Horse Species II

441 ASAS Centennial Presentation: Historical review and future outlook of equine nutrition. H. Hintz*, *Cornell University, Ithaca, NY*.

Although horses were still very important for farming in 1908 research on equine nutrition was not of high priority at most US agricultural colleges and experiment stations. The decline of the use of horses on farms, in the transportation industry and for hauling freight that started in the second decade of the twentieth century reinforced the low priority given to equine nutrition research. Nevertheless several members of the animal science community such as S. Brody (energy metabolism), P.B. Pearson (vitamin nutrition), W. D. Dawson (growth of foals) and A. L. Harvey (protein nutrition) provided valuable data in the 1930s and 1940s. In the 1960s the increased use of horses for recreation and the rapid growth of the horse population in the US stimulated interest in equine nutrition. University of Kentucky, Texas A&M, University of Florida and Cornell University started equine nutrition programs in the late 1960s. Many other universities developed equine nutrition programs in subsequent years. At the 2007 meeting of the Equine Science Society (ESS), papers related to equine nutrition were presented from 26 US universities and institutions. Most of the members of ESS are also members of ASAS. The improved knowledge of horse nutrition and hence better diets has been credited as a major factor in the improved health and increased longevity of horses. The horse industry continues to thrive and opportunities for valuable equine nutrition are endless. Examples include further studies on the microbiology of gut to help combat diseases such as founder, colic and metabolic syndrome, evaluation of nutraceuticals and other supplements, more defined studies on trace mineral requirements and metabolism, amelioration of the long existing problem of limited numbers of horses per treatment perhaps by developing regional cooperative studies or other more creative ideas. The relationship of nutrition and diseases in horses should be studied by teams consisting of researchers from several disciplines. There is much to be done.

Key Words: Horse, Nutrition, History

442 Glycemic and insulinemic responses differ in the morning versus the afternoon. L. M. Williamson[1], W. B. Staniar*[2], and R. J. Geor[1], [1]*Virginia Polytechnic Institute and State University*, *Blacksburg*, [2]*Pennsylvania State University*, *State College*.

Glycemic and insulinemic responses influence equine health through change to metabolism. The objective of this study was to quantify the morning and afternoon glycemic and insulinemic responses to a meal. A post ANOVA multiple comparison procedure was used to examine potential differences, considered significant at a $P < 0.05$. On the 4 study days, blood plasma samples were taken from 8 Thoroughbred mares via a jugular vein catheter at 0, 15, 45, 75, 105, 135, 165, 225, 285, 345, 405, 435, 465, 495, 525, 585, 645, 705, and 765 minutes. A grain meal of 1.5 kg was fed immediately following the 15 (AM (0800)) and 405 (PM (1400)) min samples. Glucose (mg/dl) and insulin (mIU/L) were measured with a glucose oxidase and chemiluminescent assay, respectively. Dependent variables were peak values for glucose and insulin, area under the curve for glucose and insulin, and the time to peak, which represents the time from feeding the meal to when glucose or insulin reached peak values. There was no detectable difference in the starch intake of the AM diets 323 ± 133 g in comparison to the PM 330 ± 127 g, or the time taken to eat in the AM 22 ± 23 min versus that in the PM 24 ± 21 min. Baseline (mean of samples 0 and 15) glucose and insulin were 94 ± 5.3 mg/dl and 6.1 ± 2.9 mIU/L, respectively. The AM peak values for glucose and insulin (143 ± 17 mg/dl, 57± 31 mIU/L) were higher than the PM peak values (123 ± 8.6 mg/dl, 37 ± 20 mIU/L). No difference was detected in the time to peak values for AM versus PM for glucose (127 ± 49, 118 ± 51 min) and insulin (137.4 ± 55.7, 118.9 ± 43.5 min). The glucose and insulin area under the curve in the AM (8103 ± 2860 min*mg*dl-1, 8468 ± 5050 min*mIU*L-1) were higher than the PM values (4170 ± 1744 min*mg*dl-1, 4358 ± 2091 min*mIU*L-1). The horse shows a higher glycemic and insulinemic response to meal in the morning when compared to a similar afternoon meal. The specific mechanism may relate to circadian patterns of other metabolic regulatory hormones like melatonin or may simply be due to the fact that glucose and insulin values have only just returned to baseline when the afternoon meal is fed. Time of day is a factor when evaluating glycemic and insulinemic response.

Key Words: Glycemic, Equine

443 Effect of different ingredients or ingredient combinations on glycemic and insulinemic responses in horses. J. L. Shelton*[1], B. D. Nielsen[2], and C. I. O'Connor-Robison[2], [1]*Cargill Animal Nutrition*, *Minnetonka, MN*, [2]*Michigan State University*, *East Lansing*.

