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DELIVERING ESSENTIAL NUTRIENTS TO YOUNG, GROWING HORSES

STEPHEN DUREN
Kentucky Equine Research, Inc., Versailles, Kentucky, USA

Introduction

The goal of raising performance horses is to produce sound athletes. One potential pitfall in raising this type of horse is unsoundness resulting from Developmental Orthopedic Disease. The term Developmental Orthopedic Disease (DOD) includes all general growth disturbances resulting from any alteration in normal bone formation (Lewis, 1995). DOD has many manifestations in growing horses including: 1) physitis, 2) wobblers syndrome, 3) angular limb deformities, 4) flexural leg deformities and 5) osteochondritis dissecans. The causes of DOD have been debated over the past ten years. Currently, the most common causes of DOD are thought to be: trauma to the metaphyseal growth plate or articular cartilage, genetics, rapid growth, nutritional imbalances and environment. With nutrition being one potential factor in DOD, adequately fortifying and properly balancing the diets for young growing horses is very important.

To properly fortify and balance a diet for a young growing horse, it is essential to have an understanding of which nutrients are most critical for proper skeletal growth. Further, one must have an understanding of the requirements for these critical nutrients. Understanding the critical nutrients and their requirements is only the first step in properly feeding growing horses. With so many different feedstuffs available, all with very different nutrient profiles, a working knowledge of feeding practices including the amount and type of feed provided and the expected growth rate of the horse is important. The following paper will discuss the essential nutrients for proper skeletal growth along with their requirements. In addition, some of the many different methods available to deliver essential nutrients to growing horses will be explored.

Critical nutrients for growth

The critical nutrients required for growth among different animals are basically similar. All animals require energy, protein (amino acids), minerals and vitamins. However, the actual nutrients which are considered in balancing diets for various farm animals are very different. For example the nutrients which are actively balanced in poultry diets are listed below.

Energy		
Protein	*Amino Acids* Methionine Cystine Lysine Threonine Tryptophan Arginine	
Minerals	*Macro* Calcium Phosphorus Sodium Potassium Chloride	*Micro* Copper Iodine Iron Manganese Selenium Zinc
Vitamins	*Fat-soluble* A D E K	*Water Soluble* Choline Pantothenic Acid Pyridoxine

As one can see, the list of nutrients is considerable. There are several reasons for this intense accountability of nutrients. First, the digestive system of the chicken does not provide extensive microbial synthesis of nutrients. Second, chickens are typically confined and gather their entire nutrient requirement from a complete diet provided to them.

In horses, the list of critical nutrients for growth is smaller. Although many nutrients are required, the most critical nutrients for growth of young horses are listed below.

Energy		
Protein	*Amino Acid* Lysine	
Minerals	*Macro* Calcium Phosphorus	*Micro* Copper Zinc

A complete discussion of energy and protein requirements of young, growing horses is provided elsewhere in these proceedings. Therefore, this paper will focus on the critical minerals necessary for proper skeletal growth.

Calcium

Calcium is the first mineral often considered in the diets of young horses. Calcium makes up about 35% of bone structure (El Shorafa *et al*., 1979), with approximately 99% of the calcium in the body found in the bones and teeth (Lewis, 1995). Calcium is also involved in other body functions including muscle contraction and blood clotting mechanisms. Inadequate calcium intake by the developing foal can lead to rickets, which is characterized by poor mineralization of the osteoid tissue and the probability of enlarged joints and crooked long bones (NRC, 1989). The scientific data pointing to the ill-effects of a calcium-deficient diet have also been reported in the field. Knight and co-workers (1985) reported a negative linear relationship between dietary calcium intake and perceived severity of DOD in young horses. Excess calcium has also been fed to young horses. In a study reported by Jordan and co-workers (1975) feeding five times the calcium requirement was not detrimental provided the level of phosphorus in the diet was adequate.

