

between age of bull and scrotal circumference at either ECRC ($P = 0.30$) or BIC ($P = 0.74$). Because hair whorl numbers are consistent from birth, within a particular breeding program, the absence and/or number of facial hair whorls may provide a visual estimate of current or future scrotal circumference in yearling bulls.

Key Words: Hair whorls, Scrotal circumference, Bulls

590 Correlated responses in carcass and meat quality traits in a line of Landrace pigs selected for increased ultrasound loin eye area. D.L. Kuhlers^{*1}, K. Nadarajah¹, S.B. Jungst², and B.L. Anderson¹, ¹Auburn University, AL, ²PIC, Franklin, KY.

Selection for increased ultrasound loin eye area (ULEA) in pigs might cause changes in carcass and meat quality traits. Five generations of single trait selection conducted in a line of Landrace pigs for increased ultrasound loin eye area (ULEA) showed a difference of 10.6 cm² in average EBVs between select (SL) and control (CL) lines for ULEA. The objective of this study was to examine the impact of increased ULEA on changes in carcass and meat quality traits. Real-time ULEA data at 10th rib of 1406 pigs at 168 d of age, and of those 192 barrows that had carcass measurements for carcass length (CLGT), backfat thickness at 10th rib (CFAT), *longissimus* muscle area (CLMA) between 10th and 11th ribs, percent lean cuts (PCNL), color (COLR) and marbling (MARB) scores (1-5 scale) were used for this study. Heritabilities and genetic correlations were estimated by the multivariate REML procedure using MTDFREML. For ULEA, the model considered the fixed effects of generation, sex, covariate of 168 d weight, and random effects of animal, litter and error. For carcass traits, fixed effect of generation, covariate of hot carcass weight and random effects of animal and error were considered. Estimates of heritabilities for ULEA, CLGT, CFAT, CLMA, PCNL, COLR and MARB were .47, .74, .71, .41, .27, .35 and .43, respectively. Genetic correlations of ULEA with CLGT, CFAT, COLR and MARB were negative and the correlation with CLMA was very high (.99). Estimates of genetic correlations of CLGT with CFAT and CLMA were -.26 and -.67, respectively. Average EBVs of SL pigs in the fifth generation were 4.35 cm less for CLGT and 0.57 cm less for CFAT than those of CL pigs. Compared to CL pigs, the average EBVs of SL pigs showed differences of 11.2 cm² for CLMA and 3.28% for PCNL, and a reduction of a point in scores for COLR and MARB, respectively. Selection for increased ULEA resulted in improvement in CLMA and CFAT with concomitant reduction in CLGT, COLR and MARB.

Key Words: Selection, Ultrasound Loin Eye Area, Carcass and Meat Quality

591 Between-breed variation in response to *Haemonchus contortus* infection in sheep. H. B. Vanimisetti^{*}, S. P. Greiner, A. M. Zajac, and D. R. Notter, Virginia Polytechnic Institute and State University, Blacksburg.

The objective of this study was to compare breed differences in resistance to *H. contortus* in sheep. A total of 131 ewe lambs representing Dorset (DO) and Dorper (DP) crossbreds (out of 1/2-Dorset, 1/4-Rambouillet, 1/4-Finnsheep ewes) and straightbred Katahdins (KT) were evaluated in 2000 and 2001. In addition, 82 DO, DP, KT and Barbados Blackbelly X St. Croix (HH) wethers were evaluated in 2001. After deworming at 4 mo of age, ewes were dosed with infective larvae and evaluated in drylot, whereas wethers were evaluated on pasture with natural infection. Parasite eggs per gram of feces (FEC), log transformed FEC (LFEC), packed cell volume (PCV; %), and body weight (BW; kg) were measured 3, 4, 5 and 6 wk after deworming and reinfection. A repeated-measures analysis of variance included breed, year (for ewes), week and their interactions. Least square means and SE (in parenthesis) for ewes (E) and wethers (W) across sampling times are shown below. Breed and week influenced all traits ($P < 0.05$) except BW in ewes. The DP had highest FEC at all times followed by DO and KT. Breed x week interaction affected ($P < 0.05$) LFEC in both sexes, BW in wethers and FEC in ewes. The DP had higher PCV ($P < 0.05$) than DO despite their higher FEC. The HH wethers had lowest FEC at all times and smallest drop in PCV 6 wk after deworming. All breeds grew throughout the study, but DP wethers grew least rapidly. The DP were clearly not more resistant to parasites than DO, whereas the KT and HH were most resistant. Mean BW was negatively correlated to FEC and LFEC and positively correlated to mean PCV. Mean PCV was negatively correlated to FEC and LFEC. Clear breed differences in resistance to *H. contortus* thus exist.

