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Iron Management To Improve Color and Performance in Veal Calves

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Poor Color Costs the Veal Industry Millions

According to the 1998 National Veal Quality Audit, poor color costs the veal industry $10.29 for every calf produced - $6 million in 1998! This estimate was based on the cost of commonly occurring dark or very dark carcasses. There are two primary causes of dark color in veal meat: excessive iron supplementation and inadequate ventilation. This article will focus on iron management to improve calf performance and improve veal color.

Goldilocks and Iron for Veal Calves – Finding the Level That's "Just Right"

Remember Goldilocks? She was the little girl that sat in the bears' chairs, ate their porridge, and slept in their beds when the bears were away from home. Today we'd call her a burglar but years ago she was heroine in a fairy tale along with three bears who were not pleased when they found Goldilocks in their home. Regardless of the circumstance, Goldilocks found that one chair was too big, one was too small, and one was just right. She made similar discoveries regarding the porridge and the beds always concluding that one was just right. This discovery applies to iron and veal – calves could have too little iron (iron deficiency), too much iron (iron excess), or an iron level that is "just right".

Too Little Iron

Iron deficiency results in anemia which occurs when blood hemoglobin drops to 5.5-6.0 g/dl (Enjalbert, 1981). Iron deficiency is characterized by many negative effects like rough hair coat, poor health, reduced feed intake, excessive licking, pale nose and/or gums, poor feed conversion, lower feed digestibility, and chaulky colored manure with thick consistency which becomes thin and watery in severe anemia. Iron deficient calves have a higher incidence of sudden death under stress (shipping, handling) than calves with adequate iron status. In severe anemia, calves may die because the oxygen carrying capacity of the blood is inadequate to supply the calf's oxygen needs despite increases in heart rate and respiration rate.

Too Much Iron

Providing too much iron has very little effect on calf performance. In fact, massive amounts of iron are tolerated before adverse effects are noted such as reproductive failures in breeding cows. In veal, too much iron results in dark colored meat (red) which has lower value in the marketplace. In one Nouriche research study (V02 QCO 00), we collected blood from every calf in weeks 1, 2, 4, 6, 8, 10, 12, 14, 16, and 18. We found that there was no significant relationship between blood hemoglobin levels and final weight or total gain in calves provided that they were not anemic. Significant correlations between weight gain and hemoglobin level were detected only during weeks 6, 8, and 10 most likely because calves that arrived at the farm from the sale barn with extremely low iron stores were borderline anemic during those periods. Preventing anemia in every calf is of utmost importance but the common belief that giving "extra" iron will make calves gain more weight is not supported by our research or other published research.

Just Right Iron

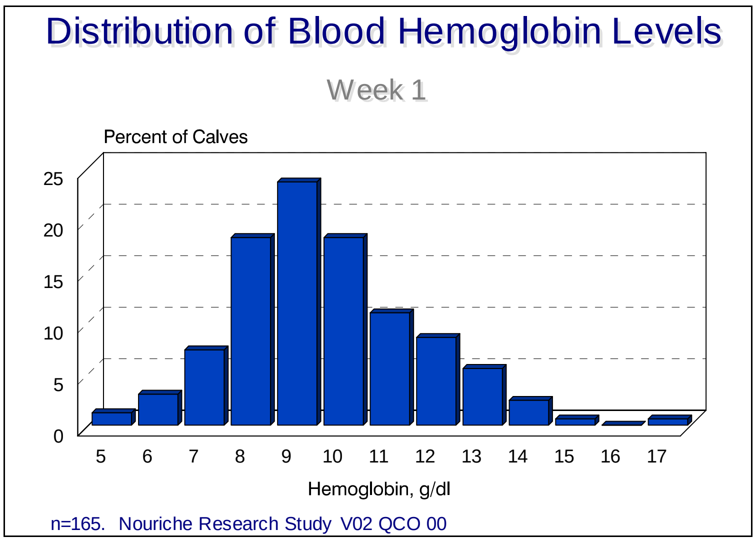
We strive for iron levels that are "just right" – high enough to avoid anemia and all the problems that go with it, but not so high to produce red meat. If we are to reduce the incidence of dark color and supply adequate iron to every calf to prevent anemia, we must examine several issues regarding iron management and adopt some research-based solutions to help improve iron management, calf performance, and profit potential.

