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A GUIDE TO CALF MILK REPLACERS
Types, Use and Quality

Introduction

Today's high-quality calf milk replacers—when correctly matched with specific calf-rearing systems—provide several benefits to dairy producers and calf raisers, including improved biosecurity, calf performance and economics. In the last 15 years, the formulation of milk replacers has changed significantly. Many of today's products are the result of extensive research and, when fed properly, will support optimal calf growth and performance. However, the price, ingredients and nutritional quality of milk replacers vary significantly. It is important, therefore, that calf raisers make informed decisions on which replacer to use in order to maximize calf performance and economic benefit.

Formulation of Milk Replacers

Modern milk replacers can be classified by protein source, protein/fat levels and the medication or additives in the replacer. Protein levels in calf milk replacers range from 18-30% and fat levels from 10-28%. Generally, when milk replacer is fed, each calf receives at least 1.5 lb (0.68 kg) of high-protein formula (≥22%) daily on a dry matter basis. Fat sources for calves should be highly digestible and preserved with an antioxidant to prevent rancidity. Calf growth is regulated by the daily intake of protein and energy; therefore, feeding level has the biggest impact on performance. Calf growth, as it relates to milk replacers, depends on many factors: the amount of milk replacer fed, replacer protein levels and protein/energy ratios, and protein source interactions. Some conditions, such as cold weather, require feeding at higher energy levels, with the metabolizable energy content of milk replacers being primarily determined by fat and carbohydrate levels in the replacers.

Quality Evaluation

Dry powder

Color: Dry powder should be cream-colored to light tan and free of lumps and foreign material. If the powder is orange to orange-brown in color and has a burnt or caramelized smell, it may have undergone Maillard Browning (non-enzymatic browning) because of excessive heat during storage. Though still safe to feed, if milk replacer has "browned," there will be some loss of nutrient quality and palatability.

Odor: Dry powder should have a bland to pleasant odor. If the odor is characterized as smelling like paint, grass, clay, or gasoline, the fat portion of the product may be rancid.

Reconstituted liquid

Mixing: The product should go into solution easily. Milk replacer should be mixed at the manufacturer's recommended ratio of powder to water and at the correct water temperature. Mix until all powder is in suspension without clumps on the surface or at the bottom of the container. Ingredients in suspension, but not soluble, will settle out of the solution (i.e., form a sediment at the bottom of the container) if allowed to stand without agitation. This sediment layer will be more apparent as the fiber content and/or level of added minerals and/or medication increases. In some feeding situations (e.g., automatic feeders, nipple bottles, etc.), milk replacers containing significant amounts of insoluble components may not be acceptable. Care should be taken not to over mix. If agitation is continued after the product is in solution, excessive foaming can occur, or the fat portion of the product may separate and form a greasy layer on the surface.

Flavor: The liquid should taste milky with no "off" flavors. Some milk replacers are supplemented with organic acids, causing a tangy taste, which should not be confused with the "off" lactic acid taste found in sour milk.

Rennet coagulation (i.e., clotting of milk replacer) is no longer considered an accurate measure of milk replacer quality. Most of today's milk replacers contain whey protein (i.e., lactalbumin protein) which does not clot when mixed with rennet.

Milk Replacer Labels and Ingredients Used in Calf Milk Replacers

The following information provides some criteria for choosing and evaluating milk replacers. The product label provides information about the types of ingredients and medications used in the replacers and their intended uses. If you have questions about the inclusion levels of a product's ingredients, contact the manufacturer's technical services.

Crude protein
Provides essential amino acids for tissue synthesis. Content should be evaluated as to the amount and source of protein (protein sources vary in their bioavailability).

Crude fat
Provides essential fatty acids and is a concentrated energy source (2.25 times the energy of carbohydrates). Smaller frame-sized calves and those raised in cold environments have higher energy requirements.

Crude fiber
Crude-fiber content in milk replacers has been used as a measure of product quality. This measure is no longer considered a valid criterion for evaluating milk replacers. Crude-fiber levels above 0.15% indicate the presence of plant protein; however, levels below 0.15% do not necessarily mean the absence of plant protein. The ingredient list should be reviewed to determine protein sources.

