The Myth of Using High Fat Milk Replacers For Winter
And Why More Powder Is Truly Better Than More Fat

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It is widely believed that during winter, calves need higher fat content, higher energy milk replacers to accommodate the increased energy needed to keep warm. But, when fat is used to increase the energy content of milk replacers, other sources of energy such as lactose (called “milk sugar”) must be reduced. Contrary to popular belief, increasing fat content does not have as much impact on energy density as one might expect. In fact, doubling the fat content of milk replacer from 10 to 20 percent (+100%) only increases energy density from 1860 to 2086 kCal/lb which is an increase of about only +12 percent.

The Solution is Simple: By increasing the amount of milk replacer powder fed from 8 to 10 ounces per feeding, producers provide +25 percent more energy to calves, and increasing powder to 12 ounces provides +50% more energy. As temperatures drop to freezing, calves have a 50% increase in maintenance energy requirement, and as temperatures drop to 0^{o} F, the energy requirement is 100% higher than calves in thermoneutral conditions. The increased energy demands of cold temperatures (freezing and below) can only be met by feeding more milk replacer powder each day, not by increasing fat content of milk replacer. Furthermore, lowering the percent fat and increasing the total amount of milk replacer powder per day (additional 12 ounces/day) actually provides the best nutritional balance and is most cost effective strategy for cold weather ($<35^{o}$ F) because it delivers more total energy from milk replacer and will consistently maximize starter feed intake. Thus, more milk powder instead of higher fat percent maximizes daily energy intake. This paper explains how cold affects the energy requirements for young calves and presents details for strategies to meet the increased energy demand.

Cold Temperatures Increase Maintenance Energy Requirement of Calves

There are several definitions of cold stress in calves, but for this discussion consider "cold stress" to mean the point where calves stop gaining weight due to cold temperatures. To prevent cold stress from robbing valuable weight gain, calf producers must provide more calories of energy for both maintenance and weight gain every day. Most producers are surprised to learn that the temperature at which calves begin to increase their maintenance energy requirement is 68^o F for calves younger than 3 weeks of age and about 40^o F for calves older than 3 weeks of age. Who would consider a cool summer night of 68^o F to be "cold weather?" Young calves do!

Maintenance energy sustains basic body functions like respiration, blood circulation, and regulating body temperature. Calves use the energy contained in milk replacer to meet their maintenance requirement first, and then, additional calories are available for growth which is called "energy for gain." This relationship can be expressed as a mathematical equation:

Intake energy – maintenance energy = energy for gain

Feeding 1 lb of a 20% fat milk replacer per day to a calf that weighs 100 lb, with an ambient temperature of 68^o F results in the following energetics:

Energy for gain = Intake energy (2000 kCal) – maintenance energy (1735 kCal) = 265 kCal

In this example, the calf has 265 kCal per day available for gaining weight at 68^o F which is enough energy to gain about 0.2 lb/day.