Phosphorus

Phosphorus is also a critical mineral for proper skeletal development. Phosphorus is often considered with calcium since it also is a major component of bone, making up 14 - 17% of the skeleton (El Shorafa *et al*., 1979). Two major problems can exist with growing horses relative to phosphorus supplementation. The first is inadequate phosphorus in the diet. A simple phosphorus deficiency can result in DOD and bone demineralization. The second condition is excessive phosphorus content in the diet, a situation in which phosphorus concentration is actually greater than calcium concentration, and phosphorus interferes with calcium absorption.

Copper and zinc

Copper is required by growing horses as a component of several copper-dependent enzymes involved with elastin and collagen formation (NRC, 1980). Young growing horses with inadequate copper intake do not suffer from slow growth rate; instead, normal or rapid growth continues but without adequate copper for normal bone and cartilage development. The end result is foals with decreased bone density and DOD (Lewis, 1995). Cymbaluk and co-workers (1981) reported that copper absorption by the horse decreases with increasing copper intake giving horses a high tolerance to excess copper ingestion. The NRC (1989) reported the maximum tolerance level of copper to be 800 mg/kg diet.

Zinc is required as a component of many metalloenzymes involved in protein and

carbohydrate metabolism. Low zinc concentration has been correlated with an increased incidence of DOD in growing horses (Knight *et al.*, 1985). The NRC (1989) reported the maximum tolerance level of zinc to be 500 mg/kg diet.

Nutrient requirements

The National Research Council has published a booklet listing the Nutrient Requirements of Horses. The most recent edition of this booklet is the fifth revised edition published in 1989 (NRC, 1989). In this publication, a subcommittee of six equine nutrition research scientists reviewed the equine nutrition literature and updated the nutrient requirements of horses. The requirements stated in the booklet represent the *minimum* amounts needed to sustain normal health, production and performance of horses. In the introduction of this publication, the subcommittee suggested that consideration be given when applying these recommendations to, among other things, the individual variation in horses, expected performance and different environmental conditions. Therefore, the NRC should be viewed as a good starting place for the formulation of horse rations, and not as the only or best source of information.

Due to the frequency of publication of updated NRC guidelines, the last revision already seven years old, the NRC cannot contain the most up-to-date information. In an effort to remain current with advances in equine nutrition, Kentucky Equine Research continuously reviews new research, and also conducts and publishes research done in our laboratory. As a result of these efforts, Kentucky Equine Research has modified certain NRC requirements to be more practical in the production of sound, athletic horses. Modifications of NRC requirements which appear in this text along with modifications appearing in the MicroSteed™ computer program are safe additions to horse diets and are currently being used by the staff of Kentucky Equine Research.

The requirements for those nutrients critical to growth of young horses appear in the following tables. In each table, the minimum requirement established by the NRC, 1989 appears followed by the requirements established by Kentucky Equine Research.

Table 1. NUTRIENT REQUIREMENTS FOR 4-MONTH-OLD WEANLING (385 LBS) GAINING 1.87 LBS PER DAY, 1100 LB MATURE WEIGHT.

Requirement	*Ca (g/d)*	*Phos (g/d)*	*Cu (mg/d)*	*Zn (mg/d)*
NRC '89	34	19	50	198
KER	39	26	150	450

Table 2. NUTRIENT REQUIREMENTS FOR 6-MONTH-OLD WEANLING (473 LBS) GAINING 1.43 LBS PER DAY, 1100 LB MATURE WEIGHT .

Requirement	*Ca (g/d)*	*Phos (g/d)*	*Cu (mg/d)*	*Zn (mg/d)*
NRC '89	29	16	52	207
KER	36	24	150	450

Table 3. NUTRIENT REQUIREMENTS FOR 6-MONTH-OLD WEANLING (473 LBS) GAINING 1.87 LBS PER DAY, 1100 LB MATURE WEIGHT.