CALF MILK REPLACER
NONMEDICATED

GUARANTEED ANALYSIS

Crude protein, not less than	26.0%
Crude fat, not less than	20.0%
Crude fiber, not more than	0.15%
Calcium (min)	0.75%
Calcium (max)	1.25%
Phosphorus (min)	0.7%
Vitamin A, not less than	20,000 IU/lb
Vitamin D_3, not less than	5,000 IU/lb
Vitamin E, not less than	100 IU/lb

INGREDIENTS

Dried whey, dried whey product, dried whey protein concentrate, animal and vegetable fat (preserved with BHA), dried skim milk, dried milk protein, lecithin, calcium carbonate, dicalcium phosphate, DL-methionine, L-lysine, vitamin A supplement, vitamin D supplement, vitamin E supplement, niacin supplement, calcium pantothenate, thiamine mononitrate, choline chloride, vitamin B_{12} supplement, riboflavin supplement, folic acid, manganese sulfate, magnesium oxide, ferrous sulfate, zinc sulfate, copper sulfate, cobalt sulfate, ethylenediamine dihydriodide, sodium selenite, polyoxyethylene glycol (400), mono and dioleates, silicon dioxide, artificial flavor.

Manufactured for
Dairytown Company
Your Town, State
50 lb (22.7 kg) NET WEIGHT

Vitamins
Vitamin A, D and E are necessary for normal growth and health.

Ingredients
Ingredients should be listed in descending order based on the inclusion level in the formula. However, this type of listing is not required; therefore, using the order of ingredients listed for evaluation might result in erroneous conclusions.

Medications
Medicated milk replacers should not be used as a substitute for good management and sanitization. Choosing to feed medicated or nonmedicated milk replacer and which medication to use should be based on the health status and stress level (e.g., shipping, poor weather, less than optimum housing, low birth weight, etc.) of the animals. Withdrawal periods, when applicable, should be followed according to the manufacturer's recommendations.

As of Jan. 1, 2017, milk replacers medicated with neomycin, chlortetracycline, or oxytetracycline require a Veterinarian Feed Directive (VFD). The VFD also necessitates that a Veterinarian Client Patient Relationship (VCPR)* exist with the farm. Milk replacers containing lasalocid or decoquinate as medications do not require a VFD.

Common Milk Replacer Ingredients

Animal fats and vegetable oils
Fats and oils are obtained by removing the lipid portion of animal and vegetable tissues. Typical animal fats used are edible lard and tallow. Vegetable oils used vary widely. In some products, fats and oils are encapsulated to minimize fat separation in rehydrated milk replacer.

Animal plasma
Animal plasma is a concentrated source of protein obtained by removing the red and white blood cells from fresh whole blood. The resulting plasma is dried (78% protein).

Casein (dried milk protein)
Casein is the primary protein in skim milk. Concentrated by coagulating milk (85% protein).

Dried skim milk
After fat is removed from milk, the remaining protein, lactose, and minerals are dried (34% protein).

Dried whey
Dried whey is produced by draining liquid from cheese and then drying it. Dried whey contains lactalbumin (12% protein) and is high in lactose.

Dried whey product (delactosed whey)
Dried whey product is formed when a portion of the lactose in whey is removed, resulting in high levels of protein and minerals (20–26% protein).

Dried whey protein concentrate (WPC)
WPC is the protein portion of whey that is concentrated through ultrafiltration (34–80% protein).

Lecithin
Lecithin is an emulsifier, meaning it aids in the dispersal of fat in solution and enhances fat digestion.

L-lysine and DL-methionine
Lysine and methionine are essential amino acids necessary for calf growth.

Polyoxyethylene glycol (400) mono and dioleates (PEG 400)
These emulsifiers aid in the dispersal of fats in the solution.

*** https://www.fda.gov/AnimalVeterinary/ResourcesforYou/ucm380135.htm#Valid_Veterinarian-Client-Patient_Relationship**

Definitions of soy/wheat ingredients

Soy protein isolate
Isolated soybean protein with carbohydrate fraction removed. Water soluble and fiber free (86% protein).

Protein modified soy flour
Specifically processed to increase digestibility and decrease antigenicity (50% protein).

Soy protein concentrate (SPC)
Soybean protein concentrated by removing soluble carbohydrates. Contains fiber (66% protein).

Soy flour
Finely ground soybean meal (50% protein).

Wheat gluten or isolate
Isolated wheat protein with carbohydrate fraction removed.

Collective terms

Beware of collective terms (e.g., animal protein products, plant protein products) in a milk replacer's ingredients. These terms may include many different ingredients:

Animal protein products
A collective term that covers ingredients containing protein originating from animal sources. A partial, but not inclusive, list: casein, fish meal, meat and bone meal, dried skim milk, dried whey, and dried animal blood.

