Beef Session I

Veal Calf Medicine Workshop

Clyde Smith, *Presiding*

What's In A Veal Formula and Why?

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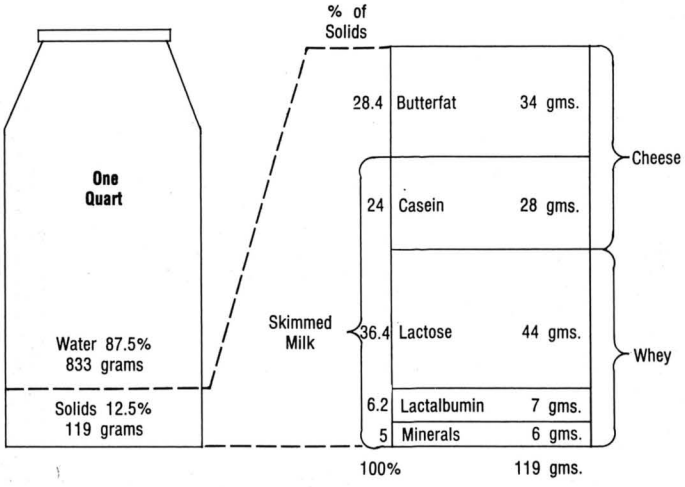
The proper formulation of a veal formula should logically begin with a basic understanding of cows' milk—the product we are replacing in the feeding of veal calves. The following chart is an overview of basic constituents (other than vitamins) of "nature's most perfect food."

The solids (dry matter) content of whole milk varies somewhat according to season and breed, but is generally considered to be 12.5%. Using this figure, a quart of fluid whole milk contains the amounts of butterfat, casein protein, lactose (milk sugar), lactalbumin protein and milk minerals shown below:



Ever increasing numbers of milk processing plants are set up with the flexibility to product both butter/skimmed milk and cheese/whey. Whether the plant produces butter/skimmed milk or cheese/whey is guided by the economics of the USDA's support price for butter, skimmed milk and cheese. Whey is not supported and is priced on the open market. As of this writing, the government supports the price of butter at $1.3975/lb., skimmed milk at $0.8075/lb. and cheddar cheese at $1.24/lb. Processing plants compare the economics of either butter/skimmed milk or cheese/whey production and manufacture the products which yield the greatest economic return. Both the skimmed milk and whey resultant of these processes are used extensively in veal feed formulations.

Veal formulas are produced utilizing by-products of the dairy processing and animal slaughtering industry and various micro-ingredients such as minerals, vitamins and antibiotics.

The composition of milk is used as a criterion to establish guidelines for the nutritional composition of a veal formula. These guidelines must encompass the nutritional requirements of the calf, price availability of ingredients and overall functionality of the total product mix.

A typical veal formula is composed of numerous ingredients. Each ingredient is added for specific reasons. The official governing body for defining the terms and format used on feed tags/labels is the Association of American Feed Control Officials, Inc. (AAFCO). To appear on the tag/label, any ingredient used in an animal feed has been approved by both Food & Drug Administration and AAFCO.

This article will attempt to list all ingredients currently used by veal feed manufacturers in the United States and also elucidate what these ingredients actually are and why they are used. The initial paragraph for each ingredient will be the official definition per AAFCO. The remaining test will elaborate on what these products are and why they are used. Please keep in mind that various feed manufacturers practice discretion on the types and qualities of each of these ingredients that are used in their specific productions.

Dried Skimmed Milk is the residue obtained by drying defatted milk. It contains 8% maximum moisture.

Dried skimmed milk is the primary source of casein protein in veal formulations. It contains 33-34% protein and negligible amounts of fat. The primary source of skimmed milk to the feed industry is the government sell-back program of the USDA's Commodity Credit Corporation. Very little, if any, feed grade skimmed milk is purchased by

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The amount of progesterone in a cow's milk closely correlates with the phases of the estrous cycle. Utilizing a technique known as ELISA (enzyme linked immunosorbent assay), the PROGESTASSAY kit measures progesterone levels and can determine with a high degree of probability whether or not a cow is in heat.

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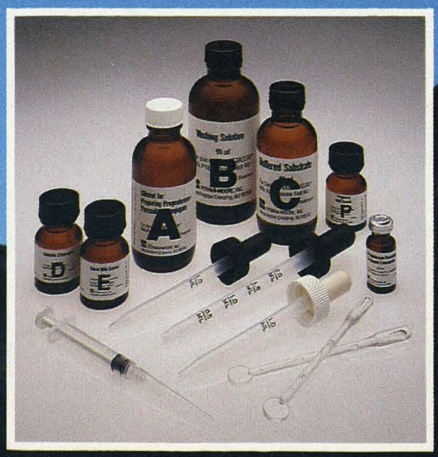

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the veal industry, since it would be of questionable quality and is available only in limited amounts. By law, no skimmed milk may enter the United States from abroad under existing United States governmental tariff authorities. However, quotas are established yearly to allow a small amount of "fat filled milk" to enter this country from several foreign countries. "Fat filled milk" is 90% dried skimmed milk and 10% fat. It is also called 90/10. The fat is either tallow and/or butterfat, depending on country of origin. The fat is deliberately incorporated into this product to fulfill the requirements of the law. For 1985, a total import quota of 16,710,000 lbs. of "fat filled milk" from Hoof and Mouth disease free countries has been established for the feed industry. Most, if not all, of this "fat filled milk" is used by the veal industry. The 1985 individual quotas, by country, are 12,500,000 lbs. from Ireland, 4,000 lbs. from New Zealand, 85,000 lbs. from the United Kingdom and 125,000 lbs. from Australia. Skimmed milk is primarily utilized as a protein ingredient, although it contains significant levels of lactose.

Dried Whey Protein Concentrate is the product obtained by removal or separation of water, lactose and/or minerals from whey by ultrafiltration, dehydration or other process. It shall contain 25% minimum crude protein. The minimum percent of crude protein and lactose and the maximum percent ash must be prominently declared on the label.

