Vitamins and Minerals

Vitamins and minerals are involved in metabolic functions required for growth, development, and maintenance. Because of inadequate concentrations and/or limited bioavailability of some essential vitamins and minerals provided from ingredients within a swine diet, supplementation is required to meet their requirements. The importance of formulating to correct phosphorous, Ca:P ratio, sodium and chloride, and vitamin and trace mineral concentrations are discussed in this fact sheet.

Importance of Phosphorous in Diet Formulation

Phosphorous (P) is the second most abundant mineral in the body. Besides bone mineralization, phosphorous is involved in protein accretion and energy metabolism. Deficient levels can inhibit skeletal development and growth. Phosphorous is often the third most expensive diet component and excess levels can lead to increased diet costs. Exogenous phytase is commonly added to grow-finish diets to increase the availability of phosphorous which decreases the amount of mono or di-calcium phosphorus in the diet.

Assigning Phosphorous Values in Diet Formulation

Phosphorous values can be assigned to ingredients as either total, available, or digestible. Total P values are rarely used in diet formulation as it does not accurately represent the amount available for use by the pig and can cause deficiencies. Available P is determined through the use of a slope-ratio assay method, in which a standard source of phosphorus is given a value of 100% and the availability of P in an ingredient is estimated as a relative percentage to the standard source. Although the slope-ratio method seems to be more accurate to estimate availability of P, there is a concern about assuming 100% availability in the standard source. Also, determining the available P value for each ingredient is generally expensive. Therefore, digestible P provides a better estimate of the amount of P being digested and absorbed. Digestible P can be expressed several ways. Two common ways are apparent digestible and standardized total tract digestibility. The standardized value is preferred because it accounts for endogenous loss of P.

Phosphorous Formulation Considerations

A digestible P:calorie ratio should be utilized when formulating diets as dietary energy concentration will influence the amount of feed consumed. Thus when using a standard ratio, the dietary level of P can be adjusted to account for changes in feed intake. Also, as feed efficiency and lean growth improve, the dietary P requirement concentration will increase (Vier et al., 2017). Furthermore, when using phytase, P release values should be used to ensure accurate P levels are being formulated.

Ca:P Relationship

Both P and Ca are required for bone mineralization. Since Ca and P share an absorption pathway, excess dietary Ca can have an antagonizing effect on P digestion and absorption (Létourneau-Montminy et al., 2012). Therefore, a Ca:P ratio is commonly used in diet formulation to ensure excess Ca does not interfere with phosphorous absorption. Calcium supplementation is low cost and if not limited in diets, least cost formulation will allow excess Ca into the diet to lower cost. This can lead to a wide Ca:P ratio that may lead to reductions in grow-finish pig performance especially when P is below the requirement (Stein, 2016). When diet P concentrations are adequate, increasing the Ca:P ratio can improve growth performance of grow-finish pigs (Vier et al., 2017). Furthermore, Ca:P ratios should be formulated on a digestible basis. If digestible Ca values are not available, the ratio should be formulated on analyzed Ca:analyzed P ratio.

In summary, digestible P values should be utilized when formulating a Ca:P ratio in diets and the

amount of digestible P being provided should be adequate to meet P requirements.

Sodium and Chloride

Sodium and chloride are directly involved in nutrient absorption, electrolyte balance, and regulation of pH. Dietary supplementation of these minerals is essential as sodium and chloride are low in most cereal grains used in swine diets. Salt or sodium chloride is the most common source supplemented to swine diets to meet their requirements. The sodium and chloride requirements for grow-finish pigs decrease abruptly from the nursery stage. A typical grow-finish diet has 7 to 10 lb per ton added salt which is well beyond their sodium and chloride requirements.

Trace Mineral Supplementation

Copper, iron, iodine, manganese, selenium and zinc are typically supplemented in grow finish diets through a premix to meet the dietary requirements as some trace minerals have low bioavailability in feed ingredients. However, some trace minerals are included above the pig's requirement at growth promoting levels. High levels of copper (up to 250 ppm) can be supplemented to promote growth of finishing pigs. This effect seems to be greater in younger pigs compared to older pigs (Davis et al., 2002; Carpenter et al., 2017; Coble et al., 2017). Furthermore, in periods where high levels of protein deposition are observed, such as when ractopamine is included in diets, data has shown that the zinc requirement is increased (Paulk et al. 2015). Therefore, increased levels of supplemental zinc (up to 100 ppm) can be supplemented to support the increased protein deposition. When using increased levels of copper or zinc, care must be exercised so as not to lead to toxicity. Environmental factors should also be considered.

Vitamin Supplementation

Because some vitamins are not produced by pigs or have low bioavailability in feed ingredients, vitamins are routinely supplemented to grow-finish diets. While the NRC (2012) recommends vitamin requirements which include amounts from feed ingredients (total vitamin levels), standard practice is to only consider vitamins provided by the premix (added vitamin levels). Also, vitamins contained in the premix are typically formulated above NRC (2012) recommendations to provide a margin of safety that accounts for low bioavailability in ingredients, differences in daily feed intakes, or degradation due to storage and feed processing (Flohr et al., 2016).

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Table 1. Vitamin and Mineral recommendations for growing-finishing pigs

	Growing-finishing pig weight, lb			
	55 to 130	130 to 175	175 to 220	220 to 285
Total calcium, %[1]	0.66	0.59	0.52	0.46
STTD calcium, %[2]	0.49	0.43	0.38	0.33
STTD phosphorus, %[2]	0.38	0.33	0.29	0.26
Available phosphorus, %[2]	0.32	0.28	0.24	0.21
Total Ca:STTD P[2]	1.74	1.79	1.79	1.77
STTD Ca:STTD P[2]	1.30	1.30	1.31	1.27
Na, %[3]	0.24	0.17	0.17	0.17
Cl, %[3]	0.40	0.31	0.31	0.31
Trace Minerals[4]				
Zinc, ppm	110	92	73	55
Iron, ppm	110	92	73	55
Manganese, ppm	33	28	22	17
Copper, ppm	17	14	11	8
Iodine, ppm	0.30	0.25	0.20	0.15
Selenium, ppm	0.30	0.25	0.20	0.15
Vitamins[4]				
Vitamin A, IU/ton	2,250,000	1,875,000	1,500,000	1,125,000
Vitamin D, IU/ton	900,000	750,000	600,000	450,000
Vitamin E, IU/ton	24,000	20,000	16,000	12,000
Vitamin K, IU/ton	1,800	1,500	1,200	900
Vitamin B12, mg/ton	18	15	12	9
Niacin, mg/ton	27,000	22,500	18,000	13,500
Pantothenic Acid, mg/ton	15,000	12,500	10,000	7,500
Riboflavin, mg/ton	4,500	3,750	3,000	2,250

[1]Indication of maximum calcium levels for each phase. Calcium level determined by formulating to calcium:phosphorus ratio developed from Vier (2017).
[2]Indication of phosphorous levels in grow-finish diets to optimize growth performance developed from Vier (2019).
[3]Sodium and chloride recommendations based on corn-soybean meal diet with 10 lb/ton inclusion of salt in 50 to 130 lbs and 7 lb/ton inclusion for all other weight ranges.
[4]Added levels from KSU vitamin and trace mineral premixes provided at 0.15% of the diet.