0, 2.0/0, 1.0/0.5, 1.0/0.75, 1.0/1.0, and 1.5/0.5% NaCl/KCl. Texture profile analysis and small amplitude oscillatory shear analysis were conducted on d 7, and salt intensity levels were evaluated by trained sensory panelists at d 6. Texture profile analysis indicated that the QFs were similar in hardness (16.7 ± 1.8 N) with the 1.0/0.5 QF being the softest and similar in cohesiveness (0.17 ± 0.01) with the 1.5/0.5 QF being the least cohesive. Chewiness was highest in the 1.5/0 QF and lowest for the 1.5/0.5 QF (224 and 144 J, respectively). Increasing

the total NaCl in the cheese increased the elastic and viscous moduli although the 1.5/0 QF was higher than the 1.0/0.5 QF and the 1.5/0.5 had the highest values. This suggested that the use of KCl may function differently in the matrix of QF, a weak body cheese that is expected to crumble easily. Five of the six QF had saltiness intensity scores 1.0 to 1.5; the 2.0/0 QF had a score of 2. Panelists selected 2 as the target saltiness for QF. The metallic off-flavor commonly associated with KCl was not an issue at levels used in this study. The replacement of NaCl with KCl in the ranges tested had only slight effects on the textural properties, did influence the viscoelastic properties, and did not match the saltiness intensity of NaCl.

Key Words: sodium, cheese, queso fresco

0998 (M076) Effect of potassium sorbate and sodium benzoate concentrations on growth of cheese starter cultures. D. Olson^{*}, E. Gonzalez, M. Ponce, and K. J. Aryana, Louisiana State University Agricultural Center, Baton Rouge.

Potassium sorbate and sodium benzoate are commonly added to foods as antimicrobials. The objective was to determine if varying concentrations of potassium sorbate or sodium benzoate affect the growth of DVS R-604 cheese starter cultures at a 10^{-4} dilution in peptone and M17 broth containing 5% (w/v) lactose. Potassium sorbate and sodium benzoate concentrations used were 0% (control), 0.01%, 0.05%, 0.1%, 0.2%, 0.5%, and 1%. Counts on M17 agar containing 5% (w/v) lactose were performed immediately after inoculation of cheese starter culture and at 1, 2, 3, and 4 d of storage. Immediately after inoculation, concentration of potassium sorbate or sodium benzoate did not affect counts of cheese starter cultures in either peptone or M17 broth containing 5% (w/v) lactose. For cheese starter cultures grown in peptone, the counts after 1 d in the presence of 1% potassium sorbate or 1% sodium benzoate were lower than in the presence of the lower concentrations of these antimicrobials. Also, the decrease of these counts over 4 d of storage was greater in the presence of 0.5% and 1% potassium sorbate or sodium benzoate than in the presence of lower concentrations of these antimicrobials. For cheese starter cultures grown in M17 broth containing 5% (w/v) lactose, the counts increased between 100 and 1000-fold during the first d of storage after inoculation in the presence of potassium sorbate or sodium benzoate at concentrations of 0.2% or less. However, this increase was less than 100-fold in the presence of 0.5% and 1% potassium sorbate and 1% sodium benzoate. Between d 1 and 4 of storage, the counts in M17 broth containing 5% (w/v) lactose decreased between 10- to 100-fold in the presence of potassium sorbate or sodium benzoate at concentrations of 0.2% or less, but this decrease was smaller in the presence of 1% potassium sorbate. Concentrations of 0.5% and 1% potassium sorbate and sodium benzoate were more effective than lower concentrations for decreasing the counts of cheese starter cultures grown in

either peptone or M17 broth containing 5% (w/v) lactose, but this greater effectiveness was observed in different ways in peptone versus M17 broth containing 5% (w/v) lactose.

Key Words: cheese starter culture, potassium sorbate, sodium benzoate, growth.

0999 (M077) Influence of submicronization of sodium chloride on the sensory characteristics of surface salted cheese crackers. M. Moncada*, C. Sabliov, C. Astete, and K. J. Aryana, Louisiana State University Agricultural Center, Baton Rouge.

