The transfer of vitamins from the blood plasma into the seminal plasma seems rather limited.

Key Words: Boars, Vitamins, Semen

PSA Physiology: Reproduction and Endocrinology

1936 Laying hen response to molt induction by either pelleted alfalfa or alfalfa meal. K Medvedev*[1], C Woodward[1], X Li[1], L Berghman[1], L Kubena[2], D Nisbet[2], and S Ricke[1], [1]*Texas A&M University, Department of Poultry Science,* [2]*USDA-ARS, Food and Feed Safety Unit.*

Molting is a process commonly utilized by commercial laying facilities to extend and improve the productivity of a flock. This practice usually involves the deprivation of feed for a period of several days in order to rejuvenate the reproductive system. Due to food safety and comsumer awareness factors, alternatives to this approach are being investigated. Feeding alfalfa as an insoluble fiber source with the purpose of inducing molt is one such alternative. In this study, 118 hens were fed one of four diets: Layer Ration, Alfalfa Meal, Alfalfa Pellets, and Feed Deprivation. Hen weights were monitored 5 times during the trial to assess weight loss throughout the molting phase. During the trial, 8 hens per treatment were assessed for stress level using a tonic immobility technique. At the end of the trial, 58 hens from respective diet groups were sacrificed, and ovary weights were obtained to monitor regression of the reproductive system after a completed molting cycle. The diets correlated to the final hen weight with a p value ≤ 0.05 where feed deprivation birds lost 22.55%, alfalfa meal birds lost 16.85%, alfalfa pellet birds lost 13.03%, while birds kept on layer ration gained 2.31%. Ovary weights correlated to diet with a p value ≤ 0.05 where feed deprivation birds had a mean ovary weight of 6.37g, alfalfa meal birds had 5.08g, alfalfa pellet birds had 5.73g, and layer ration birds had 35.72g. No significant differences in stress response were noted in birds from these studies. Based on layer hen response, it appears that alfalfa can induce molt with the same efficiency as feed deprivation.

Key Words: Alfalfa, Hen Response, Molt

1937 Interleukin-1β (IL-1β) reduces the activity of 3β-hydroxysteroid dehydrogenase (3β-HSD) in granulosa cells of laying hens. M. A. Alodan*[1] and M. M. Beck[1], [1]*University of Nebraska.*

It is known that high environmental temperature (heat stress, HS) significantly reduces egg production, in part at least through disruption of reproductive hormones, progesterone (P_4), luteinizing hormone (LH), and estrogen (E_2). There are many well documented systemic effects of HS that may affect these hormones, but very little is known about local mechanisms through which HS acts. Interleukin-1 is increased by stress, including HS, and recently, in mammals, it has been shown that cytokines interleukin-1α and IL-1β play a role in ovarian function. The role(s) of cytokines in the bird remain unclear. The aim of this study was to determine the effect of HS and IL-1β on the activity of 3β-HSD, one of the major enzymes involved in steroidogenesis, in the granulosa cells (GC) of the laying hen. Two groups of hens were used in this study; one group was subjected to 24C, 30%RH (control), the other group to 36C, 60%RH (HS treatment). At the end of HS, the F1 follicles were collected from both groups and the GC dispersed enzymatically. The GC preparation from the control group was divided into three aliquots. One served as a control for the HS treatment; the other two were incubated with 100ng/ml IL-1β or without IL-1β (IL control) for 5h at 39C. Approximately 10,000 viable GC from each treatment were incubated in 1.5 ml of medium (PBS, pregnenolone, NAD, and nitroblue tetrazolium, pH 7.4) using 24-well flat-bottom plates at 39C for 90 min. After the incubation period, wells were examined with inverted microscope for dark blue formazan precipitate. A total of at least 100 cells per sample were examined to determine the percentage of cells that stained positive for 3β-HSD (dark blue cells). Both HS and IL-1β significantly reduced the percentage of 3β-HSD positive cells (P=0.000, 0.053, respectively). We hypothesize that HS reduces the activity of 3β-HSD in the granulosa, and that reduction may be in part, at least, mediated through IL-1β.