Iron Status of Baby Calves – Not Dependent on Mother Cow

It is widely believed that the iron status of any particular calf is a reflection of the iron status of the mother cow that gave birth to the calf. Unfortunately, research has shown that this assumption is false. In several experiments, researchers tested variables which reflect iron status in cows and calves and found that there is no reliable relationship between cows and their calves (Miltenburg *et al*., 1991). Among their tests were hemoglobin, hematocrit, mean corpuscular volume (MCV), plasma iron content, total serum iron binding capacity, and liver iron concentration. They found that it is impossible to predict the iron status of the calf by any of the variables measured in cows. Canadian researchers confirmed the poor relationship between iron status of calves and the iron status of the calves' dam (Gooneratne and Christensen, 1989).

Iron storage of cows changes in relationship to age (Blum and Zuber, 1975) and with various body tissues. Storage increases until age 5 and remains fairly constant through 9 years of age. Normal cows milk contains 0.5 ppm iron while colostrum contains about 3 times this amount. Iron level in the milk changes during different stages of lactation, but does not reflect the iron status of the cow.

In some Nouriche research studies, hemoglobin levels of baby calves have ranged from less than 6 to more than 17 g/dl. How can we explain this wide variation in iron status of baby calves? And, more importantly, how can we possibly manage calves with such wide variation, and deliver a group of uniform color calves to the packer? First, let's look at the variation and then we'll look at ways to overcome it. (Calves receive iron from their dam while still in utero. In fact, the cow gives the developing fetus a higher priority for many nutrients, including iron, and draws on her own body reserves of iron to satisfy the needs of the developing calf.)



Some Reasons for Hemoglobin Variation

Although cows might have differing levels of iron stores, the requirements of the calf in utero are fairly constant from one calf to the next which explains the fairly consistent meat color of bob calves, for example. Hemoglobin is transferred from the dam to the calf after birth through cord blood transfer. Iron and hemoglobin in cord blood influences the calf's iron storage after birth. Secondly, blood volume of the calf at birth is about 8.4% of its body weight, but increases to 9.3% after the calf consumes colostrum (Möllerberg et al, 1975). The increase in blood volume dilutes the hemoglobin in the blood and lowers the concentration of hemoglobin. Finally, the level of hydration (or dehydration) influences the concentration of hemoglobin in the blood. Remember that we cannot visibly detect dehydration in calves (droopy ears, sunken eyes, etc.) until the calf has lost about 6% of its body weight. This means that a calf which has lost 1-5% of its body weight will appear normal to us, but have an artificially high hemoglobin reading because of the dehydration. To take an accurate blood sample to test, we should make sure that calves have had several days with milk replacer plus extra electrolyte solution between feedings to help calves re-hydrate before we try to determine actual hemoglobin content.

Blood Variables & Flank Color Don't Predict Rib Eye Color – Large Muscles Retain Color Longer
Most everyone in the veal business has experienced situations where the blood variables suggest the color should be good, the flank color looks good, but the rib eyes are dark. We've also had the situation where the blood variables make us worry, the flanks look dark, but the rib eyes have very good color. There is a poor correlation between the hot flank color and cold rib eye color – in fact, our research shows only a 0.14 adjusted R^2 value. This basically means that if we were to predict the color of the cold rib eye based on the hot flank color, we'd be correct only about 14% of the time.

Long-term effects of feeding high amounts of iron are greater for rib eye muscle than for blood and/or flank muscle. Miltenburg *et al*. (1992) conducted an experiment in which calves were fed 60, 100 or 150 ppm iron for the first 7 weeks. Five days prior to slaughter, calves in all three groups had similar hemoglobin levels (9.1, 9.6, and 9.4 g/dl, respectively). Flank color was similar for all three groups, but rib eye and top round muscle color was significantly darker in calves that had been fed the highest iron levels for the first 7 weeks. This indicates that very large muscles, such as the rib eye and top round muscles, retain iron and myoglobin for a much longer period of time than blood and thin muscles such as the flank. This study illustrates the poor correlation among blood, and flank and rib eye muscles.

Beware of Copper in Your Iron Supplements - Copper Poisoning Causes Icterus
Copper is a trace mineral which is needed to absorb iron, but copper is very efficiently absorbed by milk-fed calves and accumulates in the liver of the calf over time. The copper requirement for veal calves is very low – about 5 ppm in the total diet. Feeding higher amounts causes copper to accumulate over time, culminating in copper poisoning. The most common signs of copper poisoning are icturis (yellow jaundice, yellow fat) and sudden death when the hemolytic crisis occurs. Many calves with copper poisoning appear normal but are condemned at the packing plant due to yellow fat and yellow-orange colored liver due to jaundice.