The objective of this study was to determine the effect of different ingredients and ingredient combinations on glycemic and insulinemic responses in horses. A 12x12 Latin square design was used with mature Arabian horses (average age of 16 yr). Horses were maintained entirely on a roughage diet and subjected to a glycemic response test once weekly. The 12 treatments were: dextrose, EnergX (food grade identity preserved corn co-product), cracked corn, pelleted corn, steam pelleted corn, whole oats, steam rolled oats, steam crimped barley, COB (steam pelleted corn, steam rolled oats, steam crimped barley at a ratio of 1:1:1), COB+4% molasses, COB+8% molasses, EnergX+2% soy oil. The control treatment consisted of an oral dextrose drench given at the rate of 0.5 g dextrose/kg of BW. All remaining treatments were fed to provide 1 kcal DE/kg of BW. Once a week for 12 weeks, horses were jugular-catheterized after a 12-h fasting period. A fasting blood sample was taken 30 min later. Thirty min later, another baseline blood sample was taken and horses were fed their respective treatment. Blood samples were taken at 30, 60, 90, 120, 150, 180, 210 and 240 min after treatment. Samples were analyzed for glucose and insulin concentrations. Glucose and insulin area under the curve (AUC) were analyzed using the mixed model of SAS. When the individual ingredients were fed to horses, there were differences in glucose and insulin AUC ($P < 0.05$). For glucose AUC, EnergX had the lowest and steam processed corn had the highest. For insulin AUC, EnergX had the lowest and whole oats had the highest. As corn was further processed, differences between the corn treatments existed for glucose and insulin AUC ($P < 0.05$). Adding molasses to the COB product had a minimal effect on glycemic or insulinemic responses. These data indicate that glycemic and insulinemic responses can be affected by feeding different ingredients to the horse. Also, nutrients other than starch and sugar can play a role in reducing glycemic index in feeds for horses.

Key Words: Horse, Glycemic Response, Insulin

444 Glycemic response to meal length in equines. J. R. Bland*[1], E. L. Wagner[1], and W. H. McElhenney[2], [1]*Auburn University*, *Auburn, AL*, [2]*Tuskegee University*, *Tuskegee, AL*.

Cereal grains are an ideal feedstuff for horses with high energy demands because of their high soluble carbohydrate content. However, consumption of a single meal high in soluble carbohydrates causes an immediate increase in blood glucose. This increase could be problematic for horses with certain health conditions such as insulin resistance or laminitis. Because some horses require additional energy for growth, performance, pregnancy or lactation, it becomes difficult to completely cut cereal grains out of their diet. Therefore, new feeding management strategies are needed to attenuate the blood glucose response to a soluble carbohydrate-rich meal. The objective of this study was to examine the relationship between time to consume a concentrate meal and the glycemic response to that meal as measured by peak plasma glucose, glucose area under the curve, time to peak plasma glucose, and insulin response. Eight mature horses were used in an experiment consisting of eight 7-d periods where treatment combinations were arranged in a 2x4 factorial. Horses were offered approximately 4 Mcal of oats or sweet feed twice daily starting at 0600 and 1800 hrs. Horses were offered their respective concentrate in 1, 2, 3 or 4 equal portions at 15 minute intervals, thereby restricting rate of intake of the concentrate. Blood was collected via jugular catheters at the evening feeding on d 7 of each period, with a baseline sample collected 30 min prior to feeding (1750 hrs), then every 30 min post-feeding until 2400 hrs. Plasma glucose and insulin concentrations were determined, and resulting data were analyzed by the GLM procedure in SAS. Time to peak plasma insulin was longer for horses consuming oats ($P < 0.05$), but there were no other significant differences for concentrate type, portions or treatment interactions for glucose and insulin. A period effect ($P < 0.05$) was noted for peak plasma glucose and time to peak plasma glucose. There was a trend toward a period effect ($P < 0.10$) for glucose area under the curve, but no period effects were observed for measures of insulin. Glucose and insulin responses to a concentrate meal were not altered by time to consume the meal in the present study.

Key Words: Glycemic Response, Meal Length, Horse

445 Aquacid alters markers of bone metabolism in yearling Arabians. B. D. Nielsen*, R. E. Cate, C. I. O'Connor-Robison, and D. S. Rosenstein, *Michigan State University*, *East Lansing*.