Key Words: Heat stress, Progesterone, 3β-HSD

1938 Expression of the activin type II receptors and the inhibin/activin subunits during follicular development in broiler breeder hens. A. J. Davis* and S. N. Slappey, *University of Georgia.*

There are two known activin type II receptors (ActRII and ActRIIB). An activin type II receptor must bind with an activin type I receptor to form a complex that can bind activin and then elicit downstream signaling by phosphorylation of proteins. The expression of mRNA for ActRII, ActRIIB, follistatin and inhibin/activin subunits was investigated in the follicles of broiler breeder hens. Total RNA was isolated from individual granulosa and theca layers of the F_1 through F_5 follicles, a pool of the F_6-F_7 follicles, the small yellow follicles (5-12 mm) and from the combined granulosa and theca layers of the large white follicles (2-5 mm) from 6 birds. 40 μg of total RNA per sample was run on a 1.5% agarose/formaldehyde gel and then transferred to nylon membrane for Northern analysis with chicken cDNA probes for the activin type II receptors, follistatin, the inhibin/activin subunits and GAPDH (control). Two ActRII mRNA transcripts of 6.5 and 3.7 kb were detected in all of the theca and granulosa samples. Both transcripts were equally expressed in granulosa samples, but in theca samples expression of the 3.7 kb transcript was significantly greater than the 6.5 kb transcript. ActRIIB was not detected by Northern analysis in any of the samples. Expression of the mRNA for the activin/inhibin binding protein, follistatin was detected in both theca and granulosa samples with the greatest expression found in small yellow follicle samples for both cell layers. Expression of the inhibin α-subunit was detected in the granulosa layer of all the follicles. Expression of the inhibin α-subunit was highest in the F_6-F_7 granulosa layer. Granulosa layers from large hierarchical follicles expressed the most inhibin/activin β-A-subunit, while expression of the inhibin/activin β-B-subunit was highest in nonhierarchical follicles. This is the first report, to our knowledge, of the detection of activin type II receptor mRNA in the hen ovary, and characterization of the expression pattern of the inhibin family in both the theca and granulosa layers throughout follicular development. The presence of activin receptor and follistatin mRNA in both the theca and granulosa layers of the small developing follicles suggests that locally produced activin might have a vital role in early follicular development.

Key Words: Activin receptors, Chicken

1939 Immunization of male broiler breeders against mammalian Gonadotropin Releasing Hormone. J.A. Vizcarra*[1], M.L. Rhoads[1], C.C. Hsu[1], J. Washington[1], J.L.M. Morgan[1], J. Yang[1], H. Tang[1], K. Shaffer[1], and J.D. Kirby[1], [1]*Department of Poultry Science, University of Arkansas, Fayetteville, AR 72701.*

Twenty broiler breeder males were used to evaluate the effect of immunization against mGnRH on the development of antibody titers, adult testis weight, pulsatile LH and FSH secretion, and expression of mRNA for FSH-beta in the pituitary and LH receptors in testis. A mGnRH-fimbriae antigen (Intervet International) was emulsified in Freund's incomplete adjuvant and DEAE. At 10 wk of age (WOA), males were randomly assigned to two treatments, and received a primary immunization against mGnRH (50 g), or were not immunized. Booster immunizations (total of 60 g) were given at 3, 6 and 14 wk after the primary immunization. Weekly plasma samples were obtained from 10 WOA until the end of the experiment to evaluate titers against mGnRH and concentrations of testosterone by RIA. At 28 WOA, a jugular cannula was inserted, and blood samples (1 ml) were collected at 10-min intervals for 8 h. Plasma was stored at -20 C and analyzed for LH and FSH concentrations. At the end of the 8 h acute sampling period, males were killed. Pituitaries were removed to evaluate the expression of mRNA for FSH-beta subunit, and testes were obtained to evaluate daily sperm production (DSP), and expression of mRNA for LH receptors. There was a remarkable variation in titers between birds immunized against mGnRH. Only 2 of 10 birds had titers greater than 50% after the second booster immunization, and 4 of 10 birds had titers greater than 20%. Titers of 4 of 10 birds were

slightly above control (7%). Testosterone concentrations were decreased only in birds with titers greater than 20%. Testis weights and expression of mRNA for FSH-beta were significantly reduced in immunized birds. Concentrations of LH, FSH, DSP, and expression of LH receptor mRNA were not affected by treatment. Despite a significant variation in the response to the p-fimbriae antigen, immunization against mGnRH decreased testis weight and FSH-beta expression in adult broiler breeder males.