Reducing the particle size of sodium chloride crystal would increase its dissolution rate leading to a more efficient transfer of the ions to the taste buds and hence perhaps a saltier perception of foods. The objective was to evaluate the effect of developed submicro salt on the sensory characteristics of surface salted cheese crackers. The cheese cracker treatments consisted of three different salt sizes (regular, micro, submicro salt) and three different concentrations (2, 1.5 and 1% w/w). A Balanced Incomplete Block Design was used to conduct the consumer analysis of cheese crackers for submicro salt (2, 1.5 and 1%), microsalt (2, 1.5 and 1%) and regular 2% (control as used by industry) using 476 participants in total at wk 1 and 4 mo. At 4 mo, submicro salt treatments (2, 1.5, and 1%) resulted in having significantly ($P < 0.05$) more preferred saltiness scores compared to control (regular 2%). At 4 mo, submicro salt (1.5 and 2%) showed significantly ($P < 0.05$) more preferred just-about-right saltiness scores compared to control (regular 2%). The consumers purchase intent increased by 25% for the submicro salt 1.5% after they knew about the 25% reduction in sodium content of the cheese cracker. The reduction of 25 and 50% salt content in cheese cracker through use of submicro particulated salt did not adversely influence sensory color, aroma, crunchiness, overall liking and acceptability scores, which were the same compared to control (regular 2%) and microsalt treatments (2, 1.5, and 1%). Compared to the micro salt, the sub micro salt particle size was reduced 10 times and yet there was no increase in saltiness of crackers with submicro salt. This may be because instead of taking salt directly it was taken as a surface salting on a product containing protein, fat and other biomolecules which, masked the saltiness of the surface salted cheese crackers. Reduction in sodium chloride particle size by 10-fold may increase its surface area but not the saltiness of surface salted cheese crackers.

Key Words: submicronization, salt, cheese cracker

1000 (M078) Submicronization of sodium chloride and its effect on the physicochemical and microbiological characteristics of surface salted cheese crackers. M. Moncada*, C. Sabliov, C. Astete, and K. J. Aryana, Louisiana State University Agricultural Center, Baton Rouge.

Reducing particle size of salt to submicron range increases its surface area. The objective of this study was to develop submicro salt (sodium chloride) by using a nanospray drying method and using the developed submicro salt in surface salted cheese crackers and evaluating their physicochemical, and microbiological characteristics. The sodium chloride solution (3% w/w) was sprayed through the nozzle size of 4 μm with air flow of 125 l/min, pressure of 3800 Pa, head temperature of 95°C and spray percentage of 90%. The processing parameters were optimized to ensure formation of the smallest size submicrosalt, as measured by Scanning Electron Microscopy and Dynamic Light Scattering. The cheese cracker treatments consisted of three different salt sizes (regular, microsalt and submicrosalt) and three different concentrations (2, 1.5, and 1%). The 9 (three sizes x three concentrations) different cheese cracker treatments were tested for salt concentration and sodium content at wk 1. Water activity (A_w), yeast and mold counts, texture-fracturability, and color were determined at wk 1 and 4 mo of storage. Completely Randomized Design (CRD) was used for salt and sodium content and CRD with repeated measures was used for A_w , yeast and mold counts, texture-fracturability, and color. The 80% of the submicro particles produced by the nanospray dryer B-90 was between 500 nm to 1900 nm. Yeast counts and A_w in all treatments increased from 1 wk to 4 mo. Submicrosalt treatments (2, 1.5, and 1%) had positive effect in yeast reduction at 4 mo compared to regular salt (2, 1.5, and 1%). There was no mold growth in all treatments at all times. The L^* , b^* , C^* and h^* values in all treatments increased significantly ($P < 0.05$) from 1 wk to 4 mo. The sodium chloride micro and submicro particles maintained low counts in yeasts, no counts in molds and did not adversely influence quality attributes.

Key Words: submicro, salt, cheese cracker

1001 (M079) Influence of various health beneficial spices on some characteristics of yogurt culture bacteria and *Lactobacillus acidophilus* and sensory acceptability of spicy probiotic yogurt. M. Sánchez-Vega, and K. J. Aryana*, Louisiana State University Agricultural Center, Baton Rouge.