Simply stated, whey protein concentrate is lactalbumin protein concentrated by liquid whey. Liquid whey contains relatively small amounts of very high quality lactalbumin protein. The technology for the removal/concentration of this protein has existed for many years, but the equipment necessary to capture this technology has not. It is only within recent years that high quality equipment suitable for the large scale production of this product has existed. Whey protein concentrate is primarily available from domestic suppliers, although imported product from Hoof and Mouth free countries is also available and used by the veal industry. Whey protein concentrate is primarily utilized as a protein ingredient, although it contains similar levels of lactose as in dried skimmed milk.

Dried Whey is the product obtained by removing water from whey. It contains not less than 11% protein nor less than 61% lactose.

Whey is the by-product of the cheese making industry. Whey contains high levels of lactose (milk sugar) and smaller amounts of lactalbumin protein and minerals. Lactose is one of two sugars that are present in veal feed ingredients that are known to be available to the calf. The other sugar is dextrose (glucose). Lactose is actually a disaccharide (two sugars) which, when hydrolyzed (split) by the enzyme lactase, yields the two monosaccharides (single sugars) glucose and galactose, both of which are absorbed directly into the bloodstream.

Whey is available in large quantities from domestic suppliers and is of ever-improving quality. Whey is collective term for the by-product derived from any kind of cheese manufacture. Cheese types vary from "hard" cheeses such as cheddar, swiss, mozzarella, etc. to the "soft" cheeses such as cream and cottage cheese. Great care and selection is practiced by veal feed producers in regard to the type and quality of wheys used in specific formulas. Whey is primarily used as an energy source, although the small amount of protein present is of extremely high quality.

Dried Whey Product is the product obtained by drying whey from which a portion of the lactose, protein and/or minerals have been removed. The minimum percent of crude protein and lactose and maximum percent ash must be prominently declared on the label, may also be labelled as (dried reduced minerals whey) or (dried reduced lactose whey) if appropriate.

The dried whey product most available to the veal industry is whey from which a portion of lactose only has been removed. This product is commonly known as delactosed whey or also as partially delactosed whey. The partial removal of lactose results in a whey-like product that contains lower lactose, higher protein and higher mineral content than conventional whey. Whey product is utilized in veal formulas for both its protein and lactose content. See comments for whey.

Casein is a solid residue obtained by acid or rennet coagulation of defatted milk. It contains 80% minimum crude protein.

Casein is the major (about 80%) protein present in skimmed milk. There are two basic types of casein produced. The first type is referred to as acid casein. Here the casein protein present in skimmed milk is precipitated (coagulated) out through the use of either lactic, hydrochloric or sulfuric acid. The resultant precipitate is then dried and ground into powder, which is referred to as acid casein in the market place. Acid casein contains 88-95% protein and negligible amounts of fat.

The second type of casein is rennet casein. Here the casein protein present in skimmed milk is precipitated out through the use of rennet, which is a starter culture used in the cheese-making industry. Again, the precipitated casein is subsequently dried and ground into powder form. Rennet casein contains 80-86% protein and negligible amounts of fat.

Casein is converted to a caseinate through the addition of an alkali substance such as sodium or calcium and this mixture is then spray dried into sodium or calcium caseinate. The reason for this manufacturing step is improvement of solubility of the casein. Both rennet and acid casein are relatively insoluble and must be solubilized prior to incorporation into spray dried hi fats.

When utilized by the veal feed industry, casein is most commonly converted to the caseinate form. Casein is used frequently as a protein source in the processing of milk and fat ingredients into spray dried hi fats, since some manufacturers believe the addition of supplemental protein to whey is needed to ensure the proper encapsulation of fat therein. Proper encapsulation of fat into spray dried hi fats is

essential to produce hi fat which is not greasy or from which the fat will "bleed" out. Lack of proper encapsulation can contribute toward manufacturing problems and/or caked (hard) feed. Casein, when used in veal formulations, is added for its protein content and/or functionality purposes.

No casein (other than pharmaceutical grade) is produced domestically, since the high support price of skimmed milk in this country makes the production of casein economically unattractive. All casein used in the veal feed industry is imported from Hoof and Mouth free countries only. Present suppliers of casein to the United States are Ireland, New Zealand, Australia, England and Iceland.

Dried Milk Albumin is obtained by drying the coagulated protein residue separated from whey. It contains 75% minimum crude protein on a moisture-free basis.

Milk albumin is an extremely concentrated source of lactalbumin protein derived from whey. It contains less lactose than whey protein concentrate. It is used primarily as a protein source. See comments for whey protein concentrate.

Dried Buttermilk is the residue obtained by drying buttermilk. It contains 8% maximum moisture, 13% maximum ash and 5% minimum milk fat (Roese-Gottlieb Method).

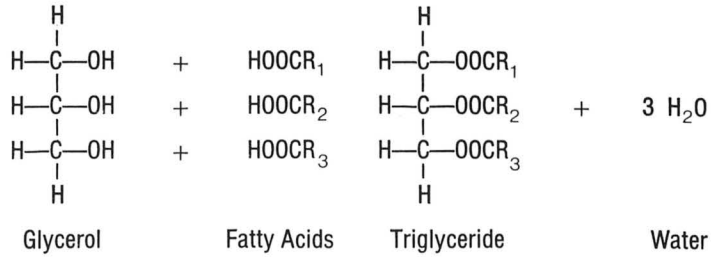
The Roese-Gottlieb method is the Association of Official Agriculture Chemists official method for detecting fat content in milk producs. The protein content of buttermilk is primarily casein, as in skimmed milk. Buttermilk is used in veal formulations for it's protein, lactose and fat content.

Dried Milk Protein is obtained by drying the coagulated protein residue resulting from the controlled co-precipitation of casein, lactalbumin, and minor milk proteins from defatted milk.

Dried milk protein is also an extremely concentrated source of total milk protein (casein and lactalbumin combined) that is directly removed from skimmed milk. It is a combination of dried milk albumin and casein and is used as a protein source in veal formulas. See comments for dried milk albumin and casein.