Key Words: GnRH, LH and FSH, mRNA

1940 Thyroid hormone and prolactin profiles in male and female turkeys following photostimulation: Validation of an ELISA for turkey prolactin. J. A. Proudman*[1], T. D. Siopes[2], F. Vandesande[3], and L. R. Berghman[4], [1]*Germplasm & Gamete Physiology Lab, ARS, USDA, Beltsville, MD 20705,* [2]*Department of Poultry Science, North Carolina State University, Raleigh, NC 27695,* [3]*Lab of Neuroendocrinology and Immunological Biotechnology, Catholic University of Leuven, Belgium,* [4]*Poultry Science Department, Texas A&M University, College Station, TX 77843.*

Reproduction in turkeys is controlled by photoperiod and is a balance between two physiological states, photosensitive and photorefractory (PR). The hen requires a period of short day lengths to establish photosensitivity while the tom does not. Further, the hen and tom are known to express the PR response differently. The PR response is thought to be programmed by the presence of thyroxine (T4) during the early wk following photostimulation (PS). The sex difference in PR response of turkeys is not known to exist in other species, and provides an opportunity to differentiate hormonal influences on programming of PR. Our objective was to compare the early, post-lighting hormone profiles in hens and toms of three hormones, T4, triiodothyronine (T3), and prolactin (PRL). In addition, PRL was measured by both radioimmunoassay and a new homologous sandwich ELISA technique that uses a monoclonal capture antibody and a polyclonal detection antibody, permitting measurement without use of radioactivity. Results showed no significant difference in T4 levels of hens and toms measured at weekly intervals for 8 wks following PS, and at 10, 12, 16, and 22 wks. The T3 levels of toms were lower than those of hens at PS, and subsequently increased, while T3 levels of hens declined. PRL levels increased markedly following PS in hens, but remained very low throughout reproduction in toms. A high correlation (r=0.94) was observed between RIA and ELISA measurements of PRL levels in hens, but absolute PRL values measured by ELISA were lower (P<.001) than those measured by RIA. We conclude that there are post-lighting sex differences in hormone profiles for PRL and T3 but not T4.

Key Words: photorefractoriness, hormones, turkey

1941 Dietary Manipulation of Rooster Sperm. Denise C. Bongalhardo*[1] and Mary M. Buhr[1], [1]*University of Guelph.*

Lipid composition of sperm has been related to sperm quality and it can be modified by dietary means. Two experiments were conducted to monitor sperm quality of birds fed diets with different lipid composition. In the first trial, 20 White Leghorn roosters were randomly allocated in one of four treatments: control diet, diet containing corn oil, fish oil or flax seed as lipid source. The birds were ejaculated at 35, 36, 37, 38, 45, 46, 47, and 50 weeks of age. From 35 to 37 and 48 to 50 weeks of age, all birds were fed the control diet. From 38 to 47 weeks, they were fed the experimental diets. Semen was collected twice a week by abdominal massage, and the semen of the second collection was analyzed for concentration (estimated by spectrophotometer), motility (subjective microscopic analysis), viability (SYBR-14/PI fluorescent staining), and volume. In the second trial, 64 White Leghorn roosters were randomly allocated in one of the 4 treatments previously described. In the first (20 and 21 weeks of age) and in the last two weeks (27 and 28 weeks of age) of experiment, all birds were fed the control diet. From 22 to 26 weeks, they were fed the experimental diets. The semen was evaluated by concentration (spectrophotometer), motility (computer-assisted analysis), viability (flow cytometer), and volume. Repeated measures design was used to analyze the normalised data. The effect of diet was not significant (P>0.05) for any trait analyzed in the older birds in the first trial. In the second trial, diets didn't change concentration, viability or motility values (P>0.05), but diets containing corn and fish oil increased (P<0.0123) the volume ejaculated (0.60 0.22 and 0.65 ml 0.22, respectively) vs. control or flaxseed diets (0.50 0.23 and 0.51 0.24 ml). Lipid composition of diets affects semen parameters.