Garlic and ginger have a beneficial influence on averting cardiovascular diseases. Onion and turmeric decrease the risk of diabetes and have anticancer properties. *Streptococcus thermophilus*, *Lactobacillus bulgaricus*, and *Lactobacillus acidophilus* are lactic acid bacteria that produce lactase and reduce the symptoms of lactose malabsorption. Earlier work has

shown the influence of spice extracts but the influence of pure spice juice on yogurt culture bacteria is not known. Characteristics of yogurt culture bacteria were measured by suspending freshly thawed cultures into 0.1% peptone water (growth), MRS-Thio broth with oxgall (bile tolerance) and skim milk (Protease activity) with 1% (v/v) of freshly extracted spice juice. Fresh spices were obtained locally and spice juice was extracted using a juice extractor. Bile tolerance was measured by enumeration in presence of bile and protease activity was measured by a spectrophotometric assay. A probiotic blueberry yogurt was made that incorporated 0.05% of individual spice juice. Apparent viscosity of probiotic blueberry yogurt was measured using a viscometer with a helipath and Wingather 32 software. A T-C spindle was used at 20 rpm and 100 data points were acquired per sample. Physico-chemical characteristics of spicy probiotic yogurts containing the three bacterial cultures used were determined. Differences of least square means were used to determine significant differences at $P < 0.05$ for main effects and interaction effects. Consumer acceptability test was conducted using 100 consumers. A nine point scale was used to evaluate overall appearance, color, aroma, taste, texture and overall liking of the product. Results indicated that all spices except turmeric improved the bile tolerance of *L. bulgaricus*. Ginger, turmeric and onion had the best overall influence on the protease activity of *S. thermophilus*. Turmeric improved the protease activity of *L. bulgaricus*. Ginger and turmeric improved the protease activity of *L. acidophilus*. All four spices decreased the pH of the spicy yogurt, while garlic, ginger and turmeric increased the titratable acidity of the spicy yogurt. Onion and ginger increased the apparent viscosity of the spicy yogurt. The control yogurt obtained 80% acceptance and the ginger yogurt obtained 84% acceptance, and both of these yogurts obtained the highest intent of purchase. Ginger can be used in spicy yogurt manufacture for direct consumption while all four spices have potential for a new product line of yogurts for cooking, marinating and dips enabling potential health benefits from both spices and probiotic bacteria.

Key Words: spice, fermented, culture

1002 (M080) Yogurt characteristics as effected by added lactose. B. Mena, and K. J. Aryana*, *Louisiana State University Agricultural Center, Baton Rouge.*

Enrichment of yogurt with lactose addition may increase growth of the yogurt starter culture (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*) and enhance yogurt physicochemical and sensory attributes. The objectives of this study were: to determine the influence of added lactose on 1) the growth of the yogurt starter culture during yogurt's shelf life, 2) the physicochemical characteristics of yogurt during shelf life, 3) the final lactose content of yogurt during its shelf life, and 4) the sensory attributes of yogurt. Fat-free plain set-type yogurt was manufactured using 0, 1, 3,

and 5% w/w added lactose to accomplish objectives 1, 2, and 3. For objective 4, a blueberry yogurt was manufactured using the same lactose levels. Analyses for plain set-type yogurt were done at 7 d intervals during 35 d of storage period. Three replications were conducted. Sensory evaluation was conducted by 100 consumers of yogurt on d 3 of its manufacture. Data were analyzed using PROC MIXED model of SAS 9.3 program. Significant differences between means were analyzed at $\alpha = 0.05$ using Tukey adjustment. Addition of lactose to yogurt at 5% w/w significantly increased growth of *Streptococcus thermophilus* ST-M5 but had no effect on growth of *Lactobacillus bulgaricus* LB-12. Lactose added at 5% w/w showed significantly the highest lactose content during entire storage period as expected, the lowest pH values, and also the highest syneresis values over storage period of 35 d. Lactose addition had no effect on appearance and color of blueberry yogurt. Samples containing added lactose showed significantly higher scores for taste, sourness and sweetness. Lactose added at 3 and 5% w/w had significantly the highest overall liking scores. Acceptability of yogurts and purchase intent markedly increased with the addition of lactose. Added lactose in yogurt manufacture favorably influenced some attributes of yogurt.

Key Words: added lactose, yogurt, probiotic properties, starter culture, lactic acid bacteria

1003 (M081) Influence of added lactose on some probiotic properties of yogurt culture bacteria.

