

Review of Recent Research Investigating Effects of Calf Feeding Program on First Lactation Performance

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Peer-reviewed studies comparing milk replacer programs
Peer-reviewed studies comparing other feeding programs
Abstracts
Summary of pre-weaning nutrition effects on production

TOPICS

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INTRODUCTION

Milk and milk replacer feeding strategies have been studied for many years. Early studies focusing on levels of milk and milk replacer feeding were published over 40 years ago after the concept of using milk replacers had gained popularity. Indeed in many species of animals there is research to study feeding levels and feed sources for the newborn or neonate and how this may affect later life issues, both during the growing period and the productive period of life.

The 'conventional' feeding program for calves in the U.S. is designed to encourage early intake of grain, stimulate rumen development, and facilitate weaning so that feed costs can be kept to a minimum. This program provides approximately 1 gallon of liquid per day, usually in two feedings of 2 quarts each. When using milk replacer typically 1 to 1.25 pounds of powder is fed each day. This feeding rate will meet the requirements for maintenance of a calf weighing 80 to 100 pounds under thermoneutral conditions. Current feeding recommendations suggest that calves be fed 10 to 12% of their body weight, rather than a fixed volume of 1 gallon per day. In addition, milk or milk replacer amounts should be increased in cold weather, particularly for calves less than 3 weeks of age that are not consuming grain.

In recent years feeding strategies have been proposed that greatly increase the amount of milk or

milk replacer fed to calves compared to conventional practices. These programs have been called by a variety of names including accelerated, enhanced, and intensified. Numerous studies have documented the effects of these programs on calf growth during the preweaning period. More recently, studies have evaluated the long-term relationship between milk intake in dairy calves with modern genetics and milk production later in life. This review will focus on the effects of increased milk or milk replacer feeding on milk production.

We reviewed all of the worldwide literature and found four peer-reviewed publications relating calf milk replacer intake levels with future events such as age at calving and first lactation milk production. Each of the studies is a bit different and reports the data in somewhat differing ways, but they have a great deal of similarity. These will be reviewed in some detail.

In addition there have been three studies published in peer-reviewed journals that focus on increased feeding of liquid feeds to dairy calves, but in many aspects these studies show the differences between milk and milk replacer feeding in the dairy calf and interestingly all have been done in Israel. Since these studies utilize systems that are very different than what we in the US would consider 'normal' or 'acceptable' feed sources or practices, these studies will be reviewed in a separate section.

COMPARISON OF MILK REPLACER PROGRAMS

In a study by researchers from the animal science department at the University of Minnesota as well as Milk Products Inc. and Hubbard Feeds (Raeth-Knight et al., 2009), 133 Holstein heifer calves from 3 farms were assigned to 5 treatments beginning at 3 days of age. Calves were fed conventional milk replacer (20% protein, 20% fat, fed at 13.9% solids and 1.25 lbs of powder per day); acidified conventional milk replacer; intensive milk replacer (28% protein, 18% fat, 1.5 lbs of powder per day) fed at 16.7% solids; intensive milk replacer fed at 12.5% solids; or intensive milk replacer fed at 16.7% solids and at an increasing rate. All calves on the first 4 treatments were fed twice daily through 35 days of age; milk replacer was reduced by half and calves were fed once daily from day 36 to weaning

at 42 days. Calves on the intensive, high solids, increasing feeding rate treatment were fed 1.5 lbs of powder per day from day 1 to 10 and 2.25 lbs of powder per day from day 11 to 42 in 2 equal feedings. On day 43 milk replacer was reduced by half and fed once daily until weaning at 49 days. All calves were fed free-choice starter; protein in the starter was 20% for conventional calves and 25% for calves fed intensive milk replacer. At 56 days of age calves were moved to group pens and fed grower rations; protein levels were 18% for conventionally fed calves and 21% for intensively fed calves. Diets fed during the later growing period and first lactation were similar across all groups. No mention was made of the breeding protocol used in this study. First lactation records were available for 95 of the

animals that began the study. Milk replacer feeding program did not affect first-lactation performance (305-d ME milk yield averaged 28,916 lbs with 3.0% protein and 3.6% fat); however, heifers fed the intensive, high rate program calved almost a month (27.5 days) earlier than those fed conventional milk replacer ($P = 0.05$).