Key Words: Sperm, Diet, Lipids

1942 Sperm mobility phenotype influences duration of fertility in turkeys after insemination at 0 or 24 hour *in vitro* storage of sperm. A. M. Donoghue[1], D. P. Froman[2], Y. K. Kirby*[1], D. J. Donoghue[3], and J. D. Kirby[3], [1]*PPPSR, ARS, USDA, Fayetteville, AR,* [2]*Oregon State University, Corvallis, OR,* [3]*University of Arkansas, Fayetteville, AR.*

Sperm motility phenotype is based upon the ability of sub-populations of sperm to penetrate a solution of Accudenz (a viscous, inert non-toxic medium) at body temperature from a sperm suspension overlay. Repeatedly, we have demonstrated that sperm mobility phenotype correlates with fertility and can be used to predict the reproductive fitness of toms or roosters. The objectives of this study were to: 1) determine if duration of fertility is different between toms of good or poor phenotype; 2) determine if mixing semen from good and poor phenotype toms influences duration of fertility; and 3) evaluate whether storing semen of high and low phenotype at 4C for 24 h influences fertility outcomes. Toms (n=57) were assessed for sperm mobility on 3 occasions and ranked. Toms with the highest mobility scores and lowest mobility scores were identified as Good or Poor, n=6/group. Equal amounts of semen from each group was pooled for the Mixed group. Hens (n=20/group) were inseminated 2 days apart with Good, Mixed or Poor semen within 1 h of collection (0 time) or after 24 h of *in vitro* storage at 4C. Duration of fertility was assessed for 50 days following the final insemination. Fertility was higher in the Good (57.84.3, 23.15.2) and Mixed (53.26.1, 25.14.3) groups compared to the Poor (42.86.6, 13.72.9) group at both 0 and 24 h storage times, respectively (P<0.05). Interestingly for all groups at the 0 time insemination and the Good group at 24 h, the level of fertility remained constant for 14 days before a daily decline in % fertile eggs was observed. However, the 24 h *in vitro* stored semen from the Mixed and Poor groups demonstrated an immediate decline in % fertility. These data suggests that sperm quality, as determined by mobility influences fertility possibly by altering the storage capability of sperm in the hen. Supported in part by the U.S. Poultry and Egg Association (#340). ®®

Key Words: Sperm, Poultry, Fertility

1943 Demonstration of ovoinhibitor, a serine-protease inhibiting protein, in the chicken brain. L.R. Berghman*[1], E. D'Hondt[2], R.W. Moore[3], B.M. Hargis[4], C.M. Oubre[1], and F. Vandesande[2], [1]*Texas A&M University, College Station TX,* [2]*University of Leuven, Belgium,* [3]*USDA-ARS, College Station TX,* [4]*University of Arkansas, Fayetteville AR.*

As suggested by its name, ovoinhibitor is a protease inhibitor that was originally purified from egg whites about 50 years ago. It is a 56 kDa protein that specifically inhibits serine proteases such as trypsin and chymotrypsin. Anti-ovoinhibitor monoclonal antibodies (MABs) were unexpectedly obtained as a side-product during the production of MABS against purified chicken bursa of Fabricius protein preparations. This event led to the first demonstration of ovoinhibitor in an avian immune organ. More recently, further immunocytochemical research also revealed ovoinhibitor-immunoreactivity in subsets of chicken pituitary cells (see companion communication) and, as described in the present report, in the brain of the chicken. Seven-μm paraffin sections of Bouin-Hollande sublimate fixed chicken brain tissue were used throughout this study. Upon standard dewaxing and rehydration, sections were incubated overnight with the MAB and detection was performed with a peroxidase-labeled secondary antibody combined with diaminobenzidine and hydrogen peroxide. Both in 18-day old embryos and in 4-week old chickens, immunopositive cells were observed surrounding the lateral ventricles, the pallial commissure and the third ventricle (i.e. paraventricularly). Interestingly, in the embryo labelled cells were also found in the cerebellum, surrounding the fourth ventricle. In line with the above observation of specifically stained cells in several circumventricular areas, cerebrospinal fluid (CSF)-contacting nerve endings were prominent around the lateral ventricles, especially in the embryo. It is tempting to speculate that ovoinhibitor may be secreted into the CSF where it could play a role in inhibiting proteolytic breakdown of regulatory peptides or proteins. Serine protease inhibitors from a different family have

recently been shown to be involved in neuronal plasticity and neuroprotective mechanisms. The precise function of ovoinhibitor in the brain will be a topic for further research.