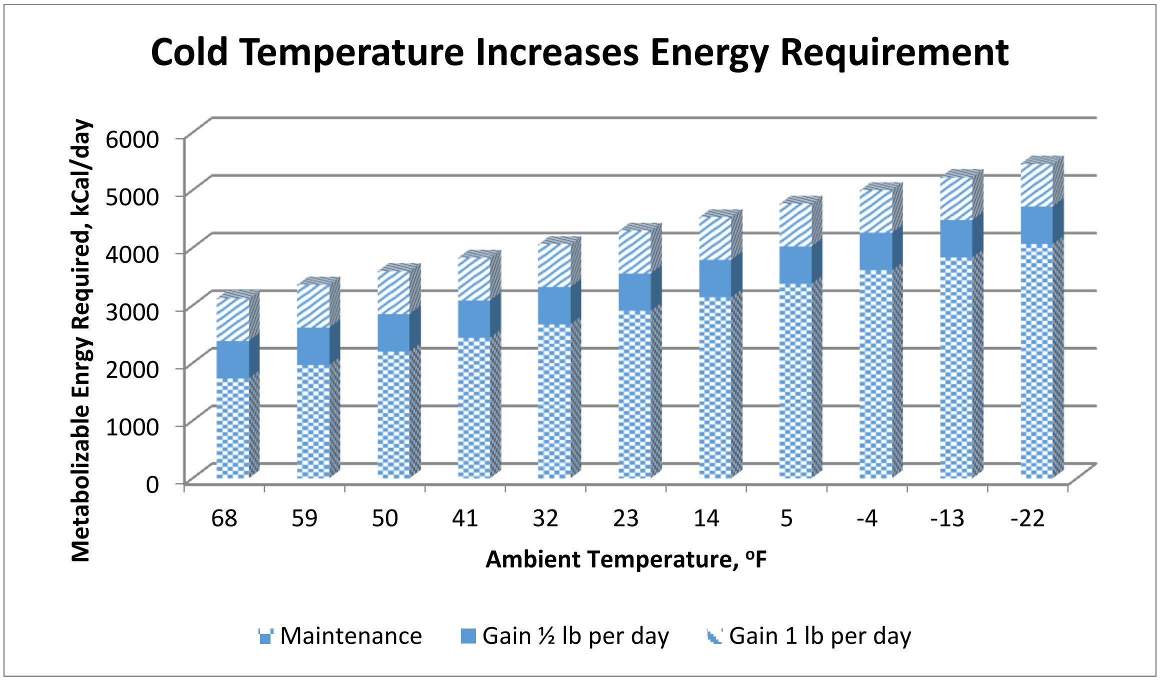
When temperatures drop, the maintenance energy requirement increases because calves need more energy to keep themselves warm, so there is less energy available for weight gain. For every degree (F) drop in temperature below 68^o F, for a calf less than 3 weeks old, there is an increase in maintenance energy of 20.7 kCal. This means that if the temperature drops to 54^o F the increased maintenance requirement is 290 kCal. The equation for feeding 1 lb of 20% fat milk replacer looks like this:

Energy for gain = Intake energy (2000 kCal) – maintenance energy (1735 + 290 kCal) = -25 kCal

At 54^o F, the young 100 lb calf fed 1 lb of a 20% fat milk replacer per day has no energy available to gain any weight. In fact, the calf is in a slight negative energy balance and loses weight. What happens when the temperature drops to 30^o F or only 10^o F? At low temperatures, maintenance energy requirements far exceed daily caloric intake and calves go into negative energy balance. Instead of gaining weight, calves in negative energy balance lose weight as they must rely on metabolizing body tissues to maintain body temperature.

Most milk replacers contain about 2000 kCal of metabolizable energy per pound assuming 20% fat and 12% ash or 16% fat and 6% ash. Protein level does not change the energy density of milk replacer because both protein and lactose contain 4 kCal/gram. Changing fat content can slightly change the energy density because fat contains 9 kCal per gram which is 2.25 times higher than the lactose it replaces. For each 1% change in fat content, energy increases or decreases by about 22.7 kCal/lb of milk replacer which is a change of less than 1.1% energy density. High-ash milk replacers (10-12%) have lower energy than low-ash milk replacers (6-8%) because lactose is replaced with sodium, potassium, and chloride which contain no energy.

The table below shows the energy needed each day by calves for maintenance and for gain of ½ lb and 1 lb per day at various temperatures. Assuming 2000 kCal per pound of milk replacer, as discussed above, one can see that the maintenance energy is approximately equal to 2000 kCal when temperature is 50° F. This is the point where calves are not growing, only maintaining body weight As temperature decreases to freezing, maintenance energy increases by about 50%. At 0° F, maintenance energy is 100% higher than at 68° F.



Higher Fat Level Cannot Possibly Satisfy Increased Energy Needs: From a practical standpoint, one cannot meet the increased energy needs by increasing the amount of fat in a milk replacer because a milk replacer would have to contain 46% fat to meet the maintenance energy requirement at 32° F, and it would have to contain 81% fat to meet the maintenance energy requirement at 0° F.

