

average polymorphism information content of the SNPs was 0.287 (0 to 0.375). The average SNP heterozygosity was 0.329 (0 to 0.50). Initial linkage analysis using variance component approach for milk, fat and protein yield has detected QTL at regions of the chromosomes known to harbor QTL based on previous studies. It is anticipated that this study will validate some of the QTL already mapped and new QTL will be discovered.

Key Words: Mapping QTL, Linkage Analysis, Dairy Cattle

564 Economic value of a marginal increase in pregnancy rate in dairy cattle. A. De Vries*, *University of Florida, Gainesville.*

Objective of this study was to estimate the economic value of a marginal (1-percentage point) increase in 21-d pregnancy rate in dairy cattle. The computer simulation program DairyVIP (<http://dairy.ifas.ufl.edu/tools>) was used. Based on user-defined inputs such as lactation curves, 21-d service rates, probabilities of conception, feed intake, involuntary culling, body weights, and costs and prices, DairyVIP first optimizes breeding and replacement decisions for individual dairy cows and then calculates many herd statistics such as pregnancy rate and profit per slot per year. An average herd in the US was modeled. Key default values were: service rate 43%, probability of conception 40% and slightly decreasing by DIM, heifer price \$1600, and milk price \$31/cwt. Default pregnancy rate was 16% and profit per slot per year was \$389. Service rates and probabilities of conception were changed simultaneously and similarly. The economic values of a 1-percentage point increase in pregnancy rate around 7%, 14%, 18%, 23% and 34% were \$32.04, \$14.49, \$9.92, \$6.76, and \$3.31 per slot per year, respectively. The greatest contributing factors were reductions in herd turnover costs resulting from lower cull rates. Sensitivity analysis by changing the default heifer price, milk price, milk yield, and risk of involuntary culling independently by 20% revealed that heifer price had the most effect on the economic value of a marginal increase in pregnancy rates. When heifer price was \$1920, economic values were respectively \$41.93, \$17.89, \$11.84, \$7.98, and \$3.73. When heifer price was \$1280, economic values were respectively \$21.71, \$10.59, \$7.44, \$5.27, and \$2.72. Twenty percent lower risk of involuntary culling and less time to become pregnant before culling also increased

the economic value of marginal increases in pregnancy rates, but typically not more than \$2. Greater milk price and greater milk yield increased the marginal value only when pregnancy rate was greater than 14%. In conclusion, the economic value of a marginal increase in 21-d pregnancy rate is considerably greater at lower levels of pregnancy rates.

Key Words: Pregnancy Rate, Economics, Value

565 Relationships between locomotion and lesion score, punch resistance and Holstein (HUKI) conformation scores. B. Winkler¹ and J. K. Margerison*², ¹*University of Plymouth, Plymouth, UK,* ²*Massey University, Palmerston North, New Zealand.*

Dairy heifers (n 20) were used to assess locomotion, lesions score (LS) in the sole horn and hoof samples were collected from all claws and analyzed for elastic modulus (ELM) and puncture resistance (PR), each measurement was replicated five times on the same area of each claw. All heifers were assessed (HUKI) for conformation. Elastic modulus of the tension test of the sole at day 100 postpartum was significantly ($P<0.01$) negatively correlated to locomotion score at 154 dpp ($R^2 = -0.61$). HUKI score for rear legs was significantly ($P<0.05$) and positively correlated to punch resistance of sole and white line horn at 40 days prepartum ($R^2 = 0.55$ and 0.50) and elastic modulus of sole at 50 dpp ($R^2 = 0.53$). HUKI score for feet was significantly ($P<0.01$) and positively correlated to punch resistance and negatively correlated to lesion score of white line area at 40 days prepartum ($R^2 = -0.50$) and to the number of days the animals were severely lame throughout the lactation ($LS > 4$ ($R^2 = -0.50$)). HUKI locomotion score was significantly ($P<0.05$) and positively correlated to punch resistance of the white line horn at 100 dpp ($R^2 = 0.50$). HUKI total score for legs and feet was significantly ($P<0.05$ to 0.01) negatively correlated to punch resistance of white line horn at 150 dpp ($R^2 = -0.50$) and the number of days the animals were severely lame throughout the lactation ($LS > 4$ ($R^2 = -0.48$)). HUKI total final score was significantly ($P<0.05$ to 0.01) negatively correlated to punch resistance of white line horn at 50 and 150 dpp ($r = -0.50$) and to the punch resistance of the sole horn at 150 dpp ($R^2 = -0.60$).

