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The objective of the study was to assess the competitiveness of Brown Swiss x Holstein crossbreds (BSH) with respect to body weight and body measurements. BSH (n = 55) were compared to pure Holsteins (HOL, n = 50) for body weight (BW), backfat thickness (BF), udder clearance, teat length, and teat placement during first and second lactation. BF was measured with ultrasonography between the hooks and the thurl. Udder clearance was measured from the floor to the bottom of the udder. All animals originated from a designed experiment. Variables in the model for statistical analysis were the fixed effects of breed group, lactation number, lactation number nested within breed group, season (fall and spring) nested within lactation number, and days in milk nested within lactation number. Cow within breed group was a random effect in the model. Across lactations, BSH had significantly ( $P < 0.05$ ) more BW than HOL (669 kg vs. 648 kg). During first (620 kg vs. 594 kg) and

second (678 kg vs. 656 kg) lactations, BSH had significantly ( $P < 0.05$ ) more BW than HOL. For BF, BSH (17.7 mm) tended ( $P < 0.10$ ) to have more BF than HOL (16.3 mm) across the two lactations. However, BSH had significantly ( $P < 0.01$ ) more BF (18.2 mm vs. 15.8 mm) than HOL in first lactation. HOL had significantly more udder clearance ( $P > 0.01$ ) than BSH in first (60.0 cm vs. 62.4 cm) and second lactation (52.3 cm vs. 56.9 cm). Rear udder clearance was significantly less ( $P > 0.01$ ) for BSH than HOL in first (59.9 cm vs. 62.7 cm) and second lactations (52.0 cm vs. 57.1 cm), respectively. Teat length was significantly ( $P < 0.05$ ) longer for BSH in first lactation (5.10 cm, front; 4.29 cm, rear) than for pure HOL (4.81 cm, front; 3.96 cm, rear). During second lactation, BSH had significantly ( $P < 0.05$ ) longer front teats (5.0 cm vs. 4.6 cm) and rear teats (4.0 cm vs. 3.6 cm) than HOL. Across first and second lactation, BSH (2.21 cm) had ( $P < 0.05$ ) wider rear teats than HOL (2.11 cm). Summarizing, BSH had more body weight across lactation and differed in various body measurements from HOL.

**Key Words:** crossbreeding, Brown Swiss, heterosis

## Dairy Foods: Dairy Foods Processing/Enzymes

**748 Whey—From gutter to gold.** P. J. Jelen\*, University of Alberta, Edmonton, AB, Canada.

Whey.. oh whey! Where are the days when whey was a bothersome liquid resulting from the manufacture of cheese or casein and when pigs loved it! Careers were built on research projects aimed at utilization of this golden-green fluid, and descriptions of its magic properties were recorded in the literature since the days of Hippocrates. When nutrition became king, products based on whey started appearing on the market with increased frequency. Use of whey by modern dairy and food industries has developed along four main avenues: 1-products based on whole whey (principally whey cheeses and drinks); 2-products based on whey protein; 3-traditional and novel uses of lactose; and 4- everything else the whey research community came up with. Historically, the first attempts to utilize whey were aimed at “cutting the losses” of the cheesemakers by finding the least expensive disposal route, including uses as spraying onto pastures, transforming whey into animal feed, or simply discharging it into nearby streams. Crystallizing lactose from whey added some value, but brought the problem of what to do with the lactose. Nowadays, lactose is being crystallized mainly from the ultrafiltration permeates which replaced whey as the bad boy of the dairy industry, while whey itself is becoming the main product of interest in cheesemaking. Development of the various whey protein-based products advanced along two parallel and sometimes intertwined lines, technological and/or physiological functionality, and brought about the needed valorization aspect of whey usage for the mainstream processors. Whey drinks and whey cheeses, the traditional routes for turning whey into profitable products, are still important mainly in local markets as shown by the continued success of the Swiss whey drink, Rivella, or the popularity of the various whey cheeses in many countries. Some of the more unusual avenues for whey valorization, some of which are still in the “pipedream stage” include direct or indirect conversion into methane, economical production of unique high value lactose-based ingredients (e.g. “humanized oligosaccharides”) or profitable utilization of the main whey ingredient, the cow-water.