The best protocol is to increase the amount of milk replacer fed each day which will provide enough energy to calves in order to meet their increased maintenance requirements while enabling weight gain. With a traditional feeding rate of 1 lb per day, calves stop growing at 50° F. By comparison, calves fed 1.5 lb milk replacer per day typically continue growing, albeit at a slower rate, until the temperature falls to about 20° F.

<u>Milk Replacer Composition and Energy Content</u>

Various nutritious ingredients are used to make milk replacers such as protein and fat which are listed on the label. Consider, for example, the label of a milk replacer that shows 28% crude protein and 15% fat. In other words, there is 28 + 15 = 43% of the total milk replacer shown on the label. Within a 50 lb bag, this is only 21.5 lb as protein and fat. So the question is what other nutrients make up the majority 28.5 lb in the 50 lb bag? Most people are surprised to learn that the nutrient that comprises the highest proportion of milk replacer is lactose, and it is not even listed on the label. As a percentage of the total, lactose is usually more than 40% of most milk replacers, followed by protein, then fat, then the mineral content (called ash), then moisture.

It is a simple process to estimate the lactose content of milk replacers from the feed tag. Once the protein and fat content are known, the ash content and moisture content can be estimated. In our example, with 28% protein and 15% fat, one can estimate 4% moisture and ash content from about 6% to 12% depending on the milk replacer manufacturer and the type of milk replacer being made. Assume for this example that ash content is 6%. The amount of lactose is: 100 - (% crude protein + % fat + % moisture + % ash). In our example the lactose content is: 100 – (28 + 15 + 6 +4) = 47% lactose. This information is important because simply increasing fat in milk replacer results in an equal decrease of lactose resulting in a very small overall effect on energy density of the milk replacer as shown in the table below.

	10% Fat	**12% Fat**	**14% Fat**	**16% Fat**	**18% Fat**	**20% Fat**	**22% Fat**	**24% Fat**	**26% Fat**
Crude Protein	28	28	28	28	28	28	28	28	28
Lactose, %	52	50	48	46	44	42	40	38	36
Ash, %	6	6	6	6	6	6	6	6	6
Moisture %	4	4	4	4	4	4	4	4	4
ME kCal/lb	**1860**	**1905**	**1950**	**1996**	**2041**	**2087**	**2132**	**2177**	**2223**
ME, % Relative	**100**	**102.4**	**104.9**	**107.3**	**109.8**	**112.2**	**114.6**	**117.1**	**119.5**
Δ ME kCal/lb	+45.36	+45.36	+45.36	+45.36	+45.36	+45.36	+45.36	+45.36	+45.36

Problems with High Fat in Milk Replacers

If calves are only fed milk replacer, for example milk-fed veal calves in naturally ventilated barns, a higher fat milk replacer might be advisable since veal calves do not have free-choice starter feed, but for replacement heifers and dairy beef calves which are fed starter feed, high fat milk replacers present many problems. The primary problems are:

1. Calves do not digest or metabolize a high fat diet very well

Calves do not have the capability to metabolize high-fat diets efficiently. Figures 1 and 5 Bazin and Brisson (1976) reprinted below show two major metabolic reasons why high fat milk replacers are bad for calves. Figure 1 shows the concentration of triglyceride fats in plasma of calves for 8 hours after feeding. Calves fed the low-fat milk replacer maintained a nearly constant triglyceride level of about 20 mg/100 ml of plasma. Calves fed the high-fat milk replacer had a very wide range of plasma triglyceride levels reaching from 10 mg/100 ml to nearly 40 mg/100 ml. Elevated triglyceride levels lasted for at least four hours in calves fed the high-fat milk replacer. Young calves do not have the metabolic capacity to efficiently metabolize high fat milk replacers.

