

ABSTRACTS

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SYMPOSIA AND ORAL SESSIONS**

Triennial Growth Symposium: Dietary Regulation of Growth and Development

1 Vitamin D mediated phosphate homeostasis—Implications for skeleton growth and mineralization. T. D. Crenshaw,* *University of Wisconsin, Madison.*

Foundational roles of vitamin D (D) in skeletal growth involve interrelationships between Ca, PTH, and conversion of D to the active hormone, $1\alpha, 25\text{-(OH)}_2\text{D}_3$. Until the past decade relatively little research focused on these interrelationships and P homeostasis. A focus on Ca was driven, in part, by the limiting amount of Ca and abundance of P in human diets. Most ingredients used in monogastric animal diets are limiting in Ca and P. Ca and P have been typically supplied in excess of requirements from inorganic sources with minor incentives to improve nutrient efficiency. Constraints on amounts of supplemental P are driven by ingredient costs and environmental concerns. Thus P, not Ca, is typically more limiting in monogastric diets. The introduction of phytase supplements has only exasperated the need to understand P homeostasis. In the past 5 yr, discovery of novel pathways for P homeostasis offer opportunities to improve P efficiency without compromising skeletal growth and animal well-being. The objective of this review is to summarize interrelations of dietary P, D and the role of fibroblast growth factor 23 (FGF23) in P homeostasis. FGF23 directly affects P homeostasis via action on a renal Na-P transport protein and renal 1α -hydroxylase activity. FGF23 is produced primarily in osteocytes which allow localized osteocyte regulation of osteoblast-mediated bone formation and regulation of systemic renal P excretion relative to needs for bone mineralization. In transgenic mice, overexpression of FGF23 led to hypophosphatemia and urinary P wasting. In contrast FGF23 knockout mice displayed hyperphosphatemia and renal P conservation. Current studies in our lab have shown that deletion of D supplements in diets fed to sows during gestation and lactation compromised ($P < 0.05$) skeletal bone mineral content in offspring at 13 wk of age and decreased the age at which pigs displayed kyphosis. These responses appear to be mediated by the efficiency of dietary P use. In summary, development of dietary inputs to balance both Ca and P homeostasis are needed to improve skeletal growth and nutrient efficiency.

Key Words: FGF23, kyphosis, Na-P transport

2 Effects of polymeric carbohydrates on growth and development. K. E. Bach Knudsen,* *Aarhus University, Faculty of Agricultural Sciences, Department of Animal Health and Bioscience, Tjele, Denmark.*

The main objective of the presentation is to provide insight into the role of polymeric carbohydrates in growth and development of pigs. Polymeric carbohydrates—starch and non-starch polysaccharides (NSP)—quantitatively represent the largest portion of the diets for pigs and are therefore the largest energy contributor. The 2 types of polysaccharides, however, have different fates and functions in the gastrointestinal tract and lead to different metabolites upon digestion. Pancreatic and mucosal enzymes in the small intestine break down the majority of starch, while NSP primarily are degraded by the microflora in the large intestine. Starch degradation leads to the release of glucose which is absorbed by an active absorption process that triggers the release of insulin from the pancreas, whereas the fermentation of NSP to short-chain fatty acids (SCFA: acetate, propionate and butyrate) occurs at a slower and more constant rate and with SCFA being absorbed by passive diffusion. Type and levels of polymeric carbohydrates influence growth and development through different mechanisms; first, the proportion of starch to NSP plays an important role for the content of available energy (digestible, metabolized and net energy); available energy relative to protein is crucial for performance and carcass quality; second, the proportion of starch to NSP will influence rate and type of metabolites (glucose vs. SCFA) deriving from carbohydrate assimilation, and finally, type of starch (types A, B, and C) and soluble NSP will influence the release of insulin, the hormone that facilitate nutrient uptake by tissues, organs and cells, and thus play a critical and essential role in protein synthesis and muscle growth as well as lipid synthesis and adipose tissue growth. In conclusion, polymeric carbohydrates influences growth and development through events in the gut and direct and indirect effects of different metabolites deriving from carbohydrate assimilation.

Key Words: polymeric carbohydrates, pigs, growth

3 Effect of feed additives on cattle growth and development. R. A. Zinn^{*1}, P. Garces-Yepez², and J. Salinas-Chavira³, ¹University of California, Davis, ²UNAM, Mexico City, DF, Mexico, ³UAT, Ciudad Victoria, Tam., Mexico.