Requirement	*Ca (g/d)*	*Phos (g/d)*	*Cu (mg/d)*	*Zn (mg/d)*
NRC '89	36	20	59	237
KER	42	28	150	450

Table 4. NUTRIENT REQUIREMENTS FOR 12-MONTH-OLD YEARLING (715 LBS) GAINING 1.10 LBS PER DAY, 1100 LB MATURE WEIGHT.

Requirement	*Ca (g/d)*	*Phos (g/d)*	*Cu (mg/d)*	*Zn (mg/d)*
NRC '89	29	16	67	270
KER	45	30	150	450

TABLE 5. NUTRIENT REQUIREMENTS FOR 12-MONTH-OLD YEARLING (715 LBS) GAINING 1.43 LBS PER DAY, 1100 LB MATURE WEIGHT.

Requirement	*Ca (g/d)*	*Phos (g/d)*	*Cu (mg/d)*	*Zn (mg/d)*
NRC '89	34	19	76	303
KER	50	33	150	450

Table 6. NUTRIENT REQUIREMENTS FOR 18-MONTH-OLD YEARLING (880 LBS) GAINING 0.77 LBS PER DAY, 1100 LB MATURE WEIGHT.

Requirement	*Ca (g/d)*	*Phos (g/d)*	*Cu (mg/d)*	*Zn (mg/d)*
NRC '89	27	15	79	317
KER	46	31	150	450

Now that we have established the critical nutrients for growth and their requirements, it is time to apply this information to feeding growing horses.

Understanding the variables

To begin the process of providing essential nutrients to growing horses, one must realize that methods of feeding vary greatly throughout the United States and the world. Many feeding variables exist, each providing a series of challenges for delivering the proper amount of diet fortification. The following are several examples of common feeding variables.

Availability and quality of natural and/or stored forage

The types of forages (pasture and/or hay) which are available to young growing horses have a significant impact on diet fortification. Young, growing horses are capable of eating 1.5 - 2% of body weight in high quality pasture or hay per horse per day. Depending on the nutritive value of the hay or pasture, this can have a profound influence on the nutrient intake of the growing horses, and thus the remaining nutrients which need to be supplied by grain supplementation. For example, the difference in nutritive value between alfalfa and timothy hay is immense, with alfalfa typically having more energy, protein and calcium than timothy hay. Further, the difference between hay or pasture utilized in a young, vegetative state vs. a mature state is important, since the nutritive value and the intake of forage decreases with increased maturity.

Amount of supplemental feed (grain) typically fed

The amount of grain fed to young, growing horses varies widely throughout the world. For example, the normal amount of grain fed to a yearling Thoroughbred in central Kentucky is much greater than typically fed to a yearling Thoroughbred in Washington. The amount of grain accepted as a “normal” intake for a Quarter Horse weanling halter prospect is much greater than fed to a Quarter Horse weanling not intended for show. These basic differences in the amount of grain considered to be “acceptable” will have large implications on the amount of fortification which should be contained in these grain mixtures. Unfortunately, many manufacturers pay little attention to the amount of grain which is actually being fed by the horse-owner.

Desired growth rate

The rate at which growing horses gain weight is a function of the amount of feed provided and their genetic capacity for growth. The body weight of a growing horse can be controlled by adjusting the intake of calories. Horse-owners who desire rapid weight gain in young horses will typically provide a larger proportion of calories from grain concentrates. Since these horses are eating more pounds of grain per day, the concentration of nutrients in that grain can be less. On the other hand, horse breeders who do not stress rapid weight gain in young horses typically feed fewer pounds of grain. Grain concentrates for these horse breeders must be more concentrated since fewer pounds are provided to the horse. Both the fast-growing and slower-growing horses need proper dietary fortification; however, the amount of energy (calories) provided with this fortification must be different.

Ability to feed horses individually

In many areas of the world growing horses are fed individually a measured amount of feed on a daily basis. This is the best case scenario for feeding young horses. Unfortunately, many breeders of horses are unable to feed their young stock individually. In these situations young horses are fed in groups where one horse potentially can monopolize the feed. A feed product destined for use in this type of situation would need to have a low energy content, or a low intake, to prevent excessive growth, but still have a safe level of fortification to provide each horse with critical nutrients for growth.