Trait	DO-E	DP-E	KT-E	DO-W	DP-W	KT-W	HH-W
BW	41.5 (0.8)	42.8 (1.1)	41.2 (0.9)	32.4 (0.9)	29.8 (0.9)	26.0 (1.2)	24.5 (1.2)
PCV	26.4 (0.3)	27.9 (0.5)	29.8 (0.4)	24.3 (0.8)	24.5 (0.9)	26.7 (1.1)	27.4 (1.1)
FEC	2043 (183)	3007 (261)	1460 (227)	1931 (196)	2269 (208)	1469 (264)	673 (257)
LFEC	7.3 (0.1)	7.6 (0.1)	6.4 (0.1)	7.2 (0.1)	7.4 (0.1)	6.7 (0.2)	5.8 (0.2)

Key Words: *H. contortus*, Parasite resistance, Sheep

**Dairy Foods
Sensory**

592 Trace thiol compounds in aged cheddar cheese. J.P. Kleinhenz¹, W.J. Harper^{*1}, and M. A. Drake², ¹The Ohio State University Columbus, Ohio, USA, ²North Carolina State University, Raleigh, North Carolina, USA.

Sulfur compounds are known to be important in the flavor of Cheddar cheese and also have sensory thresholds in very small concentrations, ranging from parts per billion to parts per trillion, depending on the individual compound. A method was developed to detect very low (ppt) concentrations of thiol compounds in Cheddar cheese. Two pounds of Cheddar cheese was warmed to 37°C and centrifuged to recover about 200 g of cheese fat. This was then diluted with an equal volume of redistilled hexane, and extracted with a basic 25% ethanol solution containing Tris carboxyethyl phosphine, a disulfide reducing reagent, and p-hydroxymercuribenzoic acid, a thiol trapping salt, to capture the thiol compounds in a reduced state. The pH of the 25% ethanol solution was then lowered to 6.5, and the p-hydroxymercuribenzoic acid-thiol complex was concentrated on an ion exchange resin. The thiol compounds were eluted with aqueous cysteine, and then recovered by extracting the aqueous cysteine solution with a 2:1 solution of pentane and diethyl ether, dried over anhydrous sodium sulfate, concentrated by evaporation under nitrogen, and analyzed by GC with a Sulfur Chemiluminescence detector. The method was shown to be specific for thiol compounds. The internal standard was 3-methoxythiophenol. The method was applied to 8 commercial Cheddar cheeses more than 6 months old, which

had been shown to differ in 4 sulfur descriptors (total sulfur, cat like, match like and egg like). Multiple thiol compounds were separated from all cheeses. The extracts from the different cheeses showed both quantitative and qualitative differences. Up to 30 compounds were shown to be present in any given cheese. Identification of the compounds has been complicated by lack of available standard compounds. One polyfunctional thiol compound shown to be present in different concentrations in most of the cheeses was 4-mercapto-4-methylpentan-2-one, which has been responsible for a catty flavor taint in Gouda cheese. Based on Kovats retention indices, other polyfunctional thiols are also present.

Key Words: Cheddar, thiols, flavor

593 Comparison of descriptive sensory analysis with electronic nose differentiation of commercial Swiss cheese. W. J. Harper^{*1}, J. Kuo¹, and M. A. Drake², ¹The Ohio State University, Columbus, Ohio, USA, ²North Carolina State University, Raleigh, NC, USA.