**Key Words:** whey, history, products

**749 Protein-interactions in heat-treated milk and effect on rennet coagulation.** P. Kethireddipalli\*, D. G. Dalgleish, and A. R. Hill, University of Guelph, Guelph, ON, Canada.

The underlying molecular processes that cause impaired rennet clotting of heat-treated bovine milk were investigated. Firstly, the effect of whey protein(WP)/κ-casein complexes bound to the casein micelle on the elastic modulus ( $G'$ ) and gelation times ( $T$ ) of renneted heat-treated milk was examined. Milks with different levels of micelle-bound WP (<5% to ~80%) were produced by heating skim milk at 90°C for 10 min at pH values ranging from 6.3 to 7.1. WP was quantified using SDS-PAGE. Lower pH produced higher micellar WP association and vice versa. Using oscillatory rheometry, we found that compared to unheated milk ( $G'$ , 83.5 Pa;  $T$ , 10 min) all heat-treated milks, after renneting, showed a remarkable reduction in  $G'$  (0.1 to 2.1 Pa) and a large increase in  $T$  (55 to 130 min). It did not seem to matter if the WP/κ-casein complexes were predominantly bound to the casein micelle (pH 6.3) or were largely present as soluble protein complexes in the lactosera (pH 7.1). In the second part, the individual effects of casein micelles and lactosera on the rennet gelation properties of heated milk were investigated. Two different milk systems were examined; one was prepared by re-suspending casein micelles from milk heated at pH values 6.3, 6.7, or 7.1 in native serum from unheated milk, and the other contained native micelles from unheated milk in the serum from the various pH- and heat-treated milks. Heat- and pH-modified casein micelles suspended in native serum significantly lowered the  $G'$  values of the resulting rennet gels. With the exception of pH 6.3, the heated lactosera also interfered with gelation of heat-treated milks. In the final part of our study, the serum from heat-treated milks was further examined after its ultrafiltration (removes WP/κ-casein complexes) or its dialysis against unheated milk (restores ionic composition). Both these processes significantly improved serum performance. This clearly demonstrated that not only serum ionic factors, but also serum WP/κ-casein complexes, and heat-modified casein micelles (with or without associated WP) significantly interfere with the rennet gelation of heat-treated milks.

**Key Words:** heat-treated milk, rennet, WP/κ complexes

**750 Effect of processing aids on mineral balance and fouling during ultrafiltration of cheese whey.** C. Marella\*, L. E. Metzger, and K. Muthukumarappan, *South Dakota State University, Brookings.*

The conventional membrane based manufacturing process for whey protein concentrate (WPC) and whey protein isolate (WPI) utilizes a three stage process that includes ultrafiltration, microfiltration and ultrafiltration. Although most manufacturers use a similar process, conventional WPC and WPI vary widely in their composition and salt content. These variations lead to variability in functionality that limits the use of WPC and WPI in some applications. The objective of the present study was to determine if mineral chelating processing aids have an impact on the removal of divalent ions and membrane fouling during the first ultrafiltration step of whey processing. Ultrafiltration experiments were conducted in triplicate using disodium phosphate, citric acid and ethylenediamine tetra acetic acid at three levels each. The level of each processing aid was based on its ability to chelate 2.5 mM (L1), 5 mM (L2) and 10 mM of calcium (L3) present in the whey. All the experiments were conducted in a lab scale plate and frame separation unit using a 10 kDa Polyether sulfone membrane, 172.4 kPa transmembrane pressure, 6.2 pH and 25° temperature. The effect of mineral chelating processing aids on membrane fouling was expressed in terms of overall and irreversible fouling resistances while the effect of these processing aids on divalent ions was expressed in terms of rejection coefficients at the end of ultrafiltration and after diafiltration. Statistical analysis of the fouling resistances showed no significant effect ( $P > 0.05$ ) of addition of processing aids on fouling of ultrafiltration membranes. Addition of citric acid at L2 resulted into the lowest rejection of calcium at the end of ultrafiltration (0.25) and after diafiltration (0.265). Addition of disodium phosphate at L3 resulted into the lowest rejection of magnesium at the end of ultrafiltration (0.175) and after diafiltration (0.24). The results demonstrate that mineral balance during the first ultrafiltration step can be modified with the addition of mineral chelating processing aids.