Each of these variables provides a series of challenges for delivering the proper amount of diet fortification. The following are actual diets which can be formulated to address these common feeding variables.

The diets

In the following examples, several feeding programs will be developed for a 12-month-old yearling weighing 715 lbs, gaining 1.1 lbs per day with an expected mature weight of 1100 lbs. The nutrient requirements for this horse are listed in Table 4.

EXAMPLE 1

The first feeding situation is an example for supplying critical nutrients using three different levels of grain intake (moderate, low, and minimal). In this example, the yearling diet consists of free-choice access to good quality pasture, with supplemental

grain feeding twice daily. In Figure 1, the yearling is on a moderate grain intake (8 lbs/horse/day) with an estimated intake of pasture dry matter of 12 lbs/horse/day. The level of fortification found in the pasture (DM) and the level of fortification necessary in the grain concentrate (as-fed) to balance the remainder of critical nutrients are shown below.

Ingredient	*Ca (%)*	*P (%)*	*Cu (ppm)*	*Zn (ppm)*
Pasture	0.37	0.27	15	28
14% Textured Feed	0.80	0.60	35	95

The same yearling on a low grain intake is shown in Figure 2. In this example, the yearling is receiving 4.5 lbs of grain/horse/day with pasture dry matter intake estimated at 15.5 lbs/horse/day. Since the yearling is eating fewer pounds of grain/day, the concentration of nutrients in that grain must be higher to satisfy the nutrient requirements. The level of fortification necessary in the low intake grain concentrate is shown below, compared with the nutrient profile of the grain used in the previous example.

Ingredient	*Ca (%)*	*P (%)*	*Cu (ppm)*	*Zn (ppm)*
14% Textured	0.80	0.60	35	95
Low Intake Sweet Feed	0.95	0.80	70	200