Key Words: chicken, ovoinhibitor, brain

1944 Vasotocin receptor mRNA expression in the brain and pituitary of broiler breeder hens. K. Shaffer*[1], J.A. Vizcarra[1], C.C. Hsu[1], J.Y. Yang[1], M.L. Rhoads[1], L.E. Cornett[2], D. Baeyens[3], N. Ali[3], and J.D. Kirby[1], [1]*Department of Poultry Science, University of Arkansas, Fayetteville, AR,* [2]*Department of Physiology, University of Arkansas for Medical Sciences,* [3]*Department of Biology, University of Arkansas Little Rock, Little Rock, AR.*

Vasotocin receptors (VTR) are members of the seven trans-membrane spanning G-protein associated receptor superfamily. Several members of the vasopressin-oxytocin-mesotocin receptor family have been characterized in vertebrates. We have previously shown that VTR-1 expression occurs primarily in the brain while VTR-2 expression occurs mainly in the pituitary. Our goal was to evaluate the expression of VTR-1 and VTR-2 mRNA in known sites of expression over the ovulatory cycle of hens. In order to study potential changes in VTR-1 and VTR-2 expression, birds (n=4-5 per time point) were killed at 3 hour intervals relative to oviposition over a 24 hour period. Blood samples were drawn within 2 minutes of handling, prior to cervical dislocation. Brain, pituitary, shell gland, and kidney were immediately removed and frozen in liquid nitrogen. Plasma was stored at -20 C prior to determination of corticosterone levels by RIA. Isolated total RNA from the brains and the pituitaries was transferred to nylon membranes for analysis of receptor steady state mRNA levels by slot blot analysis. Full length cDNAs for VTR-1, VTR-2 and 28-S rRNA were used to make random primed cDNA probes. VTR-1 and VTR-2 mRNA expression levels were normalized relative to 28-S expression for each sample. Corticosterone levels were significantly increased at nine hours post oviposition relative to all other times. Neither VTR-1 nor VTR-2 mRNA levels showed any significant variation over the 24 h cycle, in the brain or pituitary, respectively. Based on these results, we conclude that VTR-1 and VTR-2 steady state mRNA levels do not fluctuate dramatically over the ovulatory cycle of broiler breeder hens. Further work on circadian variations in membrane bound receptor concentrations in the brain and pituitary are currently underway.

Key Words: Vasotocin Receptor, Pituitary and Brain, Corticosterone

ASAS Nonruminant Nutrition: Feed Ingredients and Enzymes

1945 Effect of lactic acid and lactosucrose supplementation in diets for nursery pigs. Acie Murry*[1], Susan Sanchez[1], and Parshall Bush[1], [1]*The University of Georgia, Athens.*

Swine producers have been adding organic acids to feed for several years. Acidified feed lower the pH of the pig's stomach, inhibit certain pathogenic bacteria, increases nutrient digestibility and results in faster weight gain and more efficient feed conversion. Lactosucrose is considered a nondigestible trisaccharide produced from lactosucrose and sucrose and may be used as a substrate by intestinal bacteria in humans. The influence of these factors has not been documented in nursery pigs. The objective of this study was to evaluate the effects of lactic acid and lactosucrose supplementation in pig's diet on growth performance, feed efficiency and nutrient digestibility. Two experiments with twenty cross bred nursery pigs, average initial body weight 9.6 kg and age 28 days were conducted. All pigs were fed a corn-soybean meal basal diet (18% CP) for a 7-d adjustment period. On day seven after the adjustment period, ten pigs were randomly assigned to receive the basal diet supplemented with either lactic acid (1.8%) or lactosucrose (0.2%) for a 14-d experimental period. Daily feed intake was held constant at 5% of body weight for all pigs in an attempt to reduce the effects of different levels of feed intake on nutrient digestibility. Pigs were weighed every three days and feeding was adjusted according to the pig's individual weight. Pigs fed the lactosucrose diet were heavier ($P < 0.04$) at d 21 (15.40 vs 14.95 kg), but there was no effect of treatment ($P > 0.50$) on average daily gain (0.45 vs 0.43 kg), average daily feed (0.57 vs 0.56 kg), or gain:feed ratio (0.80 vs 0.78 kg) for lactosucrose and lactic acid, respectively. Treatment had no effect ($P > 0.20$) on apparent digestibility of DM (80.96 vs 82.46%), EE (77.45 vs 79.50%), CP (72.30 vs 74.45%), or GE (69.69 vs 69.33%) for lactosucrose and lactic acid, respectively. However, ash digestibility was greater ($P < 0.05$) for pigs fed the lactic acid diet than for those fed lactosucrose (50.43 vs 43.15%). The results from this study show that growth performance was better in pigs fed the lactosucrose diet, but ash digestibility was lower when compared with pigs fed the lactic acid.