**Key Words:** ultrafiltration, mineral balance, processing aids

**751 Impact of bleaching on the flavor of whey protein concentrate.** A. E. Croissant\*, J. Kang<sup>1</sup>, R. E. Campbell<sup>1</sup>, E. Bastian<sup>2</sup>, and M. A. Drake<sup>1</sup>, <sup>1</sup>*North Carolina State University, Raleigh,* <sup>2</sup>*Glanbia Nutritionals, Twin Falls, ID.*

The increasing use and demand for whey protein as an ingredient requires a bland-tasting, neutral-colored final product. The bleaching of colored Cheddar whey is necessary to achieve this goal. Currently, hydrogen peroxide (HP) and benzoyl peroxide (BPO) are approved for bleaching liquid whey prior to spray drying. There is no current information on the impact of this process on flavor of spray dried whey protein concentrate (WPC). The objective of this study was to characterize the impact of bleaching on flavor of liquid and spray dried Cheddar whey. Cheddar cheeses colored with annatto were manufactured in triplicate. Four bleaching treatments (HP: 250 and 500 ppm and BPO: 10 and 20 ppm) were applied to liquid whey for 2 h at 60 C followed by cooling to 5C. A control whey with no bleach was also evaluated. Flavor of liquid wheys were evaluated by sensory and instrumental volatile analysis. One HP and one BPO treatment were subsequently incorporated into liquid whey and processed into spray dried WPC along with an unbleached control. WPC were evaluated by sensory and instrumental analyses as well as color and proximate analyses. Liquid whey and WPC that were bleached had higher concentrations of lipid oxidation products including heptanal, hexanal, octanal, and nonanal compared to unbleached liquid whey or WPC ( $p < 0.05$ ). HP products were higher in oxidation products compared to BPO products. HP liquid whey and WPC were

also higher in fatty and cardboard flavors compared to the controls or BPO samples. Color values (L, a, b) of WPC powders were distinct ( $p < 0.05$ ) on all three color scale parameters with HP WPC having the highest L values. These results indicate that bleaching of liquid whey does affect the flavor of WPC and that type of bleaching agent may also impact flavor and color of WPC.

**Key Words:** whey protein, bleaching, flavor

**752 An on-line light backscatter sensor at 980 nm for monitoring curd moisture and whey solids contents with a cooking step during syneresis in a cheese vat.** M. J. Mateo\*<sup>1</sup>, C. D. Everard<sup>1</sup>, C. P. O'Donnell<sup>2</sup>, M. Castillo<sup>3</sup>, F. A. Payne<sup>3</sup>, and D. J. O'Callaghan<sup>1</sup>, <sup>1</sup>*Teagasc, Cork, Ireland,* <sup>2</sup>*University College Dublin, Dublin, Ireland,* <sup>3</sup>*University of Kentucky, Lexington.*

The aim of this study was to use on-line light backscatter at 980 nm to monitor curd moisture and whey solids contents with a cooking step as an experimental treatment during syneresis. Milk was renneted at 32°C and, following gel cutting, the temperature was raised by 1 degree every 5 min until the temperature reached 38°C (the cooking step) or held at 32°C in the case of the control. A full factorial experimental design having two final temperatures (32 or 38°C), with three replicates ( $n = 6$ ) was performed. The trials were carried out using recombined whole milk in an 11 L cheese vat, in which a light backscatter on-line sensor was installed. Samples of curd / whey mixture were taken from the vat during syneresis using an on-line sampler at 10 min intervals and curd was separated from whey using a stainless steel 75-micron sieve. The effect of added shrinkage due to cooking of the curd is shown by its negative effect on curd moisture content. A model was developed which explained 86% of the variation in curd moisture content, involving three significant factors, namely time after gel cutting, the sensor response and final temperature, in order of standardised coefficient. By comparison, the sensor response alone predicted curd moisture content with  $R^2 = 0.74$ . The sensor response predicted whey solids content with  $R^2 = 0.81$ , without relying on any other factors. These results contribute to understanding the effect of cooking on the monitoring of curd moisture and whey solids contents when using an online light backscatter sensor.