The purpose of this study was to test whether a calcified seaweed mineral supplement (Aquacid), high in Ca and Mg, but low in P, can alter markers of bone metabolism and mineralization of the equine third metacarpus (MCIII). Prior to treatment assignment, 14 yearlings (four geldings and ten fillies) had dorsal-palmar and lateral-medial radiographs taken of their left MCIII. Radiographs were analyzed using a digital densitometer to determine the radiographic bone aluminum equivalence (RBAE) of each cortex as an estimate of mineral content. Blood samples were also taken at this time. Horses were striated according to RBAE and gender, and then pair-matched and assigned to two treatment groups, which were housed in separate pastures. Horses were group-fed, with each horse receiving an average of 1.6 kg of oats divided into two equal feedings of 0.8 kg oats per feeding. Each group was supplemented with a mineral supplement in addition to their daily ration. The treated group (Aq) received 75 g Aquacid/horse/d mixed in with their oats. The 75 g Aquacid provided an additional 15 g of Ca and a negligible amount of P (0.07 g). The control group (Co) received 39.5 g of limestone mixed in with their oats to provide a similar dose of Ca (15 g) and a negligible amount of P (0.008 g). Horses remained on the study for 112 d with blood samples being taken every 28 d. At d 56 and 112, another set of radiographs was taken for determination of changes in RBAE. Blood samples were analyzed for osteocalcin (OC: a marker of bone formation) and serum crosslaps (CTX-1: a marker of bone resorption) to help detect any alterations in bone metabolism. Using d 0 values as a covariate for bone markers, there was a trend ($P = 0.07$) for OC concentrations to be greater in the Aq horses than in Co. Likewise, CTX1 concentrations were greater ($P < 0.0001$) in Aq horses than in Co. There were no differences in RBAE values. These findings suggest Aquacid, while not altering bone mass, increases bone turnover and may aid in repairing damaged bone and preventing injuries.

Key Words: Horse, Bone, Calcium

446 Inflammation and vitamin E intake in horses during a CCI/CCI*** three-day event.** C. A. Williams*[1], E. D. Lamprecht[1], and A. O. Burk[2], [1]*Rutgers, The State University of New Jersey*, *New Brunswick*, [2]*University of Maryland*, *College Park*.

The objective was to compare the vitamin E content in the total diet of horses competing in a three-day event to systemic inflammatory measures throughout competition. Competitors in the 2007 Jersey Fresh CCI**/CCI*** three-day event (n = 35) gave informed consent to participate in the study. A detailed nutritional management survey was completed by the investigators and all grain, hay and bran rations were weighed, plus pre-competition pasture intake was estimated. Calculations for daily intake of vitamin E at competition used manufacturer or NRC (2007) values, and recommended daily intakes used NRC (2007) equations. Blood samples, BW and body condition scores were taken before the competition (PRE), 20 to 30 min after cross country (XC), and 18 to 24 h of recovery (POST). Blood samples were evaluated for plasma nitric oxide (NO), tumor necrosis factor-α (TNF), creatine kinase (CK) and aspartate aminotransferase (AST). Data were analyzed using a mixed model ANOVA with repeated measures in SAS. Average intake of vitamin E from hay, grain and supplements was 1587.5 ± 230 IU/d (123.5 ± 22 IU/kg feed/d); the recommended intake was 1065.3 ± 16 IU/d (80.7 ± 0.5 IU/kg feed/d). There was a significant difference between sample times for NO ($P = 0.013$), TNF ($P = 0.013$) CK ($P < 0.0001$), and AST ($P = 0.0007$). Nitric oxide and TNF decreased ($P < 0.01$) between PRE and POST, yet was not different between XC and POST. However, CK increased between PRE and XC ($P < 0.0001$), but remained similar to XC at POST. Where AST decreased from PRE to XC ($P = 0.032$), and was higher than both PRE ($P = 0.059$) and XC ($P = 0.0002$) at POST. There was a correlation with BW and NO ($r = -0.32$, $P = 0.002$), and BW and TNF ($r = -0.41$, $P < 0.0001$). Vitamin E intake also correlated with NO ($r = -0.21$, $P = 0.04$) and TNF ($r = -0.31$, $P = 0.002$). However, there were no correlations with pasture intake and the blood chemistry measures. These results indicate that pro-inflammatory measures decrease, while muscle enzymes increased, in horses undergoing intense exercise during competition. These equine athletes are also consuming vitamin E in excess of current recommendations, which may have an impact on systemic inflammatory markers.

Key Words: Antioxidant, Equine, Exercise

447 Effect of high fat diets and fat source on immune function in yearling horses. K. R. Vineyard*, L. K. Warren, and J. Kivipelto, *University of Florida*, *Gainesville*.