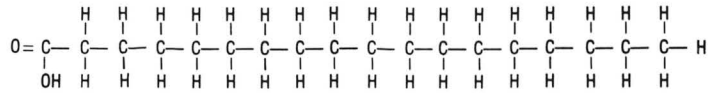
Animal Fat is obtained from the tissues of mammals and/or poultry in the commercial processes of rendering or extracting. It consists predominately of glyceride esters of fatty acids and contains no additions of free fatty acids or other materials obtained from fats. It must contain not less than 90% total fatty acids, not more than 2.5% unsaponifiable matter, and not more than 1% insoluble matter. If the product bears a name descriptive of its kind or origin; i.e., "tallow," "lard", "grease", it must correspond thereto. If an antioxidant is used, the common name or names must be indicated, followed by the words "preservative(s)".

Animal fat is the descriptive term covering fats rendered from the by-products of domestic animals used for food. Chemically described, fats are predominantly composed of triglycerides. Triclycerides are compounds composed of a combination of one molecule of glycerol with molecules of fatty acid(s). This may be represented as follows:



H = hydrogen
O = oxygen
C = carbon
R_1, R_2, R_3 = the carbon chain of variable length(s) comprising the fatty acids.

An example of a fatty acid is shown below:



This is stearic acid.

The process of digestion breaks down the fat molecule into its component parts: free fatty acids and glycerol. In any given fat, the three fatty acids may be all the same or a mixture of different fatty acids. The chain length in fatty acids varies from approximately 6 carbon atoms up to 18. The length of the fatty acid chains, and also their variations, are the factors which give the fats their individual characteristics.

The fat from beef (cattle) is harder with a high melting point and fats of this kind have a titer (solidification point of the fatty acids) of 40° C or higher. This type of fat is termed tallow in the fat and oil market. Fats predominately derived from swine are softer with a titer less than 40° C (usually 36-40° C) and are termed grease. Lard is specifically the fat rendered from pork.

Fats, when reacted with strong alkaliis, form soaps in the process of saponification. The unsaponifiable matter in fat is material which does not/will not react with alkalii to form soap—thus the term unsaponifiable. Insoluble matter is usually the protein material carried over from the rendering process.

Antioxidants are added to animal fat to prevent oxidation or rancidity of the fat. Animal fat incorporated into veal formulas is typically preserved with butylated hydroxyanisole, butylated hydroxytoluene, citric acid or ethoxyquin.

Animal fat is added to a veal formula to provide energy. Carbohydrate and excess protein are also utilized as energy sources, although fat is a much more concentrated source of energy. Digestible fat provides approximately 2.25 times as much energy per pound as compared to either digestible carbohydrate or digestible protein.

Vegetable Fat, or Oil is the product of vegetable origin obtained by extracting the oil from seeds or fruits which are commonly processed for edible purposes. It consists

predominantly of glyceride esters of fatty acids and contains no additions of free fatty acids or other materials obtained from fats. It must contain not less than 90% total fatty acids, not more than 2% unsaponifiable matter and not more than 1% insoluble matter. If the product bears a name descriptive of its kind or origin; i.e., "soybean oil", "cottonseed oil", it must correspond thereto. If an antioxidant(s) is used, the common name or names must be indicated, followed by the word "preservative(s)".

Refined coconut oil is the vegetable oil of choice in veal formulations because of its desirable content of shorter chained fatty acids. Palm kernel oil is also a suitable vegetable oil to use in veal formulas. Both products are priced virtually identically in the marketplace. Other vegetable fats and oils have historically not been considered to be ideal for inclusion in veal formulas. Fats and oils are similar in composition and function. Fats are typically solid at room temperature and oils are liquid.

Butylated Hydroxyanisole (BHA) is classified under the Food Additives Amendment as a chemical preservative and cleared for usage in feed under Food & Drug Administration Regulation 582.3169. Total content of BHA is limited or restricted to not more than 0.02% of fat or oil content, including essential (volatile) oil content of food. BHA is added to animal fat and vegetable oil to prevent oxidation/rancidity.

Butylated Hydroxytoluene (BHT) is classified under the Food Additives Amendment as a chemical preservative and is cleared for usage in feed under Food & Drug Administration Regulation 582.3173. Total content of BHT is limited or restricted to not more than 0.02% of fat or oil content, including essential (volatile) oil content of food. BHT is addded to animal fat and vegetable oil to prevent oxidation/rancidity.

Citric Acid is classified under the Food Additives Amendment as a chemical preservative and is cleared for usage in feed under Food & Drug Administration Regulation 582.6033. There is no limitation or restriction to the amount of citric acid that may be added to a feed. Citric acid is added to animal fat and vegetable oil to prevent oxidation/rancidity.

Ethoxyquin is classified under the Food Additives Amendment as a chemical preservative and is cleared for usage in feed under Food & Drug Administration Regulation 573.380. Total content of ethoxyquin is limited or restricted to not more than 0.015% of fat or oil content, including essential (volatile) oil content of food. Ethoxyquin is added to animal fat and vegetable oil to prevent oxidation/rancidity.

Soy Lecithin is the mixed phosphatide product obtained from soybean oil by a degumming process. It contains lecithin, cephalin, and inositol phosphatides, together with glycerides, soybean oil and traces of tocopherols, glucosides and pigments. It must be designated and sold according to conventional descriptive grades with respect to consistency and bleaching.

Soy lecithin acts as both an emulsifier and a nutrient in veal formulations. An emulsifier is a compound with the ability to cause the fatty portion to reconstitute with water and subsequently stay in suspension rather than rise to the top. Because the surface area of the fatty portion is increased by emulsification, the lipolytic (fat specific) enzymes present in the calf can function more efficiently. Nutritionally, soy lecithin is utilized by the calf to supply energy. As with other fatty materials, digestible lecithin provides approximately 2.25 times as much energy per pound as compared to either digestible carbohydrate or digestible protein. See comments for animal/vegetable fat. Soy lecithin also contributes significant quantities of phosphorous and the B vitamins choline and inositol.

Polyoxy-Ethylene Glycol (400) Mono and Dioleates is classified under the Food Additives Amendment as an emulsifier and is cleared for usage in feed under Food & Drug Administration Regulation 573.820. Polyoxy-ethylene glycol (400) mono and dioleates usage, under regulation 573.820, is limited or restricted to calf milk replacers. Polyoxy-ethylene clycol (400) mono and dioleates are added to veal formulations as an emulsifier. See emulsifier comments under soy lecithin.