**Key Words:** curd moisture, whey solids, light backscatter

**753 Development of rapid method for measurement of lactose in model solutions using a hand-held blood glucose biosensor.** J. Amamcharla\*, K. Shah, and L. Metzger, *South Dakota State University, Brookings.*

Current methods for lactose measurement in dairy products are time consuming, tedious and may require expensive equipment and skilled technicians. The aim of this research was to develop a novel, rapid method for measurement of lactose in model solutions. The method is based on rapid hydrolysis of lactose using  $\beta$ -galactosidase and subsequently measuring the glucose using a blood glucose meter. Blood glucose meters were developed after decades of research. Initially, lactase concentration, temperature and time required for near complete hydrolysis were determined. We found that the hydrolysis of lactose was complete in 10 minutes at 40°C using 2% enzyme. A randomized factorial experimental design with two factors, i.e. glucose meters (meter 1 & 2), test strips (lot 1 & 2), and three replications was performed. Each measurement was performed with three test strips from the same

lot using the same meter under different concentrations of lactose (50 – 400 mg/dL) in model solution. After incubation with lactase, the sample was applied onto the test strip and the glucose concentration was determined. We found that meters and replications were not significantly different ( $P < 0.05$ ). However, the test strip lots were significantly different from each other. A standard curve using all the data was linear and had a slope of 0.855 and intercept of -18.77 ( $R^2 = 0.99$ ). In order to verify the predictive ability of the method, different concentrations of lactose (1.9 – 6.5%) were prepared independently and analyzed using the proposed method as well as by HPLC. Since, the glucose meter reading was significantly influenced by test strip lot, six different lots were utilized in this experiment. Simultaneously, standard curves were also developed for each of the six test strip lots. Lactose concentration was then calculated from the combined and individual standard curves. The average absolute bias, calculated for 25 samples, was found to be between 0.08–0.17 for individual standard curve and 0.1 – 0.36 for the combined standard curve. The proposed method shows potential in rapid measurement of lactose in dairy products.

**Key Words:** lactose, glucose meter, rapid measurement

**754 Persistency of conjugated linoleic acid and vaccenic acid on Sardo cow cheese.** G. A. Gagliostro<sup>\*1</sup>, M. Martínez<sup>2</sup>, V. I. Cejas<sup>3</sup>, M. A. Rodríguez<sup>3</sup>, and M. Balán<sup>4</sup>, <sup>1</sup>*Instituto Nacional de Tecnología Agropecuaria, Balcarce, Buenos Aires, Argentina*, <sup>2</sup>*Instituto Nacional de Tecnología Agropecuaria, Salta, Argentina*, <sup>3</sup>*Instituto Nacional de Tecnología Industrial, PTM MIGuelete, Buenos Aires, Argentina*, <sup>4</sup>*PRODEO S.R.L., Chivilcoy, Buenos Aires, Argentina*.

Persistency of 9-cis 11-trans C18:2 (CLA), trans-11 C18:1 (VA) and other fatty acids (FA) was tested on Sardo cheese elaborated from milk with high CLA and VA contents. The same feeding trial and cows were also used when transfer of FA to Tybo cheese was tested. Milk was obtained from eight Holstein cows (570 kg, 109 days in milk) producing 24.8 kg milk/d and consuming (DM basis) 7.3 kg/cow of concentrate, 1.94 kg/cow/d of a TMR (corn silage, 70%, soybean oil, 22%, fish oil 5.4% and urea, 2.6%) and 8 kg of pasture. After 25 days of adaptation, milk was collected and transformed into Sardo cheese reproducing industrial conditions. Milk and cheese FA composition was analyzed by GLC and differences in FA content between milk and cheese were stated using the T-test for paired observations. Milk fat, protein and lactose contents were 23, 35.1 and 47.1 g/kg respectively, with a fat/protein ratio of 0.65. Intake of 427 g/d of soybean oil (229 g of C18:2) and 105 g of fish oil contained in the TMR reduced the atherogenicity index ( $AI = [(C12 + 4C14 + C16)/\text{total unsaturated}]$ ) of milk from a pre supplementation basal value of 2.06 to 1.16. Basal concentration

