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also supported by the FFLG data.

Serum IGF-I concentrations are presented in Figure 2. Protein concentration had linear and quadratic effects ($P < 0.01$) on serum IGF-I concentration during weeks 2 and 4 of the experiment. There were no sex effects detected for serum IGF-I concentration, thus the data for barrows and gilts within dietary crude protein concentration were pooled and presented in Figure 2. Pigs fed the diet containing 10% CP had the lowest IGF-I concentration throughout the experiment and pigs fed the 18 and 22% CP had similar IGF-I concentration during weeks 2 and 4 of the experiment. These serum IGF-I concentrations indicate that the production and release of IGF-I into the blood is inhibited by the consumption of a 10 or 14% CP diet. This reduction in serum IGF-I is supported by the reduced fat-free lean accretion rates calculated for the pigs consuming the 10 and 14% crude protein diet. However, pigs fed the 18 and 22% CP diets had numerically similar serum

IGF-I concentrations, and pigs fed the 18% CP diet had a significant decrease in FFLG as compared to pigs fed the 22% CP diets. These results suggest that the consumption of a diet marginally deficient in CP (18%) does not inhibit the production of IGF-I. However, the actions of IGF-I (i.e., muscle protein accretion) are partially inhibited. This diminished action of IGF-I is supported by the reduction in FFLG observed for pigs fed the 18% CP diet.

Conclusions

Results from this experiment demonstrate that growing pigs respond to increased dietary crude protein concentration, which is supported by the improvement in ADG, feed efficiency and fat-free lean gain in pigs fed up to 22% crude protein. A similar effect was detected in plasma urea concentration. Pigs fed the 22% CP diet had an increase concentration of plasma urea compared to the pigs fed the 10, 14, and 18%

CP diet, indicating that the CP requirement of gilts in this experiment was $> 18\%$ CP. However, serum IGF-I concentrations were decreased in pigs fed the 10 and 14% CP diets, indicating that the consumption of a diet below the pigs dietary crude protein requirement (18%) was not always associated with a reduction in IGF-I serum concentration. Therefore, future research in this area will focus on the relationship between carcass protein accretion and serum IGF-I concentration. Also, the effect of crystalline amino acids will be investigated to determine their effects on serum IGF-I concentration and how the pattern of dietary crystalline amino acid supplementation can be manipulated in diets for growing-finishing pigs without creating negative effects on carcass protein accretion rates.

¹Robert L. Fischer is a research technologist and graduate student and Phillip S. Miller is a professor in the Department of Animal Science.

Development of a NCR-42 Vitamin-Trace Mineral Mix

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Summary and Implications

A vitamin-trace mineral mix (NCR-42 VTMM) and a vitamin B-safety pak (biotin, choline, folacin, thiamin and vitamin B₆) were formulated as possible common sources of nutrients for cooperative projects for the NCR-42 (North Central Regional) committee on swine nutrition. The adequacy of the NCR-42 VTMM and the vitamin B-safety pak were evaluated in a four-week growth trial with weanling pigs. The pigs (weaned 18-23d) were fed one of six diets: 1)

NC, negative control, a common nursery diet with vitamins at minimum levels (VTMM OX); 2) treatment 1, a common nursery diet with VTMM vitamins at 100% of NRC 1998 requirements for 5 to 45 lb pigs; 3) treatment 2, a common nursery diet with VTMM vitamins at 300% of NRC 1998 requirements for 5 to 45 lb pigs; 4) treatment 3, a common nursery diet with VTMM vitamins at 100% of NRC 1998 requirements for 5 to 45 lb pigs and B-safety pak at 100% of NRC 1998 requirements for 5 to 45 lb pigs; 5) treatment 4, a common nursery diet with VTMM vitamins at 300% and B-safety pak at 300% of NRC 1998 requirements for 5 to 45 lb pigs; 6) UNL, a common nursery diet with the concentration

of vitamins/minerals regularly fed in University of Nebraska (UNL) diets. Overall, there were no differences ($P > 0.10$) in average daily gain (ADG), average daily feed intake (ADFI), or feed efficiency (ADG/ADFI). However, numerically, there were increases in ADG and ADFI as the concentrations of minerals and vitamins increased. Pigs receiving the diet conforming to the typical University of Nebraska supplement had increased ADG, ADFI and feed efficiency compared to the negative control. Results from this study will be collectively examined with identical studies conducted at other research stations.