Calcium Carbonate is a product true to name which contains a minimum of 38% calcium (Ca).

Calcium carbonate is a white to off-white source of dietary calcium in veal formulations. Calcium is the most abundant mineral element in an animals body. At least 98% of the elements present in the calf is found in the teeth and bone. The remaining 2% or less is found in the soft tissues and blood.

Calcium functions in bone formation/maintenance, teeth development/maintenance, the clotting of blood, muscle contractions, transmission of nerve impulses, regulation of heartbeat, activation of enzymes, stabilization of enzymes and the secretion of certain hormones.

Calcium Chloride The calcium salt of hydrochloric acid generally expressed as $CaCl_2$ and its hydrated forms. Minimum calcium (Ca) and chlorine (Cl) must be specified.

Calcium chloride is also added to veal formulations as a source of dietary calcium. It typically contains 27-36% elemental calcium and 48-64% elemental chlorine. It is an extremely soluble source of calcium. See comments under calcium carbonate for calcium functions.

Dicalcium Phosphate - A calcium salt of phosphoric acid is generally expressed as $CaHPO_4$ and its hydrated forms. Minimum phosphorus (P), minimum calcium (Ca) and maximum fluorine (F) must be specified. It must not contain more than 1 part of fluorine (F) to 100 parts phosphorus (P).

Dicalcium phosphate is a dietary source of phosphorus and calcium. It typically analyzes 18.5% elemental phosphorus and 21.0% elemental calcium. It is grey in color. See functions of calcium under calcium carbonate. Phosphorus functions in bone formations/maintenance, development of teeth, muscle tissue formation, control of cellular metabolism, maintenance of osmotic and acid-base

balance, energy utilization, phospholipid formation, amino acid metabolism, protein formation and is involved in numerous enzyme systems.

Tricalcium Phosphate - A calcium salt of phosphoric acid generally expressed as $Ca_3(PO_4)_2$. Minimum phosphorus (P), minimum calcium (Ca), and maximum fluorine (F) must be specified. It must not contain more than 1 part of fluorine (F) to 100 parts phosphorus (P).

Tricalcium phosphate is another dietary source of phosphorus and calcium in veal formulations. It is dark grey to tan in color and typically contains 18% elemental phosphorus and 31% elemental calcium. See comments for calcium functions under calcium carbonate and phosphorus functions under dicalcium phosphate.

Magnesium Oxide - The oxide of magnesium generally expressed as MgO. Minimum magnesium (Mg) must be specified.

Magnesium oxide is added to veal formulations for its magnesium content. It is off-white to tan in color and typically contains 51-59% elemental magnesium. The functions of magnesium are to maintain bone and teeth integrity, neuromuscular activity and activation of enzyme systems involved in energy, protein and fat metabolism.

Magnesium Sulfate - The magnesium salt of sulfuric acid generally expressed as $MgSo_4$ and its hydrated forms. Minimum magnesium (Mg) must be specified.

Magnesium sulfate (also known as epson salts) is another product added for its magnesium content. Magnesium sulfate is a colorless, sparkling crystalline substance that typically contains 9.7% elemental magnesium. See functions of magnesium under magnesium oxide.

Zinc Sulfate - The zinc salt of sulfuric acid generally expressed as $ZnSO_4$ and its hydrated forms. Minimum zinc (Zn) must be specified.

Zinc sulfate is a white to greyish-white powder that is added for its zinc content. It typically contains 36% elemental zinc. The functions of zinc are many faceted and very complex. Its role is highly specific in numerous enzyme systems. Zinc plays an active role in the areas of growth, appetite, taste, skeletal development, wound healing, brain development, behavior, immune responses, protein and nucleic acid metabolism, carbohydrate and lipid metabolism among others.

Manganese Sulfate - The manganese salt of sulfuric acid, generally expressed as $MnSO_4$ and its hydrated forms. Minimum manganese (Mn) must be specified.

Manganese sulfate is added as a dietary source of manganese. Manganese sulfate is a white to cream colored powder which typically analyzes 27-28.4% elemental manganese. Manganese is essential for cartilage formation and as a component of certain enzyme systems. It is also involved in carbohydrate metabolism. The manganese requirement of the calf has not been well documented, since no biochemical measurement is available to diagnose borderline deficiencies.

Ferrous Sulfate - The iron salt of sulfuric acid generally expressed as $FeSO_4$ and its hydrated forms. Minimum iron (Fe) must be specified.

Ferrous (Iron) sulfate is a light grey to light brown powder added to formulations for its iron content. It typically analyzes 31-32% elemental iron. Iron is an essential constituent of the respiratory pigment hemoglobin. It also functions in several cellular level oxidations, especially those involved with the transfer of electrons (energy related).

Milk and milk products are extremely low in iron content. Iron is an essential component of hemoglobin formation. Hemoglobin production must be restricted in order to raise a white calf. Two schools of thought exist as to the amount of iron that should be incorporated in a veal formulation. One school believes that low, predetermined levels of elemental iron should be incorporated into a veal formula to prevent the calf from becoming too anemic, but still not contributing enough iron to significantly increase the changes of producing a red carcass. The other school of thought is to not add iron to the formulation, since milk products contain an adequate level of iron to allow the calf to function normally to market weight. Additional iron is added to the milk on the farm, as needed, during stress situations.

Copper Sulfate - The copper salt of sulfuric acid is generally expressed as $CuSO_4$ and its hydrated forms. Minimum copper (Cu) must be specified.

Copper sulfate is a blue crystalline powder containing 25.2% elemental copper. It is added as a dietary source of copper. Functions of copper are related to the metallo-enzymes (metal containing enzymes) and their ability to undergo oxidation-reduction reactions under different physiological conditions within the animal.

Cobalt Carbonate - The cobalt salt of carbonic acid generally expressed $CoCO_3$ and its hydrated forms. Minimum cobalt (Co) must be specified.

Cobalt carbonate is a pink powder typically composed of 45-46% elemental cobalt. It is added to a formulation for its cobalt content. Cobalt is an essential component for the synthesis of vitamin B_{12} by the ruminating animal. Since veal calves do not ruminate, it still is unknown whether cobalt serves a real function in the milk fed veal calf. Cobalt, when added, more than likely is added as an insurance factor. It is speculated that extremely vitamin B_{12} deficient calves may have the ability to synthesize small quantities of vitamin B_{12} in their lower gut when cobalt is present.