Feed additives are of themselves largely non-nutritive materials that are included in diet formulations to enhance health and growth performance. This presentation will focus on use of additives intended to enhance growth performance of feedlot cattle. They include: alkalizers (e.g., sodium bicarbonate, potassium carbonate, calcium carbonate, magnesium hydroxide), ionophores (e.g., laidlomycin, lasalocid, monensin, salinomycin), non-ionophore "mycin's" (e.g., bambarmycins, virginiamycin), subtherapeutic antibiotics (e.g., chlortetracycline, tylosin), probiotics (e.g., *Lactobacillus*, *Bifidobacterium*, *Saccharomyces*), essential oils (e.g., cinnamonaldehyde, eugenol, limonene, terpinen, thymol, vanillin), enzymes (e.g., amylase, xylanase, cellulase), hormones (e.g., melengestrol acetate), and β -agonists (ractopamine, zilpaterol). This presentation will provide a brief overview of various additive classes, including possible modes of action, and practical measures of efficacy (growth performance and digestive function).

Key Words: additive, cattle, growth

4 Host targeted antibody strategies for preventing growth depression due to microbial colonization. M. E. Cook^{*1,2} and S. M. Huebner², ¹University of Wisconsin, Department of Animal Sciences, Madison, ²University of Wisconsin, Department of Nutritional Sciences, Madison.

The growth rate and feed efficiency of chicks and pigs colonized with commensal bacteria is only 80 to 90% of germ-free housed animals. Reduced growth of conventionally housed animals, when compared with germ-free animals, is the result of inflammatory processes. New information on the signaling pathways of inflammatory processes has provided scientists with new targets to improve animal growth and feed efficiency. It has become evident that inflammation can be regulated at the intestinal lumen/mucosa interface. Secretory phospholipase A2 (sPLA2) has emerged as a host target worthy of study. sPLA2 is secreted into the lumen of the gastrointestinal tract (GIT) during systemic inflammation. Following sPLA2 release, GIT permeability is increased, and sPLA2 action on phospholipids permit intracellular signal transduction for inflammatory mediator production (e.g., eicosanoids and cytokines). In addition, sPLA2 lipid products, such as lysophosphatidylcholine, can signal natural killer T cell (NKTC) cytokine production via the CD1d molecule on antigen presenting cells. Egg antibodies specific to host sPLA2 decreased lipopolysaccharide-induced PGE2 and tumor necrosis factor release in macrophages and reduced cytokine production by NKTC. Egg anti-sPLA2 was tested in chick growth trials and found to improve growth and feed efficiency approximately 5%. Feeding anti-sPLA2 to pigs, calves, fish species resulted in improved growth. Studies were also conducted in animals with bacteria and protozoan challenges, and anti-sPLA2 was found to be protective in some diseased states or to have no beneficial or adverse effect on animal health. The anti-sPLA2 example suggests that inflammatory products and pathways are useful host targets for improving animal growth. Orally delivered antibodies, such as egg antibody, may serve as useful tools for discovering key mechanisms for increasing the efficiency for production of animal products.

Key Words: growth, inflammation, egg antibody

5 Neural regulation of feed intake: Modification by hormones, fasting and disease. J. L. Sartin^{*1}, B. K. Whitlock², and J. A. Daniel³, ¹Auburn University, Auburn, AL, ²University of Tennessee, Knoxville, ³Berry College, Mt. Berry, GA.

Appetite is a complex process that results from the integration of multiple signals at the hypothalamus. The hypothalamus receives hormonal signals such as insulin, leptin and ghrelin to nutrient molecules such as glucose, free fatty acids, amino acids and volatile fatty acids. This effect is processed by a specific sequence of neurotransmitters beginning with the arcuate nucleus and orexigenic cells containing neuropeptide Y or agouti-related protein and anorexigenic cells containing proopiomelanocortin (POMC, yielding the neurotransmitter α -melanocyte stimulating hormone) or cells expressing cocaine amphetamine related transcript. These so called first order neurons end on second order orexigenic neurons containing either melanin concentrating hormone or orexin. The activity of these neuronal pathways are altered externally by nutritional alterations such as fasting or severe catabolic circumstances such as disease. In addition, there are other pathways from within the brain that may interact to dictate feed consumption patterns in farm animals. This review will begin with the central hypothalamic pathways and then discuss the ways in which hormones and metabolites may alter the process to impact on feed intake.