(Continued on next page)



Table 1. Composition of phase I and phase II diets.

| Ingredients, % | Phase ^{ab} | | | | | | Phase II ^{ac} | | | | | |
|------------------------------|---------------------|-------|-------|-------|-------|-------|------------------------|-------|-------|-------|-------|-------|
| | NC | Trt 1 | Trt 2 | Trt 3 | Trt 4 | UNL | NC | Trt 1 | Trt 2 | Trt 3 | Trt 4 | UNL |
| Corn | 38.14 | 37.99 | 37.69 | 37.09 | 37.39 | 38.04 | 49.06 | 48.91 | 48.61 | 48.81 | 48.31 | 48.96 |
| Soybean meal, 46.5% CP | 22.77 | 22.77 | 22.77 | 22.77 | 22.77 | 22.77 | 24.82 | 24.82 | 24.82 | 24.82 | 24.82 | 24.82 |
| Whey | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 | 20.00 |
| Blood plasma | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 6.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Blood cells | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Lactose | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dicalcium phosphate | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.61 | 1.61 | 1.61 | 1.61 | 1.61 | 1.61 |
| Limestone | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 |
| Sodium Chloride | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Fat | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Mecadox® | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| NCR-42 VTMM_03 ^d | 0.30 | 0.45 | 0.75 | 0.45 | 0.75 | 0.00 | 0.30 | 0.45 | 0.75 | 0.45 | 0.75 | 0.00 |
| B-safety pak ^d | 0.00 | 0.00 | 0.00 | 0.10 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.30 | 0.00 |
| UNL vitamin mix ^c | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 |
| UNL mineral mix ^f | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 |

^aNC = negative control, Trt 1 = VTMM 100%, Trt 2 = VTMM 300%, Trt 3 = VTMM 100%/B-safety pak 100%, Trt 4 = VTMM 300%/B-safety pak 300% the NRC requirements for the 5- to 45-lb pig, UNL = University of Nebraska vitamin/mineral mix.

^bPhase I diets formulated to contain: lysine, 1.35%; Ca, 0.80%; P, 0.70%; Available P, 0.39%; DE (digestible energy, kcal/lb), 1.557.

^cPhase II diets formulated to contain: lysine, 1.20%; Ca, 0.85%; P, 0.75%; Available P, 0.50%; DE (digestible energy, kcal/lb), 1.547.

^dComposition shown in table 2.

^eSupplied per kilogram of diet: retinyl acetate, 4,400 IU; cholecalciferol, 440 IU; α -tocopherol acetate, 24 IU; menadione sodium bisulfite, 3.5 mg; riboflavin, 8.8 mg; d-pantothenic acid, 17.6 mg; niacin, 26.4 mg; vitamin B₁₂, 26.4 μ g.

^fSupplied per kilogram of diet: Zn (as ZnO), 128 mg; Fe (as FeSO₄•H₂O), 128 mg; Mn (as MnO), 30 mg; Cu (as CuSO₄•H₂O), 11 mg; I (as Ca(IO₃)•H₂O), 0.26 mg; Se (as Na₂SeO₃), 0.3 mg.

Introduction

Cooperative-regional research studies investigating nutrient (e.g., lysine) utilization or management practices often rely on specific station (location) ingredients and/or vitamin/mineral premixes. Because significant variability exist among stations, the following study was conducted to develop a vitamin-trace mineral premix to be used as a common source of nutrients in cooperative projects for the NCR-42 (North Central Regional) committee on swine nutrition. The adequacies of the vitamin-trace mineral premixes (NCR-42 VTMM and the vitamin B-safety pak) were evaluated based on growth responses of weaning pigs. Only the results recorded for the UNL portion of the study are presented. Ultimately this data set/results will be combined with results collected at several other stations and presented collectively.