Veal calves absorb copper with very high efficiency – as high as 50% of copper in feed is absorbed and stored in the liver compared to only about 10% in ruminants (Suttle, 1974). Research by Bremner and Dalgarno (1973) showed that as little as 5 ppm copper added to milk replacer increased liver copper levels from 54-69 ppm to 556-586 ppm. In acute copper poisoning, liver copper levels increase to about 1000 ppm when the hemolytic crisis occurs and death ensues. Calves that do not reach the point of hemolytic crisis may show signs of copper poisoning such as yellow discoloration of the liver, fat, and icterus. Other factors may also play a role in icterus such as viral and bacterial infections, anemia, low dietary iron and unidentified toxins (Groot and Gruys, 1993). Legronne and Legardinier (1983) reported that copper poisoning was the primary problem in veal calves and did not involve viruses, parasites or toxins, even though they were able to isolate the bacteria *Welchia perfringens* type A from liver.

Nearly all feed companies supplement copper in the milk replacer because some copper is required for iron absorption. However, many milk replacers may have excessively high copper levels which can cause damage when calves are very young and accumulate throughout the growing/finishing period to create more problems for older calves (Robinson et al., 1999). Furthermore, feeding additional copper in iron supplements such as Go Max™ (30 mg copper/oz) and Red Cell® (36 mg copper/oz) may contribute to copper poisoning and increase the incidence of icterus. Nouriche's iron supplement (*Precision Iron*™) only contains iron from organic sources, and no copper or other nutrients to help avoid the incidence of copper poisoning in calves.

Beware Vitamin C – Dramatically Increases Iron Absorption
Iron occurs primarily in two forms: ferric iron (Fe^{+3}) and ferrous iron (Fe^{+2}). In the body, the majority of iron is associated with heme – the protein in hemoglobin (in blood) and myoglobin (in muscle). Iron in heme is in the form of ferrous iron which makes it possible for hemoglobin to carry oxygen. Heme iron is absorbed from the intestine very efficiently. Non-heme iron has a lower absorption rate, but absorption is enhanced by the presence of vitamin C. Vitamin C increases iron absorption two ways: vitamin C reduces iron from the ferric state to the ferrous state which increases absorption; and vitamin C chelates (joins with) ferric iron and the resulting vitamin C/iron complex is well absorbed by calves (Le Grusse and Watier, 1993).

Although some popular articles suggest that vitamin C has only a small effect on iron absorption in veal calves, the dramatic increase in iron absorption with vitamin C has actually been well-documented. When only 160 mg vitamin C was given in a recent research study (Swain, *et al*. 2006), iron absorption was increased nearly four-fold from a normalized absorption of 5.8 to 27.4 ug/l. In addition to the increased absorption of iron when vitamin C is fed (Enjalbert, 1981), vitamin C also increases iron mobilization from body stores (Jaffe, 1984).

Supplementing Iron is Best in Small Doses Because of Long-Term Effects

In one research study, calves given iron dextran injections in week 1 still had high iron levels through week 12. The standard practice of giving 5 cc iron dextran to baby calves may mean dark meat color for calves that start out with hemoglobin levels of 17 g/dl, but 5 cc is not enough iron for calves with hemoglobin levels of 6-7 g/dl. The best strategy is to prevent anemia with iron injections (5 cc) for new babies a few days after giving selenium and vitamin E injections because calves that are deficient in vitamin E and/or selenium may have an adverse reaction to iron dextran and die.

Identifying hemoglobin levels in each calf requires blood samples from every calf before giving the iron injections, but gives the grower the opportunity to move calves with extremely high (>12 g/dl) hemoglobin levels into a row where milk replacer can be fed to those calves, then iron supplements added to milk replacer before feeding the rest of the calves. Calves that are extremely low should be given additional iron injections to bring all calves to a standard of 11.0 g/dl hemoglobin. I do not recommend feeding iron for the first 3 weeks to help prevent scours due to pathogenic bacteria that require iron. Feeding cow's milk or milk replacer without iron supplementation helps give *Lactobacilli* a competitive advantage because these so-called "friendly bugs" do not require iron.

Boosting iron throughout the growing/finishing period results in more consistent and more acceptable meat color than feeding high amounts of iron early and hoping the blood levels will drop and color will improve. This is due to the constant tissue turnover of hemoglobin, myoglobin, and other iron-containing metabolites.