Key Words: appetite, leptin, NPY

6 Leucine acts as a nutrient signal to stimulate protein synthesis. T. A. Davis,^{*} A. Suryawan, R. A. Orellana, and M. L. Fiorotto, USDA/ARS Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine.

The postprandial rise in amino acids and insulin independently stimulates protein synthesis in skeletal muscle of piglets. Leucine is an important mediator of the response to amino acids. We have shown that the postprandial rise in leucine, but not isoleucine or valine, acutely stimulates muscle protein synthesis in piglets. Leucine increases muscle protein synthesis by modulating the activation of signaling components of translation initiation. Thus, leucine increases the phosphorylation of mammalian target of rapamycin (mTOR), 70-kDa ribosomal protein S6 kinase, eukaryotic initiation factor (eIF)4E-binding protein-1, and eIF4G, decreases the phosphorylation of eIF2 α , and increases the association of eIF4E with eIF4G. However, leucine does not affect the canonical upstream activators of mTOR, i.e., protein kinase B, AMP-activated protein kinase, and tuberous sclerosis complex 1/2, or the translation elongation regulator, eukaryotic elongation factor 2. The acute leucine-induced stimulation of muscle protein synthesis is not maintained for prolonged periods, despite continued activation of the mTOR signaling pathway, because circulating essential amino acids fall as they are utilized as substrates for protein synthesis. However, if circulating amino acids levels are maintained, the leucine-induced stimulation of muscle protein synthesis can be maintained for prolonged periods. The activation of the mTOR signaling pathway by leucine does not appear to be affected by the circulating levels of other amino acids. Supplementation of low protein diets with leucine stimulates protein synthesis in muscle and most visceral tissues to a rate similar to that achieved by feeding high protein diets and this stimulation involves activation of the mTOR downstream effectors. Together, these studies indicate that leucine acts as a nutrient signal to stimulate translation initiation but whether this translates into a sustained increase in protein synthesis depends on the sustained availability of dietary amino acids.

Key Words: muscle, protein synthesis, amino acids

7 Important roles for L-glutamine in swine nutrition and growth. G. Wu,* F. W. Bazer, G. A. Johnson, R. C. Burghardt, D. A. Knabe, T. E. Spencer, X. L. Li, and J. J. Wang, *Texas A&M University, College Station.*

L-Glutamine (Gln) has traditionally not been considered as a nutrient needed in diets for livestock species or even mentioned in animal nutrition textbooks. This is due to previous technical difficulties in the analysis of Gln (free and protein-bound) and the unsubstantiated assumption that animals can synthesize sufficient amounts of Gln to meet their needs. Consequently, the current 10th version of NRC (1998) does not recommend dietary Gln requirements for growing, gestating or lactating swine. This lack of knowledge about Gln nutrition has contributed to suboptimal efficiency of global pig production. Because of recent advances in analytical methods and biochemical research, Gln is now known to be an abundant amino acid in physiological fluids (e.g., milk and fetal fluids) and proteins (both plant and animal), as well as a major fuel for rapidly dividing cells (including enterocytes and lymphocytes)

and a key regulator of gene expression. Additionally, Gln participates in cell signaling via the mammalian target of rapamycin pathway, AMP-activated protein kinase, extracellular signal-related kinase, Jun kinase, mitogen-activated protein kinase, and nitric oxide. Exquisite integration of these regulatory networks has profound effects on cell proliferation, differentiation, metabolism, homeostasis, survival, and function. As a result of translating basic research into practice, dietary supplementation with 1% Gln maintains gut health and prevents intestinal dysfunction in low-birth-weight piglets and early-weaned piglets, while increasing their growth performance and survival. Also, supplementing 0.6% Gln to a corn- and soybean meal-based diet between d 30 and 114 of gestation ameliorates fetal growth retardation in gilts. Furthermore, adding 1% Gln to a conventional diet enhances milk production by lactating sows. Thus, adequate amounts of Gln in diets are necessary to support maximum growth, development and production performance of swine.

Key Words: growth, physiology, requirement