Cobalt Sulfate - The cobalt salt of sulfuric acid is generally expressed as $CoSO_4$ and its hydrated forms. Minimum cobalt (Co) must be specified.

Cobalt sulfate is a pink-red/orange powder added to formulations for its cobalt content. It typically contains 20.5-21% or 32-33% elemental cobalt, depending on the degree of hydration of the molecule. See comments for cobalt under cobalt carbonate.

Ethylenediamine Dihydriodide - An organic compound of iodine generally expressed as $C_2H_8N_2$2HI. Minimum iodine (I) must be specified.

Ethylenediamine dihydriodide (EDDI) is a white powder

added to formulations for its iodine content. It typically analyzes 79-80% elemental iodine. Iodine serves as a component of the thyroxine based hormones, which are important in the regulation of metabolic rate in animals.

Potassium Iodide - The potassium salt of hydriodic acid generally expressed as KI. The minimum potassium (K) and iodine (I) must be specified.

Potassium iodide is a white powder, again added to formulations for its iodine content. It typically analyzes 68.5% elemental iodine and 21.0% elemental potassium. See comments for iodine under EDDI.

Sodium Selenite - A sodium salt of selenious acid generally expressed as Na_2SeO_3 and its hydrated forms. Minimum selenium (Se) must be specified.

Sodium selenite is a white-light pink powder added to formulations for its selenium content. It typically contains 45% elemental selenium. Selenium is an essential component of the enzyme gluthionine peroxidase, an enzyme which acts as an antioxident, protecting tissues from breakdown by peroxides. It is also required for active fat absorption, is involved in specific energy transfer reactions and commonly is involved in specific enzyme formation and influences the absorption and retention of both vitamin E and triglyceride in the living system. Selenium is the newest mineral to receive major attention in feed formulations. Selenium is an extremely toxic compound when handled in higher potencies. It became legal to add selenium to milk replacers in 1979. It is restricted by law to a maximum usage rate of 0.1 part per million elemental selenium.

Vitamin A Supplement is a feeding material used for its vitamin A content. It must contain a minimum of two million USP Units or International Units of vitamin A per pound. The label must bear a statement of the source of vitamin A and a minimum guarantee of USP Units or International Units of vitamin A per pound with additional permissive USP Units or International Units of vitamin A per gram.

The biological activity of vitamin A is expressed as USP Units (Pharmacopeia of the United States) or IU (International Units). One USP Unit of vitamin A equals one IU of vitamin A equals the activity of 0.3 micrograms of crystalline retinol.

Vitamin A is commercially available to the feed industry for supplementation in either acetate or palmitate forms. Both vitamin A acetate and vitamin A palmitate are nutritionally acceptable forms of vitamin A and either form may be used to supplement a formula. It is a fat soluble vitamin (soluble in fats, oil and fat solvents) and is water insoluble.

Vitamin A is essential for maintenance of healthy skin and hair coat, nerve tissues and vision. It also plays an important role in disease resistance and metabolism.

Vitamin D_3 Supplement is a feeding material used for vitamin D_3 activity. It must contain a minimum of 100,000 International Chick Units of vitamin D_3 per pound.

The potency of vitamin D_3 is expressed in either IU, USP Units or ICU (International Chick Units). By definition, one IU of vitamin D equals one USP Unit equals one ICU equals the activity of 0.025 micrograms of crystalline vitamin D_3. Vitamin D_3 is a fat soluble vitamin.

The functions of vitamin D_3 include regulation of calcium and phosphorous absorption from the intestine, increases uptake and deposition of minerals in the bone, necessary for formation of healthy bones and joints and promotes normal bone calcification. It is also an essential metabolite for calcium and phosphorous metabolism (utilization).

D-Activated Animal Sterol is obtained by activation of a sterol fraction of animal origin with ultra-violet light or other means. For label identification it may be followed with the parenthetical phrase (Source of vitamin D_3).

Deactivated animal sterol is now the most common source of commercially available vitamin D_3 available to the feed industry. See comments under vitamin D_3 supplement for vitamin D_3 functions.

Vitamin E Supplement is a feeding material used for its vitamin E activity. It must contain a minimum vitamin E activity equal to 10,000 International Units of vitamin E per pound.

The biological activity of vitamin E is expressed in IU. By definition, one IU of vitamin E equals the biological activity of one milligram of dl-alpha-tocopheryl acetate. Vitamin E is a fat soluble vitamin.

Vitamin E functions as a tissue antioxident—it helps protect body tissues (especially fatty substances in tissues) from oxidation. Vitamin E is closely interrelated with selenium in metabolism and a condition such as white muscle disease (nutritional muscular dystrophy) may be caused by a vitamin E and/or selenium deficiency. Vitamin E also maintains structure and function of muscle tissue and is essential for maintaining healthy nervous system, blood vessels and liver. Vitamin E may also be referred to as dl-alpha-tocopheryl acetate or alpha tocepherol.

Vitamin K is not officially defined in AAFCO. It, like most of the B vitamins mentioned hereafter in this article, is classified by AAFCO as "additional officially recognized vitamin ingredients for animal feed use at nutritional levels and in conformity with current good manufacturing practices."

Several forms of vitamin K exist. Vitamin K_3 is the chemically synthesized form commercially available to the feed industry for supplementation purposes. Vitamin K_3 is also termed menadione. The most commercially available form of vitamin K_3 used by the feed is menadione sodium bisulfite complex (MSBC), which contains a minimum of 30% menadione. Vitamin K is needed for systhesis of the plasma protein prothrombin, which regulates normal blood clotting.

Thiamin (thiamine) is the first of the B vitamins to be considered. All the B vitamins are considered to be soluble in water to varying degrees. Thiamin is also known as vitamin B_1.

Thiamin is a necessary component of several oxidative

reactions essential for carbohydrate, fat and protein metabolism. In addition, it is necessary for nervous system function and efficient utilization of energy. Thiamin hydrochloride and thiamin mononitrate are the two commercially available forms for supplementation of thiamin into feedstuffs.