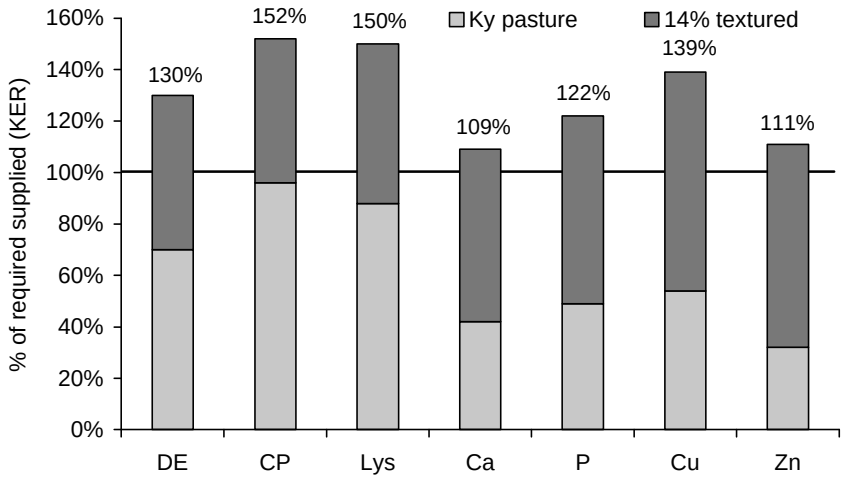

Figure 1. Yearling - high grain intake

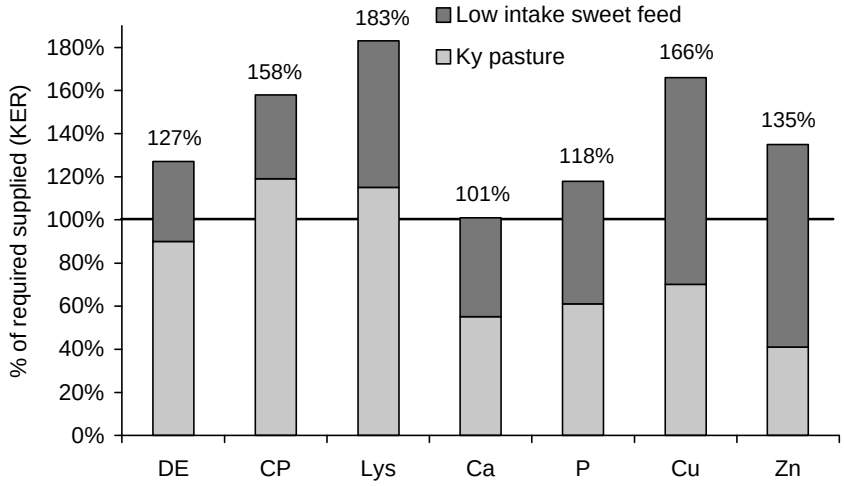

Figure 2. Yearling - moderate grain intake

Finally, there are horse feed clients who want to feed the absolute minimum amount of grain necessary to their horses. On good quality pastures, it is possible for the yearling in this example to consume enough pasture to satisfy requirements for digestible energy and protein to maintain a moderate level of growth (1.1 lbs/horse/day). However, the concentration of critical nutrients (calcium, phosphorus, copper and zinc) will not be adequate in a pasture-only diet. To properly balance a diet in this situation, it is estimated the yearling will consume nearly 16 lbs of pasture dry matter/ day along with 1.25 lbs of supplement/horse/day. The nutrient profile of this diet is depicted in Figure 3. The nutrient profile of the supplement pellet is shown below.

Ingredient	*Ca (%)*	*P (%)*	*Cu (ppm)*	*Zn (ppm)*
14% Textured	0.80	0.60	35	95
Low Intake Sweet Feed	0.95	0.80	70	200
Supplement Pellet	5.00	2.00	300	800

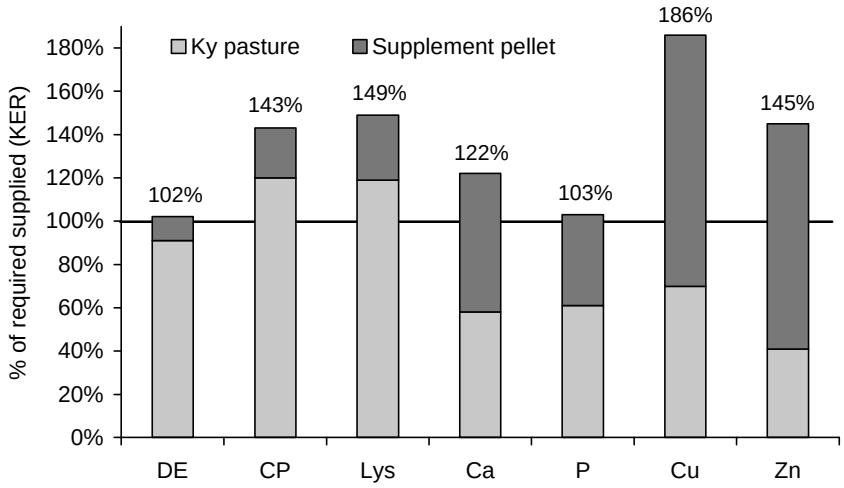

Figure 3. Yearling - supplement pellet

EXAMPLE 2

In this scenario, the horse owner is free-choice feeding good quality alfalfa hay to our example yearling. The alfalfa diet is supplying adequate energy, protein and calcium to support the desired moderate growth rate, but is marginal in phosphorus, copper and zinc. This is a situation very common to young growing horses in the west, where high quality alfalfa hay is common. To properly balance this diet, one would want to feed a low intake supplement pellet which provided essential phosphorus, copper and zinc, but did not add a significant amount of energy, protein or calcium since these nutrients are already in excess. In Figure 4, a final diet consisting of alfalfa (15.5 lbs/horse/day) and 1.5 lbs of a specially designed mixing pellet to be fed with alfalfa hay is shown. The nutrient profile of this mixing pellet is unique since it contains low protein (9%), an inverted ratio of calcium to phosphorus and high trace mineral concentrations. In formulating such a product, it is essential this supplement pellet be used only in diets for horses eating predominantly alfalfa hay (greater than 50% of the forage consisting of alfalfa).