There is need for methods that differentiate and monitor flavor quality of cheese. This includes rapid screening analytical methods, such as electronic noses. We have shown previously that similar differentiation can be obtained for Cheddar cheese using descriptive sensory analysis and an Electronic Nose with a Mass Spectrometer detector in a Negative Chemical Ionization mode for aged Cheddar cheeses. This approach

has now been extended to commercial Swiss cheese. Twelve commercial Swiss cheeses of varying ages were obtained from 8 different sources. Sensory properties of the cheeses were evaluated in duplicate by descriptive sensory analysis with a highly trained sensory panel (n=10). The Agilent Technology Chem. Sensor 4400 (electronic nose), using a Mass Spectrometer detector in chemical ionization mode was used to analyze the headspace aroma of cheeses in triplicate. The data from sensory analysis and the electronic nose were analyzed statistically to provide both cluster and principal component analysis plots. Cluster analysis of the sensory data showed separation of all 12 cheeses from each other. One cheese, with high faecal and salty scores was unrelated to the other cheeses. The other 11 cheeses grouped into 4 other clusters with a similarity of less than 50%. Only one pair of cheese had a similarity of greater than 70%. Descriptors with scores >3.5 and not present in most other cheeses appeared to be important in the differentiation of cheese flavor by the sensory panel. Good differentiation of the cheeses was obtained also with the electronic nose. Nine of the 12 cheeses showed distinctly different clusters, but the similarity was >70%. The cluster patterns were different from those obtained by the descriptive sensory panel. Two clusters with no similarity contained 6 cheeses in each cluster. Each of these clusters subdivided into 3 separate clusters. Although good differentiation was obtained by both methods, it was clear that the basis of differentiation was different in each case.

Key Words: Swiss cheese, descriptive sensory analysis, electronic nose

594 Impact of starter culture on flavor of liquid cheddar cheese whey. M. E. Carunchia Whetstone*, J. D. Parker, D. K. Larick, and M. A. Drake, *North Carolina State University, Raleigh, NC.*

Dried whey and whey protein are commonly used in dairy products and other foods. Functionality of whey products has been studied extensively. Flavor of dried whey ingredients has not been studied as widely although problems with flavor variability exist. Flavor inconsistency and flavors which may carry through to the finished product can limit whey ingredient applications in dairy and non-dairy foods. One source of flavor variability in dried whey ingredients is the raw product - liquid whey. The scope of this research was to determine the impact of starter culture rotation on the flavor of liquid Cheddar cheese whey.

Liquid Cheddar cheese whey from five culture blends from two different Cheddar cheese manufacturing facilities were collected. Whey flavor was determined using instrumental and sensory methods. Dynamic headspace analysis with gas chromatography/mass spectrometry was used to identify volatile compounds, while solid-phase microextraction was used to determine free fatty acid profiles. Free amino acid analysis was conducted using reverse phase high performance liquid chromatography. A trained descriptive sensory panel (n=8) determined the sensory properties of the liquid wheys.

There was wide variation in the headspace volatiles between samples, especially those from different manufacturing facilities. Hexanal and diacetyl were two key volatiles that varied widely with starter culture (p<0.05). The fatty acid profiles of the whey samples were also different (p<0.05). There was no differentiation in free amino acid content of wheys (p>0.05). Differences in whey flavor profiles were also confirmed by sensory analysis. The flavor of liquid Cheddar cheese whey is variable and impacted by starter culture rotation. Results from this study will aid future studies that address the impact of liquid whey flavor variability on flavor of dried whey ingredients.

595 Effect of feeding systems on composition and organoleptic quality of goat milk cheese. A. K. Soryal, S.S. Zeng*, B. Min, S. Hart, B. Bah, and K. Tesfai, *Langston University.*