Recent research suggests omega-3 (n-3) and omega-6 (n-6) fatty acids (FA) may affect immune function differently in humans. To determine if the fat source used in a high fat diet affects immune function in horses, 24 Quarter Horse and Thoroughbred yearlings were randomly assigned to one of three treatments for 42 d: a fish oil (1/3) and olive oil (2/3) blend (FISH, n=8), corn oil (CORN, n=8), and no supplemental fat (NON, n=8). All horses had free-choice access to bahiagrass pasture, and a grain mix top-dressed with 6% FISH or CORN to create a 10% fat concentrate was fed at 1.25% BW/d. NON grain mix was fed at a rate of 1.37% BW/d to make diets isocaloric. FISH contained 8.6 g linoleic acid (LA), 5.1 g eicosapentaenoic acid (EPA) and 2.4 g docosahexaenoic acid (DHA)/ 100 g fat, supplying 7.2 g n-3/100 kg BW/d. CORN contained 57.7 g LA/ 100 g fat, supplying 43.1 g n-6/100 kg BW/d. Blood samples were obtained at 0 and 42 d for determination of plasma and red blood cell membrane (RBC) FA composition, lymphocyte proliferation (LP), PGE_2 production by peripheral blood mononuclear cells (PBMC), and neutrophil phagocytic and oxidative burst activity. Horses were administered a tetanus booster on d 21, and titers were analyzed at d 42. Data were analyzed using the MIXED procedure of SAS, and contrasts were utilized to compare NON vs. fat-added treatments. Treatment did not affect weight gain, which averaged 0.7±0.1 kg/d. Horses fed FISH had higher (P<0.05) plasma and RBC EPA, DHA, and total n-3 and lower (P<0.05) plasma and RBC LA and total n-6 than CORN and NON. Plasma and RBC LA was higher (P<0.05) and arachidonic acid was lower (P<0.05) in horses fed CORN than NON. LP and neutrophil function were not affected by treatment. PGE_2 production was lower for FISH and CORN than NON (P<0.05). Using baseline titers as a covariate, horses fed fat-added diets had higher tetanus titers at d 42 than NON (P<0.05). Results indicate that fat source in a 10% total fat concentrate affects the FA profile of plasma and cell membranes, and fat supplementation may affect immune function. However, the immune response does not appear to differ between horses fed sources rich in n-6 or n-3 FA when fed at a rate to provide 12% of daily DE from fat.

Key Words: Omega-3, Omega-6, Immunity

448 Seasonal effects of diet on the omega-6 and omega-3 fatty acid composition of plasma and red blood cells in grazing horses. L. K. Warren* and J. Kivipelto, *University of Florida*, *Gainesville*.

Although low in total fat, research suggests forage may serve as a significant source of dietary α-linolenic acid. However, the fatty acid (FA) composition of pasture forage has been shown to be affected by season, which could alter the FA profile of cell membranes in grazing horses. To characterize the effect of season and diet on the FA composition of plasma and red blood cells (RBC), monthly blood samples were obtained for 24-mo from 5 mature geldings. Horses were maintained on an 8.1-ha, mixed-cultivar bahiagrass pasture. Pasture samples were collected at 1-mo intervals from areas on or near where there was recent evidence of grazing. Horses also had free-choice access to Coastal bermudagrass hay from Dec-Feb. The effect of season on plasma, RBC and forage FA composition were determined by the MIXED procedure of SAS (v 9.1), where spring=mean of Mar, Apr, May; summer=mean of Jun, Jul, Aug; fall=mean of Sept, Oct, Nov; and winter=mean of Dec, Jan, Feb. C18:2 was lowest in winter plasma (P<0.05) and tended to be lower in winter RBC (P<0.1). C20:4 was lower in winter and spring plasma (P<0.01) and tended to be lower in fall RBC (P<0.1). Plasma C18:3 was lowest in winter and spring (P<0.01) and C20:5 was lowest in spring (P<0.01). RBC C18:3 and C20:5 peaked in fall (P<0.01) and were lowest in spring (P<0.01). C22:5 and C22:6 were not affected by season in plasma, but were lowest in spring RBC (P<0.05). Total n-6 FA were higher in summer and fall in plasma (P<0.05) and tended to be higher in summer and fall in RBC (P<0.1). Total n-3 FA peaked in fall and were lowest in spring in plasma (P<0.01) and RBC (P<0.01). Pasture C18:2 was lower in winter (P<0.05) and C18:3 was higher in spring and winter. Hay C18:2 was higher (P<0.01) and C18:3 was lower (P<0.01) than pasture in all seasons, which altered FA intake during the winter. Collectively, these results indicate that plasma and RBC C18:2 and C18:3 composition mimic seasonal dietary intake in grazing horses. Longer-chain n-6 and n-3 FA in plasma and RBC appear to be dependent on the relative availability of C18:2 and C18:3 in the diet.

Key Words: Polyunsaturated Fatty Acids, Pasture, Warm-Season Forage