Plant protein products
A collective term that covers ingredients originating from plant products that contain protein. A partial, but not inclusive list: cottonseed meal, soy protein concentrate, soybean meal, brewer's yeast, soy flour, and active dry yeast.

Protein sources

More Digestible & Nutritious —Protein sources from milk or nonmilk sources, and their use in calf milk replacers is well researched.
Less Digestible & Nutritious—Protein sources that have been shown to produce deleterious results when fed to young calves.

More digestible & nutritious milk ingredients	**More digestible & nutritious non-milk ingredients**	**Less digestible & nutritious ingredients**
Dried whey protein concentrate	Soy protein isolate	Meat solubles
Dried skim milk	Protein modified soy flour	Fish protein concentrate
Casein	Soy protein concentrate	Wheat flour
Dried whey	Hydrolyzed soy protein modified	Soy flour
Dried whey product	Animal plasma	Egg products
	Wheat gluten or isolate	

Commonly Used Milk Replacer Medications/Fly Control

FAILURE TO OBSERVE LABEL INSTRUCTIONS PRECISELY
CAN RESULT IN VIOLATIVE TISSUE RESIDUES

Medication may be added to milk replacer in order to provide benefits to calf health and performance. Using medications, however, may require a withdrawal period before slaughter (see disclaimer below). The six medications listed in the table below are approved for use in milk replacers. No medication combinations, other than oxytetracycline/neomycin, are allowed with the exception that diflubenzuron may be combined with any of the medications listed (g/ton refers to grams per ton of dry powder.)

Medication/Fly Control	**Use level**	**Statement**	**Withdrawal period/Combinations**
Decoquinate	12.9 to 90.8 g/ton (to provide 22.7 mg decoquinate per 100 lb of body weight daily)	Prevention of coccidiosis in ruminating and nonruminating calves and cattle caused by *Eimeria bovis* and *Eimeria zuernii.*	No withdrawal* No combinations allowed
Lasalocid	Feed to provide 1 mg lasalocid per 2.2 lb of body weight daily	Control of coccidiosis caused by *Eimeria bovis* and *Eimeria zuernii* in replacement calves.	No withdrawal* No combinations allowed
Diflubenzuron	9.1 to 22.6 g/ton	To prevent the development of house flies, stable flies, face flies, and horn flies in the manure of treated calves.	No withdrawal, unless combined with medications that requires a withdrawal, then follow medication withdrawal

CAUTION: Federal law restricts medicated feed containing the following VFD drugs below to use by or on the order of a licensed veterinarian. For information on the VFD, visit: https://www.fda.gov/AnimalVeterinary/DevelopmentApprovalProcess/ucm071807.htm**.**

Oxytetracycline/neomycin combination for calves (up to 250 lb) – VFD Required	500 to 2,500 g/ton (to provide 10 mg/lb of body weight daily). Feed continuously for 7 to 14 days.	Treatment of bacterial enteritis caused by *Escherichia coli* or bacterial pneumonia (i.e., shipping fever complex) caused by *Pasteurella multocida* susceptible to oxytetracycline or treatment and control of colibacillosis (bacterial enteritis) caused by *E. coli* susceptible to neomycin.	5 days before slaughter*
Chlortetracycline - VFD Required	2,000 g/ton (to provide 10 mg/lb of body weight daily)	Treatment of bacterial enteritis caused by *E. coli* susceptible to chlortetracycline. Treat for not more than 5 days.	5 or 10 days* before slaughter (depends on manufacturer – follow label directions)
Oxytetracycline - VFD Required	2,000 g/ton (to provide 10 mg/lb of body weight daily)	Treatment of bacterial enteritis caused by *E. coli* susceptible to oxytetracycline. Feed continuously for 7 to 14 days.	5 days before slaughter*

*WARNING: A withdrawal period has not been established for use in pre-ruminating calves.

Disclaimer: The feeding levels and withdrawal periods are accurate as of March 2018. Milk replacers that contain only Lasalocid or Decoquinate are exempt from the requirement of a VFD. Regulations regarding medications in milk replacers are subject to change; therefore, it is wise to periodically check product labels for changes in approved feeding levels and withdrawal periods.