Riboflavin Supplement is a feeding material used chiefly for its riboflavin content, and must contain not less than 1,000 milligrams of riboflavin per pound.

Riboflavin, also known as vitamin B_2, is essential for maintenance and function of the nervous system, healthy skin and hair and tissue regeneration. It is required in a large number of enzymes involved with the utilization of protein, carbohydrate and fat.

Pyridoxine Hydrochloride also known as vitamin B_6, produces co-enzymes essential in fat and protein metabolism, energy production, hemoglobin formation and nervous system actitity. Pyridoxine is commercially available only as pyridoxine hydrochloride.

Vitamin B_{12} Supplement is a feeding material used for its vitamin B_{12} activity. It must contain a minimum vitamin B_{12} activity of 1.5 milligrams per pound. The term must not be applied to products for which there are accepted names and definitions.

Vitamin B_{12}, also known as cyanocobalamin, functions in several metabolic processes involving nucleic acids. Nucleic acids are high molecular weight nitrogen containing compounds present in every cell and which are intimately involved in cellular metabolism and structural protein function. Vitamin B_{12} is an essential component for both carbohydrate and fat metabolism and is also necessary for the formation of blood cells.

Niacin Supplement is a term that may be used in the ingredient list on a feed label of a mixed feed to indicate the addition of either Niacin or Niacinamaide. Sources containing only Niacin or Niacinamide must state the source of Niacin on their label.

Both niacin and niacinamide are recognized as sources of nicotinic acid. Niacin and/or niacinamide are necessary to maintain the integrity of skin, hair, gastrointestinal tract and the nervous system. It is also involved in the formation of enzymes involved in energy transport and utilization within the animal.

Calcium Pantothenate is a salt of d-pantothenic acid, which is the active form of the vitamin utilized by the animal. The functions of d-pantothenic acid are its necessity for maintenance of hair, skin and nervous system. It is also involved in numerous metabolic functions related to efficient energy utilization.

Folic Acid also known as folacin, plays a basic essential biochemical role in the transfer of one-carbon fragments in numerous metabolic reactions. Folic acid is essential for nervous system function and maintenance of normal red blood cell and hemoglobin levels.

Ascorbic Acid also known as vitamin C, is essential for both the formation and maintenance of intercellular (between cells) substances of skeletal tissues such as connective tissue, bones, cartilage and dentine (major portion of teeth). Body defense mechanisms against injury or disease are stimulated by vitamin C. It may also be needed to help the living organism adapt to stress.

Vitamin C plays an essential role in iron transport for storage in bone marrow, spleen and liver. It is for this reason that caution is advised when feeding massive levels of supplemental vitamin C to heavy, finishing calves, especially if the calves exhibit higher than desired hemoglobin levels.

Biotin also known as vitamin H, functions in numerous enzyme systems related to carbohydrate, fat and protein metabolism. Biotin plays a very active role in the transfer of carbon dioxide in both the systhesis of fatty acids and the degradation of amino acids. Biotin helps maintain normal blood glucose levels from the metabolism of protein and fat when dietary intake of carbohydrate is low. It is also a necessary component of healthy skin, hair and feet.

Choline Chloride is the salt of the active vitamin component choline. Choline is essential for building and maintaining cellular structure, as well as preventing fat accumulation in the liver (fatty liver syndrome) by promoting its transport as lecithin and/or by increasing the utilization of fatty acids in the liver itself. Choline is an essential component of acetylcholine, the compound responsible for transmission of nerve impulses. When oxidized to betaine, it becomes a donor of labile methyl groups (1 carbon, 3 hydrogen atoms) which are required by numerous metabolic compounds. It is also essential for normal bone development.

Sodium Silico Aluminate is classified under the Food Additives Amendment as an anti-caking agent and is cleared for usage in feed under Food & Drug Administration Regulation 582.2727. Sodium silico aluminate usage, under regulation 582.2727, is limited to a maximum usage rate of 2% in finished feed. Sodium silico aluminate is added to veal formulations as a flow agent and as an anti-caking constituent.

DL-Methionine is a product which contains a minimum of 95% racemic 2-amino-4-methylthiobutyric acid. The percentages of L-Methionine must be guaranteed. The term Methionine Supplement may be used in the ingredient list on a feed tag of a finished feed for monogastric animals to indicate the addition of DL-Methionine.

Methionine is an amino acid. Amino acids are building blocks of protein. Amino acids are composed of varying combinations of carbon, hydrogen, oxygen, nitrogen and occasionally sulfur. Twenty-two different amino acids are involved as components of protein, depending on type of protein. Only 12 amino acids are synthesized (manufactured) by animals. These 12 amino acids are termed nonessential or dispensable amino acids. The remaining 10 amino acids are not synthesized by animals and must, therefore, be supplied in the diet of the animal. These 10 amino acids are termed essential or indispensable amino acids. Veal formulations containing protein of all-

milk origin normally contain high levels of essential amino acids.

Methionine is an essential amino acid sometimes added to veal formulas to supplement the natural methionine present in the protein fraction of the milk replacer ingredients. Methionine is the only essential amino acid that contains sulfur.

L-Lysine is a product which contains a minimum of 95% a, E-diaminocaproic acid.

Lysine is another essential or indispensable amino acid added to veal formulas in the event supplemental amounts to that already present in the milk replacer ingredients are desired.

Salt is an acceptable source of sodium chloride. It must be true to name and contain not less than 95% sodium chloride.

Salt is typically added to a veal formula to enhance flavor. The author is unaware of any other purpose salt would serve in a veal formulation.

Starch is a white, granular polymer of plant origin. The principal part of seed endosperm.

Starch, at present, does not have an offcial definition established by AAFCO. The aforementioned description is prepared in cooperation with the Definitions Committee Of the American Feed Manufacturers Association (formerly the Midwest Feed Production Schools Definitions Committee) and the Feed Composition Committee of the Animal Nutrition Committee of the National Research Council.