Materials and Methods

Experimental design

Seventy-two pigs were allotted based on initial weaning weight and litter-of-origin, and

Table 2. Composition of NCR-42 VTMM and B-safety pak.

| Vitamin/Mineral | Units/lb | Amount/lb of VTMM | Amount/lb of B Safety Pak |
|------------------|----------|-------------------|---------------------------|
| A | IU | 338,800.00 | 0.00 |
| D | IU | 33,880.00 | 0.00 |
| E | IU | 1,452.00 | 0.00 |
| K | mg | 110.00 | 0.00 |
| Biotin | mg | 0.00 | 11.00 |
| Choline | mg | 0.00 | 66,000.00 |
| Folacin | mg | 0.00 | 66.00 |
| Niacin | mg | 2,420.00 | 0.00 |
| Pantothenic Acid | mg | 726.00 | 0.00 |
| Riboflavin | mg | 484.00 | 0.00 |
| Thiamin | mg | 0.00 | 220.00 |
| B ₅ | mg | 0.00 | 220.00 |
| B ₁₂ | mg | 2.90 | 0.00 |
| Copper | mg | 145.20 | 0.00 |
| Iodine | mg | 30.80 | 0.00 |
| Iron | mg | 3751.00 | 0.00 |
| Manganese | mg | 0.00 | 0.00 |
| Selenium | mg | 24.20 | 0.00 |
| Zinc | mg | 12,100.00 | 0.00 |

randomly assigned to one of six dietary treatments. There were three replications per treatment and four pigs per pen. Pigs were weaned at 18 to 23 days of age with an average initial weight of 11.9 lb. At the conclusion of the 28-day trial, the average weight was 34.2 lb. The trial was divided into two 14-day phases.

The six treatments included (Table 1): 1) negative control (NC), common nursery diet with vitamins at minimum level (0% of

NRC 1998 requirements for 5 to 45 lb pigs); 2) treatment 1 (VTMM1X), common nursery diet with vitamin-trace mineral mix (NCR-42 VTMM) added at 100% (1X) of NRC 1998 requirements for 5 to 45 lb pigs; 3) treatment 2 (VTMM3X), common nursery diet with NCR-42 VTMM added at 300% (3X) of NRC 1998 requirements for 5 to 45 lb pigs; 4) treatment 3 (VTMM 1X/B 1X), common nursery diet with NCR-42 VTMM added at 100% and B-safety pak