University researchers and feed industry personnel from the United Kingdom (Morrison et al., 2009) studied the impact of milk replacer feeding rate and protein concentration on animal performance through second lactation. Holstein-Friesian calves with an average birth weight of 95 lbs began the study at 5 days of age. Calves were fed 1.32 or 2.64 lbs per day of milk replacer powder containing 21 or 27% crude protein and 17% fat until weaning at 56 days of age. All calves were housed in groups by treatment and fed via automated feeders. Water and 22% protein calf starter were available free-choice during the milk-feeding period. After weaning, heifer calves remained in treatment groups through 12 weeks of age. All animals were offered the same diet from weaning through the remainder of the experiment. Heifers were bred after reaching 13.5 months of age and 695 lbs of body weight. Milk production data were collected for 81 heifers' first and 66 cows' second lactation. Neither age (24 months) nor body weight (1,116 lbs) at first calving was affected by the milk replacer feeding program. Milk production during first (49 lbs/d, 3.3% protein, 3.9% fat) and second lactation (54 lbs/d, 3.2% protein, 3.9% fat) was also similar regardless of treatment (based on 305-day production).

Another study conducted in Spain (Terré et al., 2009) compared feeding milk replacer containing 25% protein and 19% fat at a constant rate (1.05 lbs of powder per day for 35 days, reduced to 0.53 lbs of powder per day for 7 days during weaning) or at an increasing rate (lbs of powder per day: 1.05 for 3 days, 1.3 for 4 days, 1.6 for 7 days, 2.4 for 7 days, 2.8 for 7 days, 2.4 for 7 days, and 1.2 for 7 days during weaning) to 60 Holstein calves that began the study at 10 days of age. Water and 21% protein starter were available throughout the experiment. First lactation milk production data were only available for 14 animals, and no difference between treatments was found; average 305-day milk yield was 22,487 lbs. In addition, there was no difference between treatments in age at pregnancy (14.6 months).

Researchers at Michigan State University (Davis Rincker et al., 2011) studied the effect of intensified feeding on growth, age at puberty, age at calving, and milk production. They compared a conventional 21.5% protein, 21.5% fat milk replacer at 1.2% of bodyweight (average dry matter intake was 1.32 lbs/d) to a 30.6% protein, 16.1% fat milk replacer fed at 2.1% of bodyweight (average dry matter intake was 2.27 lbs/d) using 80 heifers (40 each group). All calves were weaned at 6 weeks of age. Starter contained 20 and 24% protein for calves on the conventional and intensive treatments respectively. Calves that did not meet the targeted average daily gain before weaning for their treatment (1 or 1.5 lbs/d) were replaced. After weaning calves were fed and managed similarly. Heifers became eligible for breeding at 875 pounds of body weight and were allowed three services before being removed from the study. No differences were detected between calves fed conventionally or intensively in age at calving, body weight at calving, or average daily milk production through 150 days of the first lactation. These researchers also examined milk yield in terms of projected 305-d ME milk production, adjusted for energy content and unadjusted for age at calving. No differences were found between treatments with this method (milk averaged 21,878 lbs with 3.15% protein and 4.13% fat). A further analysis of milk yield by including parent average removed genetic variation. Although the parent average for milk was not different between treatments, when it was included in the analysis, milk yield tended to be greater for cows fed intensively as calves (917 lbs, 305-d ME unadjusted for age; $P = 0.08$).

To summarize, these are the only peer-reviewed, published studies from around the world that specifically address the issue of first lactation performance following accelerated milk feeding programs as compared to more traditional milk replacer feeding programs. The studies from Minnesota, Michigan, and the United Kingdom have adequate numbers of animals for us to feel that they are conclusive in nature. The study from Spain is deficient in animal numbers, (the number of heifers completing the study was only half of what had been planned); however the authors did conclude that there were no differences in production.

STUDIES THAT COMPARED OTHER FEEDING PROGRAMS

We also found three studies in the worldwide literature that compared free choice or high levels of whole milk compared to a marginal amount of soy protein-based, low fat milk replacer. It is important to understand that all three of these studies were conducted at the same research center in Israel, with its unique management and feeding systems. It should not be expected that the milk replacers we commonly use in North America or Europe will react in the same manner.