Ingredient	*Ca (%)*	*P (%)*	*Cu (ppm)*	*Zn (ppm)*
Suppl. Pellet - Alfalfa	0.50	2.60	200	800

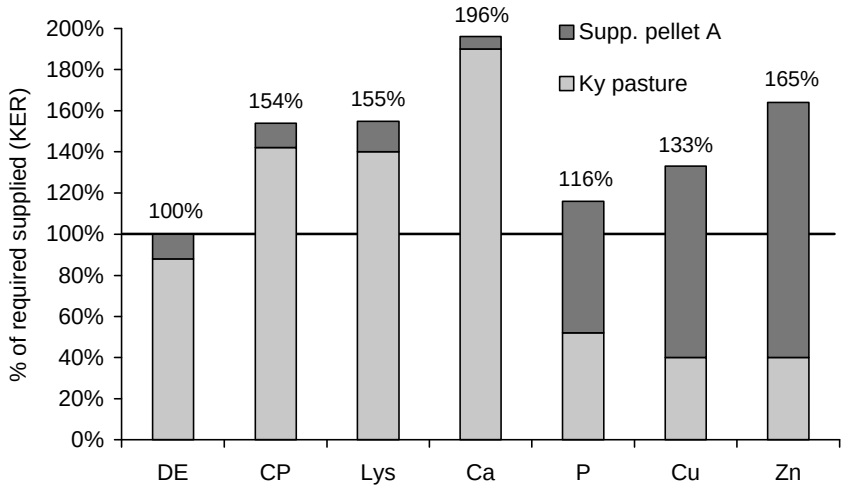

Figure 4. Yearling - maximum forage

EXAMPLE 3

Despite the best efforts of the owners, our example yearling has developed DOD. The veterinary surgeon involved has suggested an energy restricted diet to avoid any further rapid weight gain. It is important to realize that an energy restricted diet will decrease the rate of gain; however, the skeleton of the yearling will continue to grow. The end result is a yearling which has grown taller, but has become progressively thinner. Since the skeleton of the yearling continues to grow even on an energy restricted diet, it is important that the horse receive adequate levels of essential nutrients required for growth. In figure 5, the yearling can be fed at approximately 70% of energy requirements with adequate nutrients to support continued skeletal growth. The diet consists of 11 lbs of mixed hay (alfalfa/grass) plus 2.5 lbs of a protein, vitamin and mineral supplement pellet (All-Phase).

Ingredient	*Ca (%)*	*P (%)*	*Cu (ppm)*	*Zn (ppm)*
Mixed Hay	0.85	0.26	6	25
All-Phase Pellet	3.00	2.00	140	340