This study investigated effects of different feeding systems on chemical and biochemical composition, and organoleptic scores of a goat milk soft cheese. Three groups of lactating Alpine goats (BW = 54-10 kg) grazed with different levels of concentrate supplementation on pasture (A: no concentrate; B: 0.33 kg concentrate; C: 0.66 kg concentrate) and the fourth group (D) was confined and fed 0.66 kg concentrate and alfalfa hay *ad lib*. Ten kg of milk from each group was collected and made into a soft cheese twice monthly from April through September 2001. Cheese samples were analyzed for fatty acid, fat and protein contents, and were evaluated for sensory quality at fresh, 1 mo. and 2 mo. Results indicated that feeding system did not affect fat or protein content in cheese on dry-basis at any age (P > .05). However, there were significant differences in total fatty acid concentrations and sensory scores (P < .05), especially at fresh and 1 mo. old. Significant differences were also found

in fat, protein, and total fatty acid concentrations and in sensory scores of soft cheese at different stages of lactation. The cheeses showed higher fat content and higher total fatty acid concentration at the early and at the late lactations than in the mid-lactation stages (P < .01). The total organoleptic score (body & texture and flavor) increased linearly (P < .01) as lactation progressed. Cheese from A had more abundant short-chain fatty acids (C₆ to C₁₀) than cheese from D (P > .05). Negative correlations were found between total fatty acid concentration and sensory scores (r = -0.20 to -0.28) at all ages. In conclusion, milk from grazing goats supplemented with a high level of concentrate resulted in cheese with a higher total fatty acid content and a lower short-chain fatty acid concentration, and a lower sensory score of cheese compared with milk from goats without or with a low level of concentrate.

Key Words: Goat milk, Cheese, Fatty acids

596 Impact of pasture on sensory properties of Ragusano. S. Carpino*¹, J. Horne¹, C. Melilli¹, G. Licitra², and D.M. Barbano³, ¹*Consorzio Ricerca Fileria Lattiero-Casaria, s.p.a. 5, 97100 Ragusa, Italy,* ²*D.A.C.P.A, Catania University, 95100, Catania, Italy,* ³*Department of Food Science, Cornell University, Ithaca, NY 14853.*

Ragusano cheese is produced in the Hyblean region of Sicily. As the cheese is aged, the color and other sensory characteristics are changed. A quantitative descriptive sensory panel for evaluation of flavor, aroma, and texture may be biased by a darker-colored cheese and thus believe it has stronger aroma or flavor and different texture because the color would indicate it is an "older" cheese. In order to eliminate this potential source of bias in sensory analysis, colored eye glasses (Post-Mydriatic sunglasses, 100% UV protection to 400 nm, Solarettes Supplier, Optics and Service Centrostyle, Italy) that effectively blocked light of the range of wavelength reflected by Ragusano cheeses were selected and used by panelists during training and evaluation of unknown cheese samples. The objective of this study was to determine if there were any differences in flavor, aroma, and texture of cheeses made from milk produced on the same farm, but from two different groups of cows that were on different feeding regimes. One group of cattle were allowed to graze on natural Hyblean pasture, while the other group consumed a total mixed ration (TMR). Statistical analysis with repeated measures Anova was used to determine whether different feeding treatments had a significant impact (P<0.05) on panel scores for descriptive terms, and on instrumental measures of color (i.e., L, a, b -values). Pasture cheeses were found to be more yellow (higher a- and b- values) than TMR cheeses. They also reflected less light in the range of 460-500 nm. Sensory analysis demonstrated that the pasture cheeses had stronger aromatic impacts in the categories of "floral", "green", and "pungency". They also differed somewhat from the TMR cheeses in their texture qualities.

Key Words: Cheese, Sensory, Glasses

597 Flavors and off-flavors associated with full fat and low fat chocolate milk in the North Carolina marketplace and school lunch program. A.P. Hansen*, *North Carolina State University, Raleigh, N.C. USA.*

Chocolate milk samples were obtained from local dairies and grocery stores. Samples were also obtained from the school lunch program for flavor evaluation. The chocolate milk contained from 1/2 to 1% cocoa, high fructose corn sugar, vanillin, ethyl vanillin, cornstarch, guar and carageenan. Samples were evaluated over a ten-year period. The chocolate milk in the school lunch program was of the poorest quality. There tended to be more off flavors due to poor quality cocoa such as musty, malty, moldy, smoky, burnt cocoa flavors and whey flavor. Other milks lacked chocolate flavor and color with more vanillin taste.