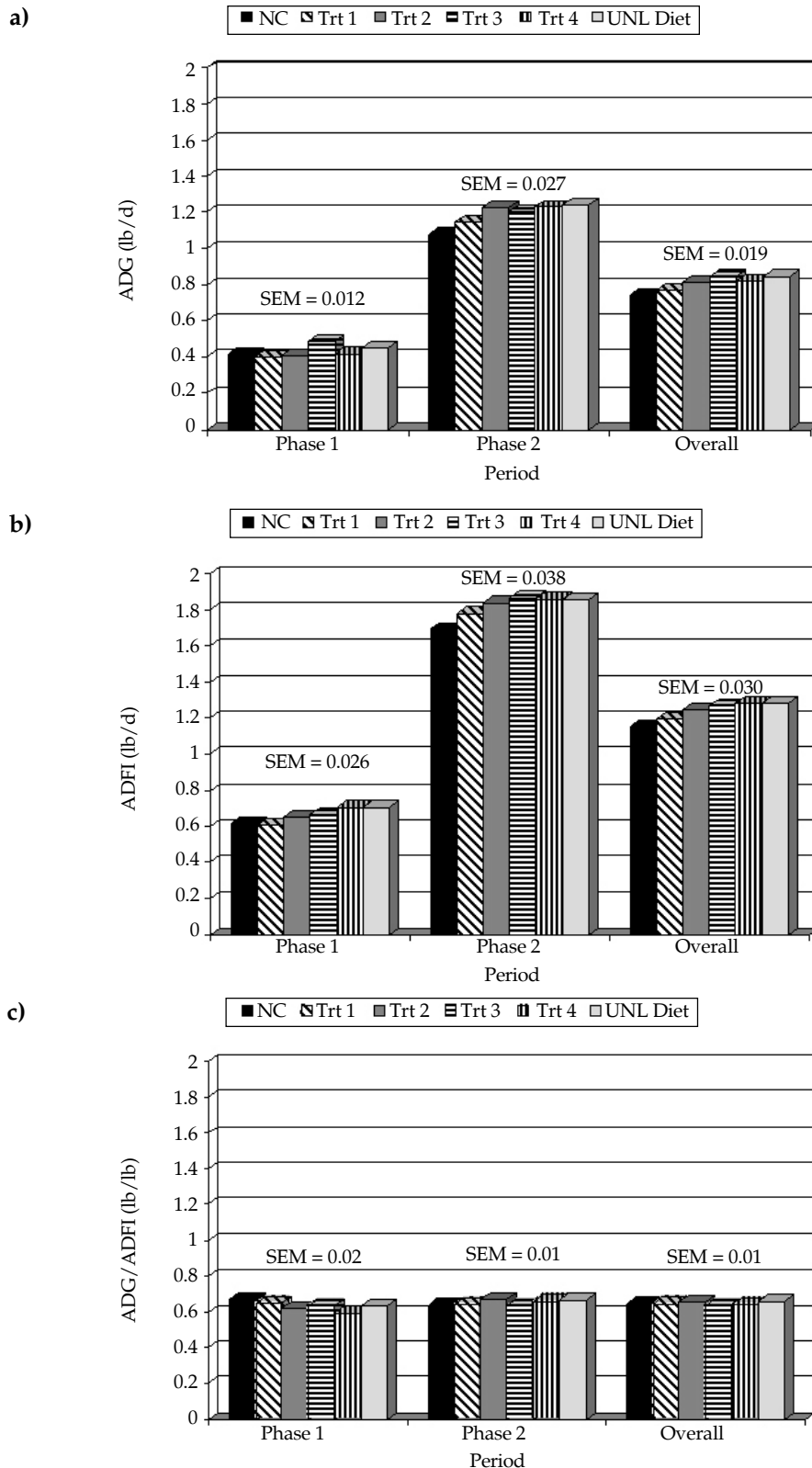


Figure 1. Phase I, phase II, and overall responses of 12 to 34 lb weanling pigs. a) ADG (average daily gain), b) ADFI (average daily feed intake), c) ADG/ADFI (feed efficiency). NC = negative control (common nursery diet with VTMM at 0% of NRC 1998 requirements for 5 to 45 lb pigs), Trt 1 (common nursery diet with VTMM at 100% of NRC 1998 requirements for 5 to 45 lb pigs), Trt 2 (common nursery diet with VTMM at 300% of NRC 1998 requirements for 5 to 45 lb pigs), Trt 3 (common nursery diet with VTMM at 100% and B-Safety Pak at 100% of NRC 1998 requirements for 5 to 45 lb pigs), Trt 4 (common nursery diet with VTMM at 300% and B-Safety Pak at 300% of NRC 1998 requirements for 5 to 45 lb pigs), UNL Diet (common nursery diet with University of Nebraska vitamin/mineral mix).

added at 100% of NRC 1998 requirements for 5 to 45 lb pigs; 5) treatment 4 (VTMM 3X/B 3X), common nursery diet with NCR-42 VTMM added at 300% and B-safety pak added at 300% of NRC 1998 requirements for 5 to 45 lb pigs; 6) UNL, common nursery diet with UNL standard vitamin-trace mineral premixes (all of the diets had trace minerals added at 100% of the NRC 1998 requirements for 5 to 45 lb pigs). The NCR-42 B-safety pak included: biotin, choline, folacin, thiamin and vitamin B₆ which were excluded in the NCR-42 VTMM premix. (Table 2). Phase I diets contained 1.35% lysine, 0.80% calcium and 0.70% phosphorus. Phase II diets contained 1.20% lysine, 0.85% calcium and 0.75% phosphorus.

Statistical analysis

Data were analyzed as a completely randomized block design using the PROC MIXED procedure of SAS. The main effect of the statistical model was dietary treatment. Pen was the experimental unit used for analyses.

Live animal care and measurements

Pigs had ad libitum access to feed and water throughout the experiment. Pigs and feeders were weighed weekly to determine average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (ADG/ADFI). Heat lamps and mats were utilized during phase I and removed for phase II.