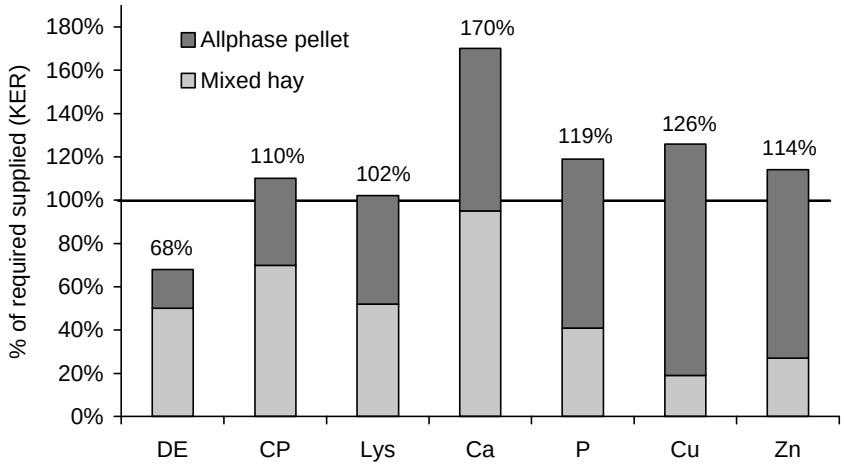

Figure 5. Yearling - DOD diet

EXAMPLE 4

The directions on the feed bag suggest that our example yearling receive the grain concentrate at a minimum rate of 8 lbs/horse/day. These directions were placed on the bag in order for the horse to get adequate diet fortification. Unfortunately, the owners of the horse do not want to feed any more than 5 lbs of grain/horse/day. If they only feed 5 lbs of this grain/horse/day along with a mixed hay (14 lbs/horse/day) the yearling will be marginal in phosphorus, copper and zinc intake (Figure 6). A method which can be used to provide the requirement of essential nutrients while still adhering to the owners' maximum of 5 lbs of grain/horse/day rule is shown in Figure 7. In this situation, the intake of mixed hay remains constant while the level of grain concentrate is dropped from 5 lbs/day to 3.5 lbs/day. The remaining 1.5 lbs, which has been set aside for grain intake, is provided as a supplement pellet rather than the normal grain. The finished diet will then consist of 14 lbs of mixed hay/horse/day, 3.5 lbs of grain concentrate and 1.5 lbs of supplement pellet (All-Phase).