Israeli researchers (Bar-Peled et al., 1997) fed 40 Holstein calves milk replacer or allowed them to nurse in pairs. Milk replacer contained 23% protein and 15% fat, and calves received 1.5 L/day from day 5 to 9, 2 L/day from day 10 to 14, 3 L/day from day 15 to 50, and 2 L/day from day 51 to 60. Calves allowed to nurse were placed with a cow for 15 minutes 3 times each day from day 5 to 42; from day 43 to 50 these calves received 4 L/day of milk replacer, and from day 51 to 60 they received 2 L/day of milk replacer. Assuming 12% total solids concentration, milk consumed by calves contained 27.3% protein and 26% fat on a dry matter basis. All calves were weaned at 60 days. Water, starter (16% protein), and hay were available beginning at day 4; however, none of the nursing calves consumed starter or hay. Twenty nine heifers completed their first lactation. Heifers that had nursed were 31 days younger at first calving ($P = 0.05$), but there were no differences in body weight between treatments. Actual milk production in a 300-day lactation tended to be higher for the nursed group than the milk replacer group (difference of 998 lbs; $P = 0.08$).

In another Israeli study (Shamay et al., 2005), 40 Holstein calves were fed either milk replacer (23% protein, 12% fat; fed 1 lb of powder per day) or fresh milk (27% protein, 28.7% fat fed 2 times per day, calves allowed to consume as much as they wanted for 30 minutes each time). Both groups of calves had free access to 18% protein starter and water and were weaned at 60 days of age. First lactation data

was available for 34 heifers. Age (23.3 months) and body weight (1,129 lbs) at first calving were similar for calves fed milk or milk replacer. Actual 305-day milk production was also similar for the two treatments (25,142 lbs). However, milk fed calves produced more fat and protein on a daily basis and had higher daily average of 3.5% fat-corrected milk (68 vs. 65 lbs/day; $P < 0.01$).

In a similar study, also conducted in Israel, Moallem et al. (2010) fed milk or milk replacer to 46 calves. Both feeds were offered ad lib 2 times each day for 30 minutes each time, and calves were weaned at 60 days of age. Milk replacer in this study contained 24% protein and 13% fat, and milk contained 26% protein and 29% fat on a dry matter basis. All calves had access to 18% protein starter and water. First lactation information was available for 36 heifers. Age at first calving (24 months) was similar for all heifers, but those fed milk during the pre-weaning period tended to have greater body weight (1,210 vs. 1,162 lbs; $P = 0.10$). Over the 305-day first lactation, average daily actual milk (66 vs. 72 lbs/day) and 4% fat-corrected milk (62 vs. 67 lbs/day) yields were greater for calves fed milk than those fed milk replacer ($P < 0.01$).

In summary, these three studies from the Volcani Center in Israel showed that feeding high rates of whole milk that contained high protein and energy levels had positive effects compared to feeding low levels of milk replacer that contained some non-milk protein and had low levels of fat (12, 13, or 15%). For those in North America and Europe where our milk replacers are often very different in composition, we should not conclude that milk replacer is bad for calves. In addition, we should not conclude that providing high levels of whole milk is the right approach for feeding young calves. These calf diets compared a high level of whole milk with milk replacers containing lower levels of nutrients than what is found in milk replacers sold in the US and Europe.

ABSTRACTS

In addition to the studies described above, there have been several meeting abstracts presented on this topic. Abstracts provide a short summary of an experiment. They do not have the detail that is

available in a full-length paper and have not been subjected to peer review, the process of other scientists validating the research methods and conclusions. Many studies are initially presented as

abstracts and later published as full papers, and information from abstracts should be considered preliminary.

Ballard et al. (2005) fed 60 Holstein calves 1 of 3 milk replacer programs: 27% protein, 20% fat fed at an increasing percentage of body weight (1.5% in week 1, 2.25% in weeks 2 through 5, and 1.25% from week 6 to weaning); the same milk replacer fed at 0.88 lbs of powder per day for 2 weeks and then 1.10 lbs of powder per day through weaning; or 27% protein, 15% fat milk replacer fed at the same increasing percentage of body weight as described above. First lactation data for 51 heifers was available. No difference was observed in age or body weight at first calving (25.4 months, 1,443 lbs). Actual milk production through 200 days was 1,449 lbs greater for calves fed 27/20 milk replacer at an increasing rate than the other treatments ($P = 0.04$). Production of 3.5% fat-corrected milk tended to be higher for these calves as well (difference of 1,558 lbs; $P = 0.10$).