The starch used in veal formulations is typically of corn (maize) origin. It may also be pregelatinized (cooked) to generate bonding power when mixed with water. Nonpregelatinized starch forms a suspension when mixed with water and will settle out if agitation is not employed, while pregelatinized starch forms a colloidal mixture when mixed with water that will not settle out. Starch is typically added to a veal formula to either limit the amount of total lactose in a veal formula and/or for its gelling or binding affect in the calves' digestive tract. As a special purpose product, not officially defined by AAFCO, AAFCO states that "it is impracticable to list all special purpose feed ingredients, together with the status, classification, tolerance, any limitations or restrictions, in the Official Publication. The AAFCO regard such common special purpose feed ingredients as salt, sugar, and pepper as safe for their intended use, when used in accordance with good manufacturing practice." Therefore, starch, as well as dextrose and sucrose fits the catagory of a common special purpose ingredient that does not need formal definition.

Dextrose is pure glucose, typically derived from corn (maize). It is typically added to a veal formula to enhance palatability and/or as an extremely available energy source. As discussed earlier in this series, lactose and glucose are the only two sugars directly absorbed by the calf. See comments for dried whey.

Sucrose is another commonly used special purpose feed ingredient that is not officially defined by AAFCO. It also is defined as safe when used in accordance with good manufacturing practice.

Sucrose is actually a disaccharide (two sugars). It is composed of one molecule of glucose and one molecule of fructose. Sucrose, when present in a veal formula is normally the result of it being used as a carrier for antibiotic. It typically is not directly added to a veal formula as an ingredient.

Questions & Answers:

Question: How do you challenge-feed these calves? How do you evaluate the calf, know which calf to give more or less to?

Answer: Individual observation of the calf. This is where your records come in and this is where the animal husbandry skills of the feeder come in. He notes that the calf in the last feeding was very aggressive after consuming his entire feeding, looking for more. He should make a written and/or mental note of that and feed that calf more at the next feeding, or, if he has milk left over at the end of his feeding cycle, divy that milk up to the aggressive eaters in the population. That point brings to mind a pet peeve of mine, and again there are two schools of thought here. What to do with the left over milk? You've mixed this tank of milk and you're going to feed a hundred calves and there are 7 gallons left at the end of the feeding. A hundred calves have been "fed", or you've got the milk out to them at least. And 7 gallons left for some reason. You can throw it down the drain, that's money down the drain. You can put it in the refrigerator and store it to the next feeding. I hate it because of the sanitation aspect of it. I hate it with a passion. Other people swear by it. I argue, go back to these calves, these hundred calves I cited, and give it to the aggressive calves. Get it into the animals, one way or another. Because almost all of the time there are enough aggressive animals in there to sop up the overage. And the same thing goes with the calf that you would give a ¾ or a half feeding, the sick calf, the off feed calf, for whatever the reason. You have to go by your records of the previous feeding.

Question: What is the rationale for a 2, or 3, or 4 feed system?

Answer: The system that I described here, or alluded to, was a two-feed system, starter and finisher. Dr. Smith's schedule, I believe had starter and finisher only on it with a long blend period incorporated into it. Protein requirement per lb. of calf is highest when the calf is young, lowest at market age. Energy requirement is the inverse of that. So basically it's a straight line phenomenon both ways. Ideally, we want to feed this calf a different ration of protein and fat every day it's in the barn. We also have to be practical. And so practically speaking most manufacturers have brought this down to a 2 or 3 feed system. Now, another way to skin that cat is to have a relatively high protein, relatively low fat starter feed, the opposite in the finisher feed and go through a very, very lengthy blend period. You can beat that argument to death, though, however, I think. And people make mistakes when they do too much blending, play too many games. They sometimes can make mathematical mistakes. The hired man that feeds the weekend may do something in error. I don't get

all hung up on that principle. I would rather have him have a good two or three feed program blend between feeds and then devote his skills to the calves, and not worry too much about the ideal feed on any given day. So to answer your question, 2-3 feed programs are the practical answer that the industry shows up. Now there are also on-the-farm mixing efforts out there where the growers buy the individual ingredients. They buy the skim and the whey and some kind of a spray dry fat and a pre-mix and maybe some whey protein concentrate. There are different combinations. Anywhere between 4 and 6 ingredients, and compound their own feed at mixing time. They pull the water into the mixing tank and dump in the various ingredients, mix them up, feed their calves. Those people can produce a different feed every single day they want to, if they want to! This gets into quite a debate.

Question: What about iron and vitamin supplementation?

Answer: It's a can of worms. It's all over the board. Factory feed is fortified for most conditions very adequately when it comes to vitamins and minerals. Under most practical conditions I personally am a proponent of mineral addition of goodies. There are periods of stress where it is warranted. No doubt about it. And then it should be added. I don't feel the manufacturer should add all the micros such as vitamins to cover any theoretical stress situation. Because if we did, we would be over-fortifying the feed the majority of the time and it would be over-priced. So most products are very adequately fortified vitamin-wise. The iron part, though, as I indicated earlier, is a tricky one and you have to contact the manufacture of the feeds and ask or determine what is the iron content of the product you're working with. And there are seasonal differences. We have the biggest problem with red calves in the fall of the year. We're just coming off that period of time. The calves that are coming off now and have come off were out of cows that had better nutrition all the way around through the spring and early summer. So there are seasonal differences. There are regional differences. There are feed differences. There are water differences. There are ventilation differences. The tonics and elixirs that are added to the milk, by the way are some things that you should not overlook. You put x amount of feed, x amount of water in the tank, and you put in a shake of this and a glug of that. Sometimes the farmer or grower forgets that in the glug of this and the shake of this, he's got a product that has a lot of iron in it, unbeknownst to him. He's adding it for a different reason, but the iron is along for the ride. And if you don't know that, you're going to have a slippery pig to catch a hold here!

Question: What about poor ventilation and low iron?

Answer: First of all, with inadequate ventilation, we see more incidence of red meat color, it appears. And apparently mother nature is compensating for this poor ventilation by creating more hemoglobin to get that oxygen carried through the system. The poorer the ventilation, typically the redder the calf. Now, I think the other half of your question was, when that calf is too anemic, too early, what do we see? The calf typically goes stale on us and off feed, and it can get so stale that it dies. That's the ultimate, and these calves will do it. With a no-iron added feed and you just push them terribly hard and give no supplemental iron, they literally, don't just run out of gas, they run out of life. Now, hopefully before that, we can correct the situation. But, off-feed, to answer your question, would be the first symptom. Another thing related to this, we have found that the more anemic the calf is, the longer it takes and the more iron it takes to get a response out of that calf to bring those hemoglobins back up. If we are monitoring these calves and we catch them on the downhill slide, you give them some supplemental iron and they'll come back.