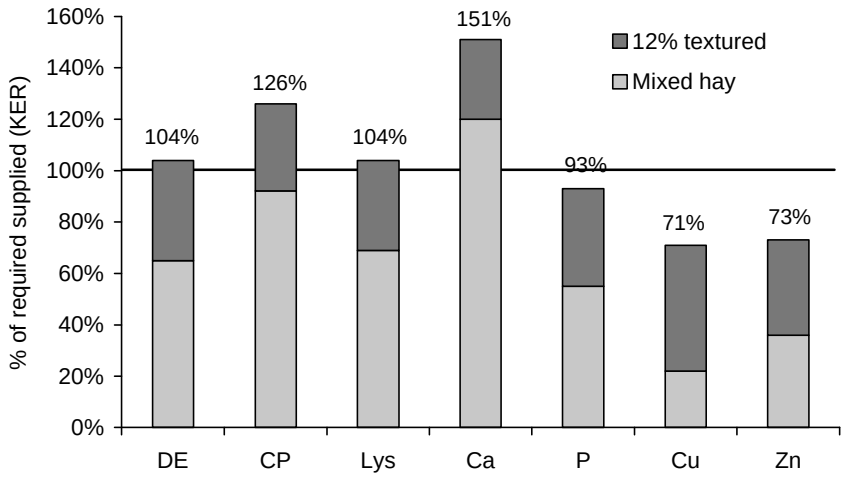

Figure 6. Yearling - low fortification

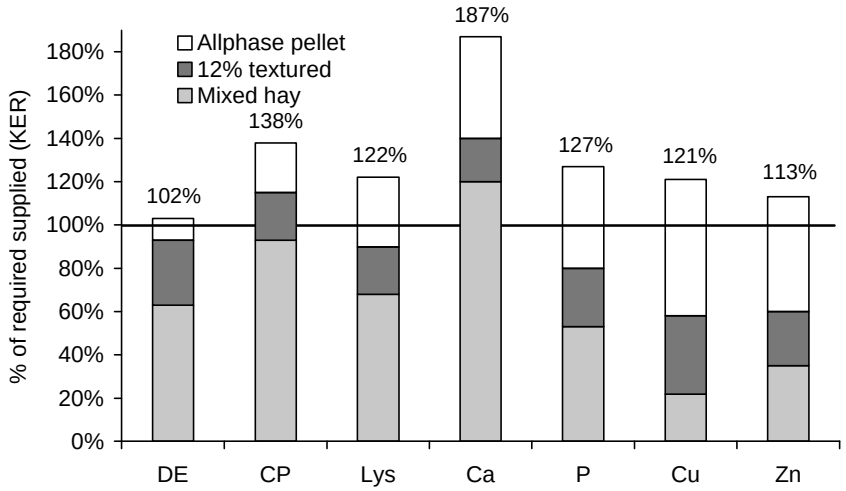

Figure 7. Yearling - balanced diet

EXAMPLE 5

Finally, there are horse owners who raise young horses in situations which do not allow them to feed grain and/or supplement pellets on a daily basis. Hay and/or pasture are available free-choice, but supplemental grain feeding is not possible. The young horses still require diet fortification, but this fortification must be provided

with a free-choice supplement. This free-choice supplement must be palatable and self limit intake. Fortified molasses blocks can be used to accomplish this goal. Figure 8 depicts a diet for our example yearling. In this diet, the yearling is eating approximately 17 lbs of mixed hay/day along with 3 lbs/day of a well-fortified molasses block. It is important that the concentrations of nutrients which are contained in the block are appropriate for the actual intake. In other words, the intake of these blocks by young horses needs to be monitored to insure proper fortification. If intake of these blocks is grossly over or under the recommended intake, the blocks will do a poor job of balancing the diet. The appropriate level of nutrient fortification in a free-choice molasses block with a targeted intake of 3 lbs/horse/day is shown below.

Ingredient	*Ca (%)*	*P (%)*	*Cu (ppm)*	*Zn (ppm)*
Mixed Hay	0.85	0.26	6	25
Forti-Sweet Block	1.75	1.00	135	245

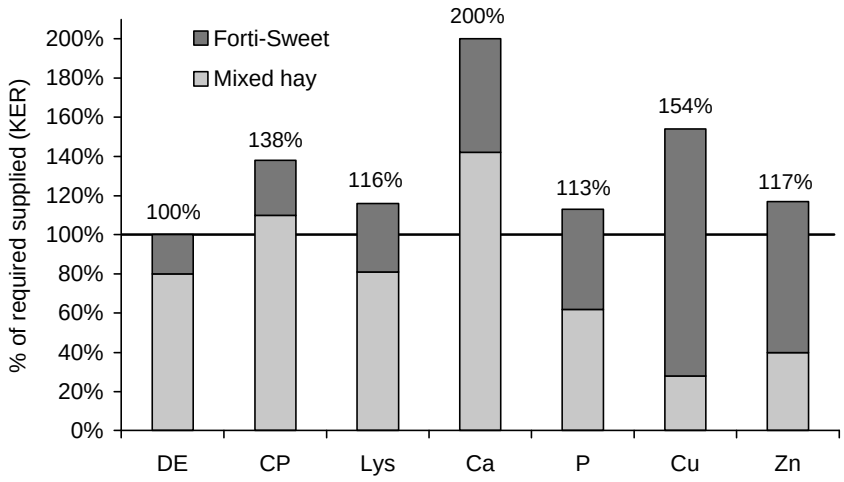

Figure 8. Yearling - no grain

Conclusion

Nutrition imbalances have been recognized as one potential cause of DOD in young, growing horses. Therefore, it is important that the diets of young horses be properly balanced with nutrients known to be critical to proper development. In young, growing horses the major nutrients of concern are protein, energy, calcium, phosphorus, copper and zinc. Each of these nutrients has minimum requirements put forth by the National Research Council (NRC, 1989). Kentucky Equine Research has elevated the

requirements for these essential nutrients to allow an increased margin of safety, and to make them more practical in the production of sound, athletic horses. Understanding the essential nutrients and their requirements is the first step in properly feeding young horses. Next, one must understand the many variables associated with feeding including: 1) the availability and quality of natural and/or stored forage, 2) the amount of supplemental feed (grain) typically fed, 3) the desired growth rate and 4) the ability to feed horses individually. Once this information is put together, a properly balanced grain or supplement can be designed to balance the diet.

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