Matching Calf Milk Replacers to Calf Rearing Systems

In choosing a milk replacer, the requirements of a particular calf rearing situation (e.g., protein source, vitamin supplementation, medication, ease of mixing, etc.) must be evaluated. Many quality problems associated with milk replacers may be caused from choosing the wrong type of milk replacer for a particular situation. The suitability of various protein sources is listed below.

Calf Rearing Systems

Differing calf-rearing systems and climates should be considered when matching a milk replacer to a specific set of conditions. The National Research Council for Dairy Cattle calf model is one resource for determining calves' nutritional needs.

Calf-rearing system	Milk replacer type	General feeding directions
Traditional	Use "acceptable" milk replacers (see previous listing) containing protein sources. Protein level of the milk replacer should be 20 or 22%.	Generally, feed 2-3 quarts, two to three times daily or a total of 4-6 quarts daily for 6-8 weeks.
Intensified, accelerated or full potential	Use milk replacers specifically designed and recommended for this feeding regime. Protein level should be matched to energy intake.	Follow manufacturer's recommendations relative to mixing rates, feeding rates and management recommendations.
Winter feeding at low temperatures (always provide deep straw bedding and calf blankets).	It is preferable to use a higher energy (20% or higher fat) milk replacer when ambient temperatures fall below freezing. In addition, milk-replacer quantities fed should be increased 25% to 50%.	Feed calves three times daily to increase energy intake, or gradually feed a greater volume of milk replacer per feeding over a 5-7 day period.
Cold *ad* libitum (self-serve/free choice/acidified feeding)	Use only a nonmedicated, acidified milk replacer specifically recommended by the manufacturer. Do not use a product that produces heavy sediment when reconstituted.	Nipple feed only from a reservoir with regular agitation and a suitable nipple assembly and hose. Keep milk available at all times until the weaning process begins.

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Always weigh milk replacer and water for accurate mixing according to manufacturer's recommendation. Feeding temperature of milk replacer and other liquid diets should be 100-105°F (38-40°C), unless acidified milk is fed. Refer to specific acidified milk feeding systems for recommended temperatures for those diets.

Beginning the first 1 to 2 days of life, all calves should have access to fresh, clean water and fresh, high-quality calf starter at all times. The starter should be at least 18% protein. Milk-replacer bags should be stored in a clean, dry area, not subject to excessive heat. Opened milk-replacer bags should be stored in an air-tight fashion to prevent contamination and exposure to pests, heat and humidity.

Summary

Extensive evaluation of the nutritional integrity of calf milk replacers involves complex chemical and microbiological analyses. This guide provides strategies for rapidly evaluating calf milk replacers, but is not meant to replace consultation with a qualified nutritionist. **Calf performance is the single best criterion for evaluating calf milk replacers.** Recommended performance measures are available from the Dairy Calf and Heifer Association website (http://calfandheifer.org/gold_standards/index.php). If calf performance does not meet the goals of the operation, more detailed evaluation of management, calf health and calf milk-replacer quality is necessary to determine the reason for poor performance.

This guide is published by the Bovine Alliance on Management and Nutrition (BAMN), which is comprised of representatives from the American Association of Bovine Practitioners (AABP), the American Dairy Science Association (ADSA), the American Feed Industry Association (AFIA), and the U.S. Department of Agriculture (USDA). The purpose of this guide is to provide dairy producers with information about how to evaluate calf milk replacers for a particular calf-raising system.

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1. *A Guide to Calf Milk Replacers, 1993*, *2014*, revised 2018
2. *A Guide to Feeding and Weaning Healthy and Productive Dairy Calves, 2003,* revised 2017
3. *Direct-fed Microbials (Probiotics) in Calf Diets,* revised 2011.
4. *Feeding Pasteurized Milk to Dairy Calves, 2008.*
5. *Managing a Pasteurizer System for Feeding Milk to Calves, 2008.*
6. *Heifer Growth and Economics: Target Growth, 2007.*
7. *Introduction to Nutrient Management for Cattle, 2007.*
8. *Handling Foreign Animal Diseases in Cattle, 2005.*
9. *A Guide to Colostrum and Colostrum Management for Dairy Calves, 2001.* (Spanish version available)
10. *An Introduction to Infectious Disease Control on Farms (Biosecurity), 2001.* (Spanish version available)
11. *Biosecurity on Dairies, 2001.* (Spanish version available
12. *Biosecurity of Dairy Farm Feedstuffs, 2001.* (Spanish version available)

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