Note in Figure 5 below that blood glucose was elevated for a longer period of time in calves fed the low-fat milk replacer compared with calves fed high-fat milk replacer. High blood glucose levels of approximately 110 mg/100 ml are favorable and needed for growth of muscle tissues, synthesis of all body tissues, and eliciting insulin responses which promote tissue growth. After feeding, calves fed low-fat milk replacer had a higher blood glucose level for about 4 out of 8 hours compared with calves fed the high-milk replacer diet where blood glucose levels feel sharply after 2 hours.

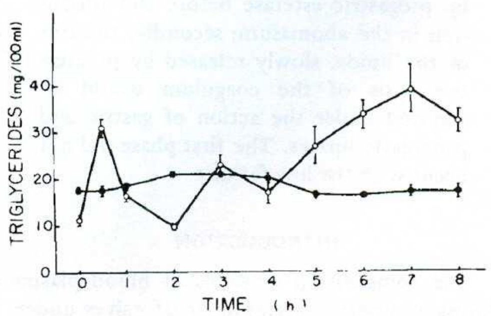


FIG. 1. Concentration of plasma triglycerides in blood of calves over an 8-h period after feeding. The values plotted are means ± standard errors. These were derived from the results of two experiments, each with six calves per group (o——o high-fat diet, •- - -• low-fat diet).

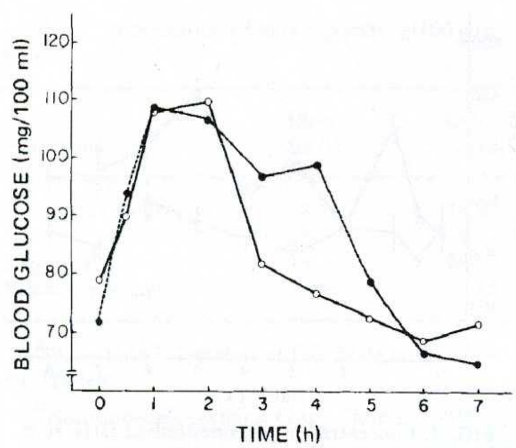


FIG. 5. Concentration of blood glucose (o——o high-fat diet, •- - -• low-fat diet).

Source: Bazin, R.C., and G.J. Brisson. 1976. Plasma lipids, ketone bodies, and glucose concentrations in calves fed high– and low-fat milk replacers.

2. Increased fat intake decreases dry starter feed intake and delays weaning

Many studies and field experience confirm that calves fed high fat milk replacers reduce their intake of dry starter feed. Since daily starter feed intake is the primary factor determining when to wean calves, feeding high fat milk replacers leads to delayed weaning which increases cost of production for calf producers. Milk replacer is many times more expensive than dry starter feed and individual calf care in hutches is more expensive than feeding weaned calves in groups. Barr and Bring (1977) found that calves fed 15% fat in milk replacer consumed 61.9 lb starter feed compared with 56.9 lb in calves fed 20% fat during the milk-feeding period. Research by Kuehn et al. (1994) found that calves fed high-fat milk replacer consumed less starter feed and less total digestible energy than calves fed low-fat milk replacer. Calves fed high-fat milk replacer consumed more energy from milk replacer because of the high fat, but the net effect of higher-energy milk replacer and their lower starter intake resulted in lower total energy intake. Heat produced during fermentation of dry starter feed should not be overlooked as a significant source of warmth for calves during cold weather. Kuehn et al. (1994) also found no benefit of additional fat in either the milk replacer or starter feed.

3. Increasing level of fat in milk replacer reduces digestibility of feed

Hill et al. (2009) compared performance of calves and digestibility of feed constituents at four levels of fat (14, 17, 20, and 23%) in milk replacers containing 27% protein. Digestibility of dry matter, organic matter, fat, calcium, phosphorus, and fiber were linearly reduced ($P<.01$) as fat level increased. Average daily gain was lowest in calves fed 23% fat in milk replacer and highest in calves fed 17% fat (quadratic $P=0.04$) during the 28-day period when calves were fed milk replacer.