Key Words: Lactosucrose, Lactic Acid, Digestibility, Pigs

1946 The potential for egg by-products to replace spray-dried porcine plasma in early-weaned piglet diets. L.D. Schmidt*, C.M. Nyachoti, D. Boros, and B.A. Slominski, *University of Manitoba Winnipeg, MB, Canada.*

Egg-breaking facilities produce substantial quantities of egg by-products each year that are unsuitable for human consumption. Due to the excellent amino acid profile, the potential for spray-dried egg proteins to replace spray-dried porcine plasma (SDPP) in early-weaned pig diets was investigated in two 3-week performance trials. In both experiments, 5 pens containing four piglets (17 ± 1d old) stratified by sex were assigned to the experimental diets in a completely randomized design. Experiment 1 comprised of four corn-soy diets containing 7% of either SDPP, spray-dried technical albumen (SDTA), heat treated SDTA (hot room storage at 70°C for 72h) or spray-dried whole egg (SDWE). Average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratios (FCR) were determined. In addition, five piglets per treatment were euthanized to determine ileal amino acid and energy digestibilities. Relative to the SDPP diet, ADG (266, 219, 199,194 g/d), ADFI (323, 304, 277, 278 g/d) and FCR (1.22, 1.38, 1.46, 1.44) were poorer ($P<0.05$) for SDTA, heat treated SDTA and SDWE, respectively. The SDTA diet had numerically better performance parameters than the other diets containing egg proteins. Apparent ileal digestibility of methionine, lysine and threonine in SDPP and SDTA diets ranged from 80-90% and was generally higher ($P<0.05$) than in the SDWE diet. Ileal digestible energy content was similar ($P<0.05$) in all diets (3.1-3.2 Mcal/kg). In the second experiment, the effect of substituting SDPP with 25 or 50% SDTA was investigated. Pig performance was not affected by dietary substitution of SDTA for SDPP as values for control (7% SDPP) and the two SDTA diets were similar ($P<0.05$) for ADFI (380, 402, 376 g/d), ADG (275, 284, 265 g/d) and FCR (1.38, 1.42, 1.45), respectively. The results suggest that technical albumen can replace 25% of SDPP in early-weaned pig diets without compromising performance.

Key Words: Egg by-products, Nutritive Value, Early-weaned pigs

1947 Comparison of edible grade whey, granular whey, and Dairylac 80O as lactose sources for nursery pig diets. J.M. DeRouchey*, M.D. Tokach, J.L. Nelssen, R.D. Goodband, S.S. Dritz, J.C. Woodworth, and B.W. James, *Kansas State Univesity, Manhattan, KS.*

A total of 210 pigs (BW of 5.6 kg and 18 2 d of age) were used in a 14-d growth assay to determine the ability of granular whey or Dairylac 80® to replace a high quality, edible grade whey in nursery diets. Pigs were blocked by weight and allotted to one of seven dietary treatments. Treatments included a negative control without lactose and a 2 x 3 factorial consisting of two lactose levels (9 and 18%) and three lactose sources (Edible whey, Land O' Lakes; Granular whey, International Ingredient Corp.; and Dairylac 80®, International Ingredient Corp.). There were five pigs/pen and six pens/treatment. All diets were pelleted and contained 3% animal plasma and 2% select menhaden fish meal and were formulated to 1.60% lysine. Either edible whey or granular whey (12.5 and 25%) replaced corn and soybean meal in the control diet. Diets containing Dairylac 80® were formulated to replace the lactose provided in the dried whey diets. Fish meal replaced the amino acids provided by dried whey to maintain a constant soybean meal level. Pigs fed additional lactose from d 0 to 14 had greater ADG ($P<.04$) and ADFI ($P<.07$) compared to pigs fed no supplemental lactose. Pigs fed edible whey had greater ADFI (quadratic, $P<.05$) and ADG (linear, $P<.06$) with increasing lactose from 9 to 18%. As granular whey level increased, ADG and ADFI increased (linear, $P<.02$) over the control diet from d