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Lactose is a source of energy for lactic acid bacteria in dairy fermented products. Acid tolerance and bile tolerance are important probiotic properties. The influence of lactose on acid tolerance and bile tolerance of yogurt culture bacteria is not known. The objective was to determine the influence of lactose on acid and bile tolerance of yogurt starter culture *Streptococcus thermophilus* ST-M5 and *Lactobacillus bulgaricus* LB-12. Acid tolerance was conducted on pure cultures of *S. thermophilus* in M17 broth at pH 2.00 and *L. bulgaricus* in MRS broth at pH 2.00 both at 30 min intervals for 2 h of incubation. Bile tolerance of pure cultures was determined using MRS-THIO broth with 0.3% oxgall for *L. bulgaricus* and MRS broth with 0.3% oxgall for *S. thermophilus*. Dilutions were plated every hr for 12 h. Three replications were conducted. Data were analyzed using PROC MIXED model of SAS 9.3 program. Significant differences between means were analyzed at $\alpha = 0.05$ using Tukey's adjustment. With use of lactose at 3 or 5% (w/v), the *Streptococcus thermophilus* ST-M5 had significantly higher acid tolerance than control at 120 min. In presence of lactose at 3 or 5% (w/v), the *Lactobacillus bulgaricus* LB-12 had significantly higher acid tolerance than control at 60, 90, and 120 min. Lactose, when used at 5% (w/v), significantly improved bile tolerance of *L. bulgaricus* compared to control. With use of lactose at 1%

(w/v), *S. thermophilus* had significantly higher bile tolerance compared to control at 2 h of incubation. Use of lactose at 5% (w/v), favorably influenced acid tolerance of *S. thermophilus* and the bile tolerances of *S. thermophilus* and *L. bulgaricus*.

Key Words: added lactose, acid tolerance, bile tolerance, starter culture

1004 (M082) Evaluation of the perten dough lab for production of imitation mozzarella cheese.

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The functional properties of imitation mozzarella cheeses (IMC) are influenced by the equipment and manufacturing procedure used to produce them. To test new formulations a pilot scale twin screw cooker with a batch size of 4.5kg is routinely utilized. However, in situations such as when experimental ingredients are being evaluated, a smaller batch size is desired. The Dough lab (Perten Instruments, Hagersten, Sweden) is a commercial twin screw heating and blending system that is used for dough rheology applications. As compared to a typical pilot scale twin screw cooker the dough lab has a batch size of 600 g. The objective of this study was to compare imitation mozzarella cheese (IMC) manufactured with the Perten dough lab (PDL) to IMC made with a pilot scale Blentech twin screw (BTS) cooker (cheese Therm cooker- Blentech Corporation, Santa Rosa, CA). Initially a typical control IMC was produced in the BTS cooker using a cook temperature of 90°C, a cook time of 4 min and 30s ec and at a stirring speed of 140 rpm. The same IMC formulation was then produced with the PDL using four different stirring speeds (75, 100, 115, and 125 rpm) at a cook time of 4 min and 50 sec and a cook temperature of 90°C. Of the IMCs made in PDL at four stirring speeds, the utilized 115 rpm had similar functional properties as compared to IMC made in the BTS. IMC was then manufactured in triplicate using the PDL operated at 115 rpm stirring speed and samples were analyzed for chemical (Fat, Protein and Moisture) and functional (Texture Profile Analysis (TPA)—Hardness, Melt and Stretch) properties. Method comparison statistics (mean comparison, graphical representation, repeatability) were used to evaluate the agreement between the two methods. The TPA-hardness, schreiber melt and stretch characteristics of the IMCs made with PDL were similar to the IMC produced in the BTS. The results indicate that the Perten Dough Lab can be used to produce a 600-g batch of IMC that has functionality similar to IMC produced in a pilot scale twin screw cooker.

Key Words: dough lab, twin screw cooker, imitation cheese

1005 (M083) Genome analysis of two *Lactobacillus curvatus* strains that have emerged as dominant non-starter lactic acid bacteria in cheese.