British researchers (Aikman et al., 2007) looked at first lactation performance of cows fed the same 26% protein, 16% fat milk replacer free choice or at 1 gallon per day through 6 weeks of age. After weaning calves were managed similarly. There were no differences between treatments in age at first breeding (13.8 months), age at first calving (23.6 months), daily milk production (60.8 lbs), total first lactation milk yield (20,163 lbs), or calving interval between the first and second calf (12.8 months).

Drackley et al. (2007) also compared first lactation performance for calves fed control or intensified diets in 2 trials with similar treatments. Control calves received 22% protein, 20% fat milk replacer at 1.25% of birth weight and were weaned at 5 weeks of age. Intensive calves were fed 28% protein and 20% fat milk replacer at 2% of birth weight for 1 week then increased to 2.5% of body weight in weeks 2 through 5 (in trial 1 amount fed was adjusted weekly, in trial 2 it was held at 2.5% of week 2 body weight); calves were weaned at 6 weeks. For all calves, milk replacer was reduced by half in the week before weaning. Both groups had free access to starter. Calves were managed in groups by treatment until 12 weeks, and then

managed similarly to calving. There was no difference between treatments in age (25 months) or body weight (1,252 lbs) at first calving. Actual 305-day milk production was 1,723 lbs greater for calves fed intensively (19,745 vs. 21,468 lbs; $P < 0.01$).

A study of 140 Danish Black and White calves (Foldager et al., 1997) found that heifers fed milk ad libitum for the first 6 weeks of life tended to produce more milk per day (3.5 lbs) in their first lactation than heifers fed a constant level of 10 lbs (approximately 1.2 gallons) of milk per day ($P < 0.10$). In the same study, feeding milk ad libitum for 12 weeks reduced milk production by 5.7 lbs/day in first lactation ($P < 0.02$).

In another study from Denmark (Foldager and Krohn, 1994), whole milk was fed to two groups of Danish Black and White calves (20 calves total). One group suckled the dams 60 minutes per day through weaning at 6 to 8 weeks of age and the other was bucket fed approximately 1.2 gallons of milk per day through weaning at 6 weeks of age. First lactation production through 250 days in milk was not different for daily milk ($P = 0.19$) or energy-corrected daily milk ($P = 0.15$).

Finally, there is one abstract on this topic that describes a study using regression analysis to evaluate the relationship between average daily gain (ADG) before weaning and first lactation milk production (Soberon et al., 2009). Results of a regression analysis do not describe cause and effect, but they can provide insight on the strength of a relationship between various factors in a statistical model. In this study, lactation records from 792 heifers were analyzed. Prewaning ADG ranged from 0.29 to 2.71 pounds and was identified as a highly significant factor influencing first lactation milk yield. The conclusion of the abstract was that increased growth rate, primarily through increased liquid feeding rate, had positive effects on milk yield. However, there are factors other than the amount of liquid feed that determine ADG, including illness, environmental stress, grain intake, and genetic propensity for growth. The abstract does not indicate that these factors were considered in the analysis. Therefore, while these results are interesting, they should be applied with caution.