Question: Comment on the fat sources.

Answer: Veal formulas are compounded with a mixture of lard and/or tallow and/or refined coconut oil and/or emulsifier and/or lecithin. The peroxide value and free fatty-acid content of the fats are probably the easiest and most logical way to evaluate the quality of the fats. The majority of products that are being manufactured today do utilize all edible quality fats and oils. And that's one good starting point right there. The use of edible fats and oils does not guarantee success. And also there are some inedible fats and oils that will do a very, very good job. But that is a good, major separating point to start out with. Edible quality. The fats should be homogenized and/or emulsified. We're looking for a globule size, and there are two schools of thought here. We're looking for a globule size of somewhere between either two and ten microns. That's one school of thought. The other school of thought is looking for a micron size as small and as uniform as possible, typically one and a half to three microns in size. If the quality of fat is good, I really don't thing it makes any difference at all which micron size you have if we're talking ten microns or less. The fat does have to be emulsified. Now we can do that through the use of emulsifiers, through the use of homogenizers, or some combination thereof. We don't want to see that fat after mixing float to the top. That will get us into all kinds of trouble. So watch for that symptom, separation of the fat, floating of the fat. Vegetable oils? The only two oils that appear to be well-utilized by the veal calf are palm kernel oil and refined coconut oil. Others are not. The two products may be used interchangeably. They are kissing cousins of each other, chemically. And they move parallel to each other in price over time. Because of availability, coconut oil is the one more typically used.

Question: What are manufacturers' thoughts on the use of antibiotics in the feed?

Answer: I cannot speak for the industry. I personally think that antibiotics are effective. that they do contribute towards better feed conversions. The health aspect, I don't know how much it contributes. Most of the feeds that are medicated today utilize low levels of antibiotics, typically 50-100 grams per ton addition rate. And that really doesn't do much as far as I'm concerned, health-wise. But feed efficiency-wise it does seem to have an enhancing effect, and I personally think that they have a tendency in border line situations to keep the calves on feed better. It's a personal opinion. Take it or leave it. As a manufacturer, it's a hassle to add antibiotics. If the law comes down on us tomorrow and says no more antibiotics in the milk replacer, it makes manufacturing for us easier. We do, in our particular company, offer both versions, medicated and non-medicated, depending on the wishes of the customer. By the way, our hands are really quite tied when it comes to the use of antibiotics in a milk replacer. We can only add chlortetracycline or oxtetracycline or neomycin or oxy-neo combinations. Be aware of that. By law that is all we can incorporate into a milk replacer. The only legal antibiotics we can use, and it's a pretty limited choice. Antibiotics, I think are going to be around awhile. The whole question of animal welfare makes it speculative. It appears this is the quiet before the storm again before the next wave of welfare concerns. They are not going to go away. The industry does have to address it, not just the veal industry, but the entire livestock industry.

Question: Is there a need to add more selenium to the milk replacer?

Answer: Yes, but we can't do it. 0.1 parts per million is the maximum level of selenium that can be added to a feed. And most manufacturers put it in at that level, I am sure. We do. Our hands are tied. I would like to put in .2 or .3 when it goes down to Ohio, for instance. You have to give it on the farm.

Question: Can you prescribe selenium?

Dr. Smith: It can be done. The prescribing of selenium can be done with a local operator within the state for a particular farm. But as far as a company in the state, I think it would have trouble with that type of prescription. The one thing I know, there are differences in the selenium products from a standpoint of texture. We in the milk replacer trade are always looking, with micro-ingredients in particular, for maximum fineness, minimal particular size, so it suspends better in the milk when it is mixed. And if it is going into dry feed for some other application, that type of product might be on the coarse side and may go to the bottom of the mixer.

Question: When you challenge feed a calf and you overchallenge it, what do you do? Calf scours on day two?

Answer: It depends on the severity of the problem that you encounter. If it is something of average magnitude we would be more likely to hold the calf at the level we are feeding at the time or back off a small amount. If it is a severe problem we would drop the calf, well, the maximum, we would drop it off milk completely for a day of two and bring it back gradually. The sky's the limit on the range of that question. Nutritionally, we would back that calf off a small degree or hold the calf at the level it's being fed at present. I think you are bringing up the subject of more profound problems. One of the more common rules of thumb milk-replacer wise would be to cut the silage in half and keep the water level up at the rate you are feeding at present. But it can be worse than that. We have to take these calves off completely in certain extreme situations and give water and electrolytes, or sugar water, many different combinations. It is amazing the differences you encounter from barn to barn in the severity of those kinds of problems. In fact, they are animal husbandry skills. There are feeders, and I have to compliment them for this skill, that can literally forecast when this is coming upon their animals and they cut them down accordingly, in advance. They don't even wait literally for the symptoms to manifest themselves. They know it's coming and it's going to come within 12 hours and they're prepared for it. Now those are the good ones. The other extreme is they just feed them according to a schedule on a sheet of paper. They put in the tank what the sheet of paper says and blindly feed the calves. That, of course, is where you are going to encounter your biggest challenge, needless to say.

Question: When you dilute out the milk you will not get maximum curd formation. What are your feelings on that?

Answer: The curd formation of the calf is reduced. I think we can live with that, though. Personal opinion. Right there we have a discrepancy. We have bigger problems than the curd formation in the calf at the point in time I would argue. Calves are not totally dependent on a curd formation. You may or may not know it, but many calves, especially herd replacement calves, are raised on casein free formulas. There's no curd formation at all. I'm not saying that is good. That's not ideal. But it is a fact of life also. Yes, the tension of the curd is reduced. I think we can live with it. Pay me now or pay me later. What do you want? What kind of answer? What kind of effect? The calf does need water in that situation. And there are situations where keeping the solids up simply compounds the problem. There is no nice neat answer, unfortunately, for that situation. You have to weigh your options.