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Recent studies concerning cheese microbiology have revealed *Lactobacillus curvatus* becoming an increasingly common component of the non-starter lactic acid bacteria (NSLABs) population in aged cheddar cheese. We recently sequenced the genome of two *Lb. curvatus* strains, WSU1, isolated from aged cheddar cheese manufactured at Utah State University, and LFC-1, isolated from aged cheddar cheese manufactured at the University of Wisconsin–Madison. Whole-genome shotgun sequencing was performed on both isolates and assembled into draft genome sequences. Preliminary genome annotation was performed using the RAST algorithm (rast.nmpdr.org). Initial genetic comparisons between the predicted coding sequences of the two strains showed similar genome content with strain WSU01 having 312 unique predicted proteins, and LFC-1 having 297 unique proteins using a 90% amino acid identity threshold. Both strains have genes encoding enzymes for cellobiose utilization, and the ability to ferment ribose and N-acetylglucosamine. Although both strains have genes for lactose utilization, API sugar panel results showed that only LFC-1 fermented lactose. Further analysis showed that LFC-1 also has genes that encode enzymes for maltose and trehalose fermentation, along with genes for citrate utilization. To understand why *Lb. curvatus* has become a dominant NSLAB in cheddar cheese, genome sequences were analyzed to identify possible mechanisms. Both genomes contain genes for a putative sakacin-like bacteriocin and genes for a propanediol utilization pathway, which converts 1,2-propanediol to propanol and propionic acid. To test for propionate production, both strains were grown to carbohydrate exhaustion in MRS media (PH 5.2), after which 50 mM lactate was added. Cultures were incubated under strict anaerobic conditions for 22 d with samples taken after 0, 5, and 22 d and analyzed for propionate using GC–MS. Lactate concentrations were also measured using an enzymatic assay. Results revealed that both WSU1 and LFC-1 produce a fivefold increase in propionate after 22 d. Previous studies on propionate production in other lactic acid bacteria show that lactate was converted to 1,2-propanediol, but lactate in both WSU1 and LFC-1 did not show a decrease in concentration during incubation. This observation opens the possibility that in *Lb. curvatus*, 1,2-propanediol is produced by another pathway and warrants further investigation since high levels of propionic acid have been found in aged cheddar cheese where *Lb. curvatus* is a dominant NSLAB.

1006 (M084) Use of a water-in-oil-in-water (w/o/w) double emulsion to simulate the full-fat cheese physical properties in a 30% reduced-fat cheese.

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Reduced-fat cheeses have greater hardness and elasticity than full-fat cheeses because of the reduction in number of fat particles that can interrupt long-range interaction within the casein protein matrix structure of cheese. Our objective was to produce a water-in-oil-in-water ($W_1/O/W_2$) double emulsion as the carrier for butterfat that, when used in the manufacture of cheese, would provide similar physical properties to a full-fat cheese but have 40% less fat. The $W_1/O/W_2$ emulsion was made by making a 1% (wt./vol.) solution of inulin in boiling 0.5% (wt./vol.) NaCl solution, and adding this solution in a 40:60 ratio into anhydrous milk fat (containing 8% (wt./wt.) polyglycerol polyricinoleate) at 50°C using low shear. This formed the primary W_1/O emulsion. The W_1/O emulsion was then mixed with high shear (5000 rpm for 1 min) in a 20:80 ratio with a 2% (wt./wt.) aqueous solution of whey protein concentrate to form the $W_1/O/W_2$ emulsion. A single oil-in-water emulsion was prepared as a control using milkfat emulsified into the whey protein solution and designated as O/W_2 . Immediately after emulsion preparation, the control (O/W_2) and double ($W_1/O/W_2$) emulsions were added separately (in triplicate) into pasteurized skim milk at 31°C and then made into cheese FF-

CON and WOW32, respectively) using a standard procedure for full fat cheddar cheese. Mean (\pm SE) composition for FFCON cheeses was 354 (\pm 3) g/kg moisture, 333 (\pm 3) g/kg fat, 17.2 (\pm .5) g/kg salt and pH 5.37 (\pm .02), while for the WOW32 cheese it was 424 (\pm 6) g/kg moisture, 228 (\pm 2) g/kg fat, 17.6 (\pm 0.7) g/kg salt and pH 5.30 (\pm .02). Rheological properties (at 25°C) were analyzed after 1 mo of storage. Storage modulus (G') and loss modulus (G'') for both cheeses were linear over the range of 10^{-3} to 10^{-1} percent strain. The WOW32 cheese was slightly softer ($P < 0.1$) than the FFCON cheese with mean G' between 0.1% and 0.01% strain of 112 kPa and G'' of 33 kPa compared to G' and G'' of the FFCON cheese of 177 and 52 kPa, respectively. This softening of the WOW32 cheese compared to the FFCON cheese was considered beneficial as normally a 30% fat reduction causes cheese to become firmer. We successfully produced a cheese with 30% less fat and similar (slightly softer) properties to a full fat cheese, with the extra moisture in the WOW32 cheese attributed to moisture coming from the W_1 phase of the $W_1/O/W_2$ double emulsion.

Key Words: cheese reduced-fat emulsion