Analysis of premium chocolate milk samples tends to yield good chocolate flavor. Some samples have a higher level of vanillin and ethyl vanillin, which tend to overpower the chocolate flavor. The store brands tend to have a better chocolate flavor than the school lunch chocolate milk. Flavors associated with store brands were malty, overheated or burnt, alkaline, lacks chocolate flavor, vanillin and ethyl vanillin. Some samples are just sweet, brown in color and almost have no chocolate flavor. Over the past 2-3 years the quality of chocolate milk store brands has been improving due to the competition from the national brands. People can taste and are looking for good quality chocolate milk.

Key Words: Chocolate milk, Flavor, Marketplace

598 Quality attributes of lightly salted sweet cream butter in the North Carolina marketplace. A.P. Hansen* and M.D. Keziah, *North Carolina State University*.

Approximately 300 samples of sweet cream butter were obtained from local stores in North Carolina and nearby states. The samples were collected over a three-year period and analyzed for flavor. This evaluation was conducted with 15 trained dairy judges according to ADSA protocol. The variation in quality and uniformity was quite different across brands. The color of the butter went from whitish to yellow in color depending on if it was winter butter or summer butter. The flavors identified in the National Brands were coarse and slight feed but they were consistently good month after month. The store brands tend to have many more flavor defects. Going from the most to the least they were as follows: old cream, high salt, neutralizer, storage, flat, coarse, acid, scorched and oxidized. The store brands also had slight coarse and slight feed as the national brands and some store brands were consistently better than other store brands. In most cases, it was related to the price of the butter.

Key Words: Butter, Marketplace, Quality

599 Characterization of volatile nutty flavor compounds in Cheddar cheese. M.A. Drake*¹, Y.K. Avsar², Y. Karagul-Yuceer¹, and K.R. Cadwallader³, ¹*North Carolina State University*, ²*Mustafa Kemal University*, ³*University of Illinois*.

Cheese flavor is the one of the most important criteria in determining consumer choice and acceptance. Cheddar cheese flavor ideally is com-

posed of sulfur and nutty flavors. The aim of the present study was to characterize the volatile compounds responsible for nutty flavors in Cheddar cheese.

Cheddar cheeses (1-3 years old) were screened for nutty flavor by a descriptive sensory analysis panel (n=7). Samples with and without nutty flavor (4 cheeses each) were selected and analyzed for volatile aroma compounds. Cheeses were grated and extracted with diethyl ether containing internal standards (2-methyl-3-heptanone and 2-methyl-pentanoic acid). Volatiles were isolated by high vacuum distillation. Volatile extracts were separated into acidic and basic/neutral fractions, which were then analyzed by gas chromatography-olfactometry (GCO). Identification of odor active compounds was carried out by comparison of GC-MS data, retention indices and odor properties against reference standards.

Results showed that the compounds found in the neutral/basic phase, 2-acetyl-1-pyrroline and 2-acetyl-2-thiazoline (popcorn/nutty/roasted), 2-isopropyl-3-methoxy pyrazine (earthy), 3-(methylthio)propanal (boiled potato), 2,3-butanedione (buttery), trimethylpyrazine (nutty/dirty) and δ -decalactone (sweet/fatty) were the most odor-active compounds and their intensities were higher in nutty cheeses. Volatile fatty acids including acetic, propionic, pentanoic and butanoic acids were found in acid fractions of both nutty cheese and not nutty cheeses. The data obtained in this study will be used for better understanding Cheddar cheese flavor and for identification of the chemical pathways for the formation of these compounds.

Key Words: Cheddar Cheese, Flavor, Nutty Flavor

Food Safety Foodborne Pathogens

600 Acid resistance status of *Escherichia coli* O157 in bovine feces as shed from naturally contaminated cattle. E. D. Berry* and G. A. Barkocy-Gallagher, *USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE*.