Key Words: Conformation, Lameness, Dairy heifers

Companion Animals: Pet Food Ingredients - Mining, Dredging, and Extrapolating Effective Nutrient Delivery

566 Advances in evaluating pet food ingredients: Methodologies. G. C. Fahey, Jr.*, *University of Illinois, Urbana.*

Many ingredients exist that may be included in complete and balanced diets for pets. Dogs and cats are unique in that they can spend considerable numbers of years in the senior and (or) geriatric states, making the list of potential dietary ingredients even longer than would be the case for other species. It is important that ingredients be described in detail in order to allow for maximal utilization of their nutrients. Several levels of evaluation exist, beginning with a thorough analytical description of the ingredient. Modern analytical

methods allow for near complete descriptions of macronutrients and micronutrients. In vitro testing constitutes the next level of evaluation and is very useful in predicting digestive physiological behaviors. The third level of evaluation is conducted in vivo with an animal model (e.g., use of the cecectomized rooster to determine true metabolizable energy and true amino acid digestibility values). The fourth and final level of evaluation is conducted with the target species and can take a number of forms: palatability, growth performance, and tolerance assays; digestibility evaluations, both ileal and total tract; balance studies; and gestation/lactation performance tests.

Key Words: Pet, Nutrient Bioavailability, Ingredients

567 AntiNutrients: Factors limiting utilization of nutrients in pet food ingredients. C. M. Grieshop* and G. Kuhlman, *The Iams Company, Lewisburg, OH.*

Companion animal nutritionists face many of the same challenges as other species animal nutritionists regarding the need to understand and correctly process ingredients used in their diet formulations. As with many farm animal diets, certain ingredients contribute antinutritional factors that require unique handling practices or formulation strategies to allow their optimal use. Many of the vegetable protein sources commonly used in farm animal diets (ie. soybean meal and corn gluten meal) are also used in companion animal diets and as with all species, unique amino acid composition or particular nutrient inhibitors, (ie. trypsin inhibitor in soybean meal) must be accounted for and properly handled before these ingredients can be used in companion animal diets. When ingredients such as these are incorporated into pet food diets the same precautions must be taken to deal with antinutritional factors as with diets of most species. In addition, some of the more unique ingredients that are used in companion animal diets also offer challenges in obtaining maximal nutritional value. Chicken by-product meal; a major protein source found in many companion animal diets, can be extremely variable in digestibility due to: different processing conditions, time of year the birds are harvested, type of bird used, and content. Another commonly used protein source, fishmeal, can be highly variable in salt and fatty acid content. In addition, companion animals have unique vitamin and mineral requirements as it has recently been realized that due to very poor bioavailability, copper sources obtained from copper oxide should not be considered when meeting the copper needs of the cat. Further confounding these issues, is the fact the pet food diets are most often produced under high temperature high moisture conditions and these processing variables can alter starch cook, nutrient availability and overall product digestibility. Raw material quality, processing conditions, and final diet content can all play a significant role in the ability of the animal to optimally utilize all available nutrients.