European Color Management System to Equalize and Treat Calves

Nouriche has adapted two different European concepts into a new program where calf body weight and hemoglobin levels are integrated into iron supplementation to equalize hemoglobin levels. Instead of giving 5 cc iron dextran to every calf, blood samples are taken and calves are given iron dextran according to their needs. Calves with low hemoglobin levels may receive up to 9 cc iron dextran, while calves with high hemoglobin levels receive none. The amount of iron given depends on the calf's total body iron content. For example, a 95 lb calf with hemoglobin of 6 g/dl has a total body iron content of about 620 mg while the same calf with a hemoglobin level of 16 g/dl has a total body iron content of 1862 mg. At the same hemoglobin level, heavier calves have more hemoglobin and more iron than lighter calves because blood volume is fairly constant among calves of different weights at the same age. The concept of this program is to equalize all in-coming calves to hemoglobin 11 g/dl by calculating the amount of iron present based on body weight and blood assay and only provide iron dextran to those calves that need iron. Calves with hemoglobin levels higher than 11 g/dl receive no supplemental iron until their hemoglobin levels drop to the group target level. A 95 lb calf with hemoglobin of 6 g/dl would receive 7.5 cc iron dextran, while a 95 lb calf with hemoglobin of 9 g/dl would receive 2.5 cc. We've developed a simple chart with hemoglobin level and body weight that shows the number of cc iron dextran needed. By providing iron based on the calves' body weight and blood hemoglobin levels, we can equalize calves in each group and produce more uniform calves – ultimately, more uniform color.

Although this European program requires more effort when the calves are young (first 6 weeks), the variation within groups is about half of the variation within typical groups of calves and more uniform meat color. This program relies on injectable iron during the first 6 weeks and requires milk replacer without iron being fed during this time. Oral supplementation can be added at the farm after the first 6 weeks, based on results of blood testing. After all, poor color costs the industry about $10.29 per calf. Certainly enough incentive to try some new things!

If you would like additional information about this new program, please contact Dr. Drew Vermeire at 636.625.1884 or by email at veaux@earthlink.net.

Literature Cited

Blum, J.W., and U. Zuber. 1975. Iron stores of liver, spleen and bone marrow, and serum iron concentrations in female dairy cattle in relationship to age. Res Vet Sci 18:294-298

Bremner, I. and A.C. Dalgarno. 1973. Iron metabolism in the veal calf. 2. Iron requirements and the effect of copper supplementation. Br J Nutr 30:61-76

Enjalbert, Francis Claude Léonce. 1981. Le fer dans l'alimentation du veau de boucherie. Etude bibliographique et enquete statistique. These pour le doctorat veterinair. Université Paul Sabatier de Toulouse.

Gooneratne, S.R., and D.A. Christensen, 1989. A survey of maternal and fetal tissue zinc, iron, manganese, and selenium concentrations in bovine. Can J Anim Sci 69:151-159

Groot, M.J. and E. Gruys. 1993. Yellow discoloration in veal calves: the role of hepatic copper. Vet Rec 132:156-160

Jaffe, Gerald M. 1984. Vitamin C. In : *Handbook of Vitamins. Nutritional, Biochemical, and Clinical Aspects*. Ed Lawrence J. Machlin. Marcel Dekker, Inc. New York.

Le Grusse, J. and B. Watier. 1993. *Les Vitamines. Données Biochimiques, Nutritionnelles et Cliniques*. Centre d'Etude et d'Information sur les Vitamines. Produits Roche, 92521 Neuilly-sur-Seine Cedex

Lengronne, D., and J.C. Legardinier. 1983. Observation de plusierurs series d'intoxications par le cuivre chez le veau d'élevage. Le Point Vétérinaire 15 :59-61

Miltenburg, G.A.J., T. Wensing, J.P.M. van Vliet, G. Schuijt, J. van de Broek, and H.J. Breukink. 1991. Blood hemoglobin, plasma iron, and tissue iron in dams in late gestation, at calving, and in veal calves at delivery and later. J Dairy Sci 74:3086-3094

Miltenburg, G.A.J., Th. Ensing, F.J.M. Smulders, and H.J. Breukink. 1992. Relationship between blood hemoglobin, plasma and tissue iron, muscle heme pigment, and carcass color of veal. J Anim Sci. 70:2766-2772

Robinson, Farrel, John M. Sullivan, David R. Brelage, Richard L. Sommers, and Robert J. Everson. 1999. Comparison of hepatic lesions in veal calves with concentrations of copper, iron and zinc in liver and kidney. Vet and Human Toxicol 41:171-174

Suttle. N.F. 1974. Comparative responses of hypocupremic ewes to oral and intravenous copper and their use in assessing the availability of dietary copper. Intl Symp Trace Elem Met in Anim. 1973. p 608-611

Swain, James H., LuAnn K. Johnson, and Janet R. Hunt. 2006. An irradiated electrolytic iron fortificant is poorly absorbed by humans and is less responsive than $FeSO_4$ to the enhancing effect of asorbic acid. J Nutr 136:2167-2174