Exposure to low pH and acids in the bovine gastrointestinal (GI) tract may result in the induced acid resistance of *E. coli* O157. Because bovine feces are a source of carcass contamination, and acid tolerance of bacteria can affect the efficacy of decontamination procedures, the acid resistance of this organism as shed from cattle was determined. The objectives of this study were to examine the capacity of naturally-occurring *E. coli* O157 shed in bovine feces to survive exposure to low pH and to assess the relative acid resistance status of *E. coli* O157 as shed from cattle. Fecal grab samples and freshly-dropped feces were collected randomly from cattle in the MARC feedlot from August through October in 2000 and 2001. Initial numbers of *E. coli* O157 and numbers following exposure to pH 2.5 for 6 h were determined in fecal slurries, using a most probable number-immunomagnetic separation procedure. Isolates were confirmed as *E. coli* O157 and genotyped by pulsed-field gel electrophoresis. Fifteen positive fecal samples containing at least four distinct genotypes were obtained. Initial populations ranged from 0.99 to 4.86 log₁₀ CFU/g, and log reductions following acid challenge ranged from 0.68 to 3.21 log₁₀ CFU/g. For each unique isolate, acid resistance was determined in vitro for cells both in mid-log and stationary phases of growth, cultured with and without glucose (acid-adapted [AA] and nonacid-adapted [NA], respectively), by exposing the cells to the same acid challenge as the fecal slurries. Stationary phase cells were resistant to the acid challenge; generally, reductions of AA cells were <0.20 log₁₀ CFU/g and NA cells were <0.60 log₁₀ CFU/g. Log reductions of all mid-log phase cells were >4.00 log₁₀ CFU/g and many populations were reduced below detectable levels. Comparison of the in vivo and in vitro acid resistance data indicates that residence in the bovine GI tract does not result in the development of extreme acid resistance of *E. coli* O157.

Key Words: *E. coli* O157, Acid Resistance, Cattle

601 Effect of preconditioning and distance of transport on shedding of *Escherichia coli* and *E. coli* O157:H7 by calves destined for feedlot. S.J. Bach*¹, T.A. McAllister¹, G.J. Mears¹, A.L. Schaefer², and K.S. SchwartzkopfGenswein³, ¹*Agriculture and Agri-Food Canada, Lethbridge, AB*, ²*Agriculture and Agri-Food Canada, Lacombe, AB*, ³*Alberta Agriculture, Food and Rural Development, Lethbridge, AB*.

The effects of stressors (weaning, transport) on shedding of total *Escherichia coli* and *E. coli* O157:H7 were investigated using 174 range steer calves (80 Angus; 94 Charolais) blocked by breed and birth date and assigned to 4 treatments. The calves were preconditioned (P) or not (NP), and transported by commercial cattle liner for 15 h (long haul, L) or 3 h (short haul, S). Preconditioning comprised vaccinating 29 d prior and weaning 13 d prior to hauling; NP calves were weaned 1 d prior to transport (no vaccination). The NP calves were also penned (water only) for 24 h, followed by a second (2-h) haul. This simulated transport from ranch to feedlot for P calves; and from ranch to auction to feedlot for NP calves. Following transport, calves were allotted to 16 feedlot pens. Fecal samples were collected at weaning, day of transport, day of feedlot arrival, twice in the first week, and on d 7, 14, 21 and 28 for enumeration of *E. coli* Biotype 1, and culturing for *E. coli* O157:H7 (+ or -). Higher levels ($P < 0.005$) of *E. coli* were shed by NP-L calves than by P-L, NP-S or P-S calves at weaning, on day of arrival at the feedlot, and after 1, 7 and 21 d. Repeated measures analysis revealed the same was true over the entire experimental period ($P < 0.005$). No calves were positive for *E. coli* O157:H7 prior to transport. Chi-square analysis revealed that after transport, more ($P < 0.005$) calves were positive for *E. coli* O157:H7 in the NP-L group than in P-L, NP-S or P-S. Holding facilities or the feedlot may have served as source of infection, fostered by intensive association of animals during transport and relocation. Lack of preconditioning coupled with long-haul transport increased fecal shedding of *E. coli* O157:H7 by calves following transport. Management strategies to reduce stress-associated shedding of *E. coli* O157:H7 may include preconditioning.

Key Words: Cattle Transport, *E. coli* O157:H7, Fecal Shedding