Results and Discussion

Figures 1a-c show the growth criteria responses to dietary treatments. Due to illness during the first week of the trial, one pen receiving treatment 3 was excluded from the data analysis. There were no significant statistical differences ($P > 0.10$) for ADG, ADFI or feed efficiency among treatments

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(treatment main effect) during phase I, II and the overall experimental period. However, there were numerical increases in ADG, ADFI and feed efficiency with the additions of the VTMM premix and B-safety pak. Increases in ADG and ADFI were observed as the VTMM premix was added at 100% of the NRC 1998 requirements for 5 to 45 lb pigs (ADG: NC = 0.744 lb/d, trt 1 = 0.770 lb/d; ADFI: NC = 1.152 lb/d, trt 1 = 1.194 lb/d). Numerically, ADFI and ADG were maximized at the 300% premix addition (ADG = 0.822 lb/d, ADFI = 1.281 lb/d). Pigs receiving the UNL diet performed equal to or slightly greater than pigs receiving treatment 4 (VTMM 300%, B-safety pak 300% of the NRC 1998 requirements for 5 to 45 lb pigs). Feed efficiency (ADG/ADFI) was improved with the addition of the

VTMM premix at 300% of the NRC 1998 requirements for 5 to 45 lb pigs (ADG/ADFI = 0.641). Overall, pigs receiving higher concentrations of the VTMM premix and the B-safety pak or the UNL diet had numerically greater ADG and ADFI than pigs receiving the negative control.

Conclusion

Overall, there were no significant differences in ADG, ADFI or feed efficiency when adding supplemental vitamins to the diet. However, there were numerical increases in ADG and ADFI as the supplemental premixes were added to the diet. These numerical differences suggest that growth performance is increased as the VTMM and B-safety pak premixes are supplemented to the diet. In

addition, results suggest that the concentration of vitamins/minerals used in diets at the University of Nebraska is adequate given that the pigs consuming this diet performed as well as those consuming other dietary treatments. Data from other stations and data from this trial will be combined in order to form premixes with concentrations sufficient to support maximal growth performance. Collectively, these results will help identify vitamin and mineral premixes that can be used in future multi-site cooperative swine nutrition projects.

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Incidence and Inheritance of Splayleg in Nebraska Litter Size Selection Lines

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Summary and Implications

Incidence of abnormalities at birth is low in most populations, but accounts for a significant proportion of preweaning deaths. Splayleg pigs (SL) is the most common defect in newborn pigs and a high percentage of SL pigs die before weaning. In research at other institutions, SL incidence was associated with the Landrace breed and with large litters; however, a genetic association with litter size was not demonstrated. The University of Nebraska selection lines originated from a Landrace-Large White composite population and have been selected for 22 generations for increased litter size. These lines pro-

vided an excellent resource for the objectives of this study, which were 1) to identify traits associated with the SL condition, 2) to estimate genetic parameters for SL, and 3) to estimate the correlated response in incidence of SL to selection for increased litter size. Variables associated with the SL condition were sex, line, generation, line by generation interaction, birth weight, dam's number of live pigs born, dam's number of nipples, dam's age at puberty, dam's embryonic survival, and inbreeding of the dam. Boars were 234% more likely to display SL than gilts ($P < 0.01$). Decreased birth weight was associated with an increase in likelihood of SL ($P < 0.01$). The percentage of SL pigs increased as litter size increased ($P < 0.01$). Increased incidence of SL occurred in litters by gilts that reached puberty at younger ages ($P < 0.01$)

and that had fewer nipples ($P < 0.05$). Decreased embryonic survival to d 50 of gestation also significantly increased the probability of SL pigs in the litter ($P < 0.05$). Inbreeding of the pig did not significantly affect the incidence of SL, but the likelihood of SL increased with dam's inbreeding ($P < 0.05$). Estimates of 0.16 for maternal heritability and 0.32 for genetic correlation between number of pigs born alive and SL were obtained. Selection to increase litter size was not associated with genetic potential of individual pigs to be born with SL. However, selection for increased litter size indirectly increased the genetic potential for sows to create a uterine environment more likely to produce litters with SL pigs. The SL condition should be treated as a trait of the sow, rather than the individual piglet.