4. Carbohydrates are preferentially used for growth and fat is preferentially used to deposit body fat

Toullec et al. (1973) fed veal calves milk replacer containing 21% fat or milk replacer in which 52% of the fat was replaced with additional carbohydrates to provide equal energy per day in order to compare growth of calves from fat or carbohydrate. Calves fed the high-fat milk replacer had average live weight of 354 lb compared with 396 lb for calves fed high-carbohydrate milk replacer. This showed that replacing a significant portion of lipids with carbohydrates helped increase weight gain. More recently, Tikofsky et al. (2001) compared milk replacers with low, medium or high fat in which daily intake was different to provide equal energy and equal protein intake for the three milk replacers. Although daily gain was not different among calves fed the three milk replacers, body composition of calves fed higher fat contained significantly higher amount of fat in the carcass, 11.0% fat for calves fed high fat, 9.9% fat for calves fed medium fat, and 8.5%% fat for calves fed low fat milk replacers. Dairymen who are concerned about producing “fat” heifers should not feed high fat milk replacers because fat consumed by calves is preferentially used to increase body fat, not growth of body muscle or bone.

Best Strategy for Feeding Calves in Cold Temperatures

The most efficient feeding practice for calves, both bulls and heifers, is to feed 12 ounces of milk replacer per feeding in 2 quart bottles. To meet the protein requirements with this amount of energy, the recommended milk replacer composition should include 28% protein and to 12-15% fat to avoid over-feeding fat. . If one were to feed a milk replacer with less than 28% protein at this feeding rate, calves would be fed too little protein to gain muscle and bone and feeding a milk replacer containing higher than 15% fat results in calves being fed too much fat per day.

Bull calves can be weaned by 35 days of age to minimize cost-of-gain but with heifer calves the objective is to maximize lifetime milk production so a 56-day feeding schedule is recommended. This is the highest return-on-investment for the dairyman. When temperatures fall below 35° F feeding one more bottle per day and weaning 1 week older is recommended. Consistency is important so temperatures start dipping below 35° F, and the winter schedule is adopted, stay with the winter schedule until warm weather arrives in spring. Increasing and decreasing the quantity of milk replacer is a recipe for disaster.

Milk Replacer Feeding Schedule – 12 Ounces Per Bottle

a. Bulls – lowest cost of gain from day 1 to 20 weeks

Days > 35° F	**Bottles per day**
1-28	2
28-35	1
36 +	0

Days <35° F	**Bottles per Day**
1-28	3
28-35	2
36-42	1
43+	0

b. Heifers – highest Return-on-Investment for Dairyman

Days > 35° F	**Bottles per day**
1-14	2
15-35	3
36-49	2
50-56	1
57+	0

Days <35° F	**Bottles per Day**
1-14	3
15-35	4
36-49	3
50-56	2
57-63	1
64+	0

Summary: For Successful Milk Replacer Management In Cold and Warm Weather

Two bottles of milk per day containing 12 ounces of milk replacer powder per bottle is an optimally cost efficient and well balanced feeding strategy which fits well with warm weather. At near-freezing temperatures, 35° F or below, feeding three bottles per day with 12 ounces of milk replacer per bottle keeps calves growing in spite of increased energy demands of cold weather.

For most operations, summer feeding should include a 28/15 milk replacer to provide enough protein for maximum growth of muscle and bone and minimize excess fat. During winter feeding, lower protein/lower fat milk replacer such as 22/12 fed at the rate of 3 bottles per day will lower milk replacer cost without sacrificing performance and keep protein and fat intake similar to 2 bottles of 28/15 milk replacer. In essence, the calf is provided with additional lactose from the additional powder to compensate for increased maintenance energy demands with similar amounts of protein and fat as in warmer weather feeding schedule.

In summary, calf growth depends upon calves receiving adequate energy. The best way to provide extra energy when cold or even cooler temperatures challenge growth is with additional, seasonally balanced milk replacer power, not additional fat. Extra fat does not and cannot meet the true energy requirements, and extra fat interferes with various digestive and metabolic functions. More milk replacer powder instead provides both the energy and proper nutrient balance for steady growth and successful calf performance.

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