Key Words: Trypsin Inhibitor, Phytate, Biogenic Amines

568 Proteins: Advances in rendering animal and marine products. C. R. Hamilton* and D. Kirstein, *Darling International Inc., Irving, TX.*

The United States rendering industry (RI) annually processes over 23.6 million t of animal byproducts and mortalities to make 45,000 t of red meat and 4 million t each of animal proteins (AP) and animal fats. Research to improve the nutritional value of AP and develop novel proteins is sponsored by both industry and individual companies. Industry research is managed by the Fats and Proteins Research Foundation (FPRF) and the Animal Co-Products Research and Education Center at Clemson University (ACREC). Research from FPRF studied factors affecting AA digestibility of conventional AP. For meat and bone meal (MBM), AA digestibility is affected by processing temperature, but not by specie the raw material was derived from or ash content. Reducing processing temperature improved total essential AA digestibility 9.1%. Other processes to improve the value of AP in pet food include air classification to make low-ash AP and blending AP to improve nutrient consistency. Enzymes may improve digestibility and antigenicity by hydrolyzing fish, poultry or mammalian proteins. Enzymatic hydrolysis of beef protein resulted in low molecular wt peptides (31.7% < 2,000 Da; 88.9% < 10,000 Da). A primary focus

of ACREC is improving the microbial safety of rendered products to support a Code of Practice (COP) adopted by the RI. Facilities certified under this COP must comply with government regulations and demonstrate use of certain good manufacturing practices (GMP) and HACCP-like programs. Issues which restrict use of traditional AP in pet food include consumer acceptance of AP in pet foods, bovine spongiform encephalopathy (BSE), trends to use only products derived from animals inspected and passed for human consumption and pending regulations. Regulatory issues, consumer pressures and lost markets have caused the RI to preferentially fund ACREC research that focuses on development of new, non-nutritional uses for animal proteins. For the RI to also develop new and novel products for pet food, the pet food industry must commit to pay for their value and utilize sufficient volumes of such new products.

Key Words: Rendering, Animal Proteins, Pet Food

569 Fatty acids: Approaches to prevent or modify nutrient damage from oxidation. R. G. Brannan*, *Ohio University, Athens.*

Petfood fatty acids provide energy and essential dietary fatty acids which, however, are prone to lipid oxidation. Lipid oxidation is a chemical process catalyzed by free radicals formed from reactive oxygen and nitrogen or other pro-oxidants such as enzymes or transition metals. Primary products of lipid oxidation are lipid hydroperoxides, which decompose into many secondary products that research has shown may be efficiently absorbed in the intestine. Consumption of oxidized fatty acids may promote an increase in cellular oxidative stress which could lead to the promotion of oxidation-related disease syndromes. Fatty acids in petfoods can be from meat or added in bulk or emulsified form. Meat, especially precooked and restructured meat products, have low oxidative stability. The type of fatty acids from bulk oils or emulsified systems is often determined by nutritional targets that focus on n-3 and n-6 fatty acids ratios and the presence of essential fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Thus, vegetable and marine oils are often chosen due to their high unsaturated and n-3 levels. However, vegetable and marine oils suffer from high susceptibility to oxidation, a condition that is exacerbated during storage at ambient temperature. There are many antioxidant choices that can be utilized in fatty acid-containing petfoods. Free radical scavengers detoxify free radicals produced during lipid oxidation. Metal chelators, singlet oxygen quenchers, and enzyme inhibitors all work to inhibit lipid oxidation catalysts. Certain other molecules work synergistically with antioxidants to enhance or prolong antioxidative activity. Regardless of the type, these antioxidants can be naturally derived or synthetic. However, the efficacy of any antioxidant system will necessarily depend on other physical and chemical factors such as location, interactions with other ingredients, and environmental conditions. Approaches to prevent or modify oxidative damage to fatty acids must take into account both the chemical reactivity of the antioxidant and the physical environment of the system.