(g/100g) of the atherogenic FA C12:0 (4.04) C14:0 (12.52) and C16:0 (29.16) were decreased by intake of oils (C12:0 = -1.66, 41%, C14:0 = -3.48, 28% and C16:0 = -4.89, 11%). After oil supplementation milk CLA content increased from a basal value of 1.42 to 3.58 g/100g and VA from 2.56 to 3.58 g/100g FA. Elaborated Sardo cheese contained 26.73% fat and 31.23% protein (w/w) with an atherogenicity index of 1.22. Significant differences between milk FA and cheese FA content were not detected. Transfer of 9-cis 11-trans CLA to Tybo cheese averaged 98%. Assuming that the cheese fat contain 95% FA, intake of 90 g/d of Sardo cheese rich in CLA may allow to obtain the suggested anticancer dose (800 mg) of CLA. These results were obtained using a feeding strategy that may be easy carried out by the farmer and the grazed forage represented about 46.4% of total dry matter intake.

**Key Words:** Sardo cheese, conjugated linoleic acid, vaccenic acid

**755 Dairy food intake among historically African American college campus students.** A. M. Patterson\* and S. A. Ibrahim, *North Carolina A & T State University, Greensboro*.

Dairy foods, such as milk, cheese, and yogurt are one of the greatest sources of essential nutrients such as potassium and calcium. Dairy foods are also mostly known for their importance in bone health and overall diet health. Previous studies have shown a low consumption of dairy foods among African American, but no recent studies have been conducted with African American college campus students. The purpose of this study was to survey a sample of students about the consumption of dairy foods from a historically African American college campus. Fifty four male and female students provided information on their intake of dairy products by completing the Food Frequency Questionnaire (FFQ). The section of the FFQ of interest to this study related to what type of dairy products (cheese, yogurt, ice cream, liquid milk) and other food items that include dairy products (pizza, hamburgers, etc.) are eaten and how often consumed. The survey also inquired about their intake amounts, and their feelings and attitudes about those foods that are consumed and the ones that are not consumed. Our results indicated that there was a low dairy products intake among the students that participated. Ninety percent of the respondents reported consuming less than the recommended daily amount; males tended to consume more than females. Both males and females received most of their dairy from cheeses that were included on foods such as pasta, pizza, cheeseburgers, but the most popular dairy product that was consumed was ice cream. The results suggest that African American college campus students need to increase their dairy food consumption, but do so by choosing healthy dairy foods such as yogurt, low-fat cheeses and milk.

**Key Words:** historically African American, dairy products

## Forages and Pastures: Grazing and Pasture Utilization

**756 Effect of fall grazing system on annual ryegrass quality and beef cattle performance.** J. M. Kelzer<sup>\*1</sup>, S. Bird<sup>2</sup>, R. D. Mathison<sup>2</sup>, P. R. Peterson<sup>1</sup>, and R. S. Walker<sup>3</sup>, <sup>1</sup>*University of Minnesota, St. Paul*, <sup>2</sup>*University of Minnesota, Grand Rapids*, <sup>3</sup>*University of Minnesota, Andover*.

Windrowed and stockpiled annual ryegrass as fall grazing systems were evaluated for forage quality and beef cow performance over two separate years. In 2007 and 2008, two 6-acre paddocks were seeded in early spring with annual ryegrass, rotationally grazed during summer, fertilized, and stockpiled in August. In mid-October, forage from one-

half of each replicated 6-acre paddock was cut while the other half was left standing. Two windrows in each cut section were raked together 1 d following swathing to represent the windrow treatment. Dry, pregnant Angus beef cows ( $n = 32$  each year) averaging  $651 \pm 75$  kg BW,  $5 \pm 2$  yr of age,  $125 \pm 22$  d pregnant, and BCS of  $5.5 \pm 0.5$  for 2007 and  $582 \pm 80$  kg BW,  $4 \pm 3$  yr of age, 131 d pregnant, and BCS of  $5 \pm 0.4$  were assigned randomly to one of four 3-acre paddocks representing one of two grazing treatments: 1) windrowed annual ryegrass (WIN), and 2) stockpiled annual ryegrass (STO). Data for forage quality and animal performance were collected and analyzed by year. Forage CP, ADF,