OVERALL SUMMARY OF PRE-WEANING NUTRITION EFFECTS ON PRODUCTION

In the past 15 years there has been a large amount of research addressing this issue. Each study has its own objectives and differences/limitations as it relates to much of the North American dairy industry. The three studies from Israel using low fat milk replacers containing non-milk protein in comparison to high levels of whole milk found a positive relationship (one a trend, two showed significant effects) between early life nutrition and milk production. One study reported a decrease in age at puberty and another of these reported a decreased age at first calving with the higher levels of nutrient intake before weaning. The differences in diet components being (by US standards) deficient in fat (12, 13, or 15% fat) of unknown fatty acid composition (Bar-Peled milk replacer contained animal and vegetable fat; fat sources were not described in the other papers) and questionable on protein level or amount of digestible protein (Moallem milk replacer contained 92% milk protein, sources of protein were not described in the other papers). These issues make for a complete confounding of nutrition when compared to high levels of whole milk containing 24 to 25% crude protein with highly digestible protein sources that are of high biological value for the calf. In addition, the milk diets contained 24 to 29% milk fat that is known to be highly digestible and of high value to the calf, which makes this diet comparison valid **ONLY** for these specific diets. **These studies do not imply that milk replacers used in the US are not adequate for feeding dairy calves or that changing to whole milk from milk replacer will by itself impact age at puberty, calving, or lactation.** These studies do imply that poorly formulated milk replacers fed at low rates (marginal compared to NRC (2001) nutrient requirements) might be detrimental to the productivity of the animal compared to adequate to high levels of whole milk. This same effect also has been shown in the past. High incidences of disease as well as inadequate housing, management, or nutrition in young calves can have long term negative effects on production.

The four peer-reviewed studies that directly compared milk replacers more typical in the US,

with similar protein and fat source quality, all met or exceeded NRC (2001) requirements for young calves. These studies compared levels of milk replacer fed and offer a more valid comparison of the real issue in question. These studies all showed that there were no significant effects of early nutrition on lactation performance, although the Michigan study observed a tendency for improved milk production if genetic variation was included in the analysis. In addition, there have been three abstracts published that compare similar milk replacer diets at different levels in systems done in or similar to those used in North America. Two of the three showed no effects of early nutrition on milk production. Two additional abstracts describe studies comparing different feeding rates of whole milk. Neither study found significant effects of higher feeding rate on milk production in the first lactation. **Therefore, based on multiple peer-reviewed publications conducted by separate research groups from around the world that represented university and industry groups working together, the results clearly show that there are no effects of a standard milk replacer feeding rate as compared to an accelerated milk replacer feeding rate on milk production.**

It is worth noting that increasing the feeding rate for young calves has been proven to improve growth rates and body condition of calves, particularly during the milk-feeding period. Detailed discussion of these results is beyond the scope of this review, but increasing milk replacer feeding rate can have positive impacts on calf growth with no negative impact on milk production later in life.

Calves on an accelerated feeding program must continue to be fed and managed well to maintain the growth advantage gained before weaning and to capitalize on that growth by conceiving and calving at an earlier age. However, research trials and experience on farms show that in many cases calves on an accelerated program lose their growth advantage after weaning, which calls into question the economic payback for the additional investment required for the program.

Summary of studies investigating effects of calf feeding program on first lactation milk production.

| Reference | Comparison | Effect on First Lactation Milk |
|---|--|---|
| <i>Peer-reviewed: milk replacer vs. milk replacer</i> | | |
| Morrison et al., 2009 | Conventional vs. intensified milk replacer | No effect on 305-d actual |
| Raeth-Knight et al., 2009 | Conventional vs. intensified milk replacer | No effect on 305-d ME |
| Terré et al., 2009 | Conventional vs. intensified milk replacer | No effect on 305-d actual |
| Davis Rincker et al., 2011 | Conventional vs. intensified milk replacer | No effect on projected 305-d Positive trend with genetic effect included in analysis |
| <i>Peer-reviewed: whole milk at high levels vs. milk replacer of poor quality</i> | | |
| Bar-Peled et al., 1997 | Suckled milk vs. milk replacer | Positive trend |
| Shamay et al., 2005 | Milk vs. milk replacer | No effect on 305-d actual Improved 3.5% FCM |
| Moallem et al., 2010 | Milk vs. milk replacer | Improved 305-d actual Improved 4% FCM |
| <i>Abstracts</i> | | |
| Ballard et al., 2005 | Conventional vs. intensified milk replacer | No effect on 3.5% FCM Improved actual at 200 DIM |
| Drackley et al., 2007 | Conventional vs. intensified milk replacer | Improved 305-d actual |
| Aikman et al., 2007 | Ad lib vs. restricted milk replacer | No effect |
| Foldager and Krohn, 1994 | Suckled milk vs. restricted milk | No effect on milk or energy-corrected milk at 250 DIM |
| Foldager et al., 1997 | Ad lib vs. restricted milk | Trend for improved daily milk |

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