Key Words: Fatty Acid, Lipid Oxidation, Antioxidants

570 Minerals: Effect of form on requirements and bioavailability. L. L. Southern*, *LSU Agricultural Center, Baton Rouge, LA.*

Organic (non-salt) trace minerals have been reported to have positive effects on reproduction, immunity, overall productivity, and integrity of hair, skin and hooves. Organic trace minerals are widely used in the dairy, swine, and poultry industries by feeding consultants, and by large animal enterprises. Seemingly, these entities would only use these minerals if economic value was obtained. Unfortunately, there is not a lot of comparative scientific data to support these suggestions. In general, organic trace minerals (depending on source) are more bioavailable than inorganic minerals. This response is based primarily (but not always) on tissue mineral concentrations. However, the higher bioavailability of organic trace minerals would not seem to account for some of their proposed benefits. Examples of results among different species for the trace minerals Zn, Mn, Cu, Se, Cr, and I will be discussed. For example, organic Zn fed during lactation increased number of pigs born alive and improved immune status of the pigs, but data are limited. Organic Mn and Cu are usually more bioavailable,

based on slope ratio technique for tissue concentrations, than inorganic Mn and Cu (usually the sulfate form), but there is very little comparative scientific data to assess the proposed benefits of organic Mn and Cu supplemented as the only organic mineral in the diet. Organic Se supplementation results in greater tissue concentrations of Se, but inorganic forms have equal or greater efficacy in affecting GPX activity. In broilers previously fed organic Se compared with those fed inorganic Se, tissue Se concentrations and GPX activity were greater when the broilers were subsequently fed a Se deficient diet. Organic Cr supplementation decreases plasma glucose levels, increases glucose clearance rate, and improves numbers of pigs born - these responses are relatively consistent. Excess iodine intake of dams at levels well below those considered toxic may have negative effects on the offspring. Where applicable, how these results may apply to companion animals and the selection of trace mineral form will be highlighted.

Key Words: Organic Trace Minerals

Dairy Foods: Chemistry and Microbiology

571 Protein interactions in heat-treated milk and effect on rennet coagulation. P. Kethireddipalli* and D. G. Dalgleish, *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 normal 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 the 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 -casein Complexes

572 Flavor variability and stability of US-produced whole milk powder. M. A. Lloyd* and M. A. Drake, *North Carolina State University, Raleigh.*

Whole milk powder (WMP) produced in the United States (U.S.) is used both domestically and internationally. Much of the available literature on WMP was generated using internationally produced WMP. Flavor variability and stability of US-produced WMP has not been characterized. The objectives of this study were to characterize flavor and flavor variability of domestic WMP. Freshly produced WMP was collected from 4 production facilities at 5 timepoints over a year period. At each timepoint, two 23-kg bags from different production runs were collected. Each sample was analyzed initially and every 2 months for flavor profile, volatiles, color, water activity, and moisture over a year of storage. Samples were reconstituted to 10% solids using deodorized water for descriptive and volatile analysis. Volatile analysis was performed using solid phase microextraction (SPME) followed by gas chromatography/mass-spectrometry. Relative abundance was calculated for the following compounds, based on the internal standard recovery (2-methyl-3-heptanone): toluene, hexanal, 2-heptanone, heptanal, octanal, 2-nonanone, nonanal, 2-undecanone, delta-decalactone, and delta-dodecalactone. Descriptive analysis was conducted using a 10-member trained panel. All WMP were between 2-3% moisture and 0.11-0.25 water activity initially. WMP varied in flavor and volatile composition within and between production facilities ($p < 0.05$). WMP had distinct flavor profiles initially, with varying levels of cooked, milkfat, and sweet aromatic notes ($p < 0.05$). Several samples also had feed flavors. During storage, grassy and painty flavors developed while sweet aromatic flavor intensities decreased ($p < 0.05$). Some WMP developed grassy or painty flavors as early as 4 months, and all samples developed painty flavor by 12 months. Painty and grassy flavors were confirmed by increased levels of lipid oxidation products such as hexanal, heptanal, and octanal ($p < 0.05$). There is wide variation in flavor and flavor stability of U.S. WMP. Further research should be done to determine specific factors that can be controlled to optimize flavor and flavor stability.

Key Words: Whole Milk Powder, Flavor, Stability