

Feed Additives—the Good, the Bad, and the Useless

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■ Take Home Messages

- ▶ Dairy managers must evaluate each feed additive based on the “four R” approach: anticipated response, economic return, available research, and field responses.
- ▶ Feed manufacturers should add an additional “three Rs” when selecting feed additives: reliability, repeatability, and relativity.
- ▶ Each dairy manager must evaluate the choices of available feed additives and determine if a product is warranted.

■ Introduction

Feeding high producing cows continues to challenge dairy farmers and nutritionists. Also, dairy profit margins vary as milk prices and feed costs shift yearly. Feed costs represent the largest input cost to producing milk (estimated to be 35 to 50 percent). Feed additives are a group of feed ingredients that can cause a desired animal response in a non-nutrient role such as pH shift, growth, or metabolic modifier (Hutjens, 1991). Several feed additives contain nutrients such as sodium in sodium bicarbonate or protein in yeast culture. Feed additives are not a requirement or guarantee for high productivity or profitability.

■ Evaluating Feed Additives at the Farm Level (4 R’s)

Four factors can be considered to determine if a feed additive should be used: anticipated response, economic return, available research, and field responses (Hutjens, 1991). Response refers to the performance changes the user could expect or anticipate when a feed additive is included.

Several examples are listed below:

- Higher milk yield (peak milk and/or milk persistency)
- Increase in milk components (protein and/or fat)
- Greater dry matter intake
- Stimulate rumen microbial synthesis of protein and/or volatile fatty acid (VFA) production
- Increase digestion in the digestive tract
- Stabilize rumen environment and pH
- Improve growth (gain and/or feed efficiency)
- Minimize weight loss
- Reduce heat stress effects
- Improve health (such as less ketosis, reduce acidosis, or improve immune response)

Returns reflect the profitability of using a selected additive. If milk improvement is the measurable response, a breakeven point can be calculated. For example, a consultant recommends an additive that raises feed cost 10¢ per day. If milk is valued at 12¢ per 0.45 kg, every cow must produce 0.38 kg more milk to cover the added cost associated with the additive. Another consideration is if all cows receive the additive, but only cows fresh less than 100 days respond. Responding cows must cover the additive costs for all cows (responsive and non-responsive cows). One guideline is an additive should return two dollars or more for each dollar invested to cover non-responsive cows and field conditions that could minimize the anticipated response.

Research is essential to determine if experimentally measured responses can be expected in the field. Studies should be conducted under controlled and unbiased conditions, have statistically analyzed results (determines if the differences are repeatable), and have been conducted under experimental designs that would be similar to field situations.

Results obtained on individual farms are the economic payoff. Dairy managers and nutritionists must have data to compare and measure responses. Several tools to measure results (to evaluate responses on a farm) include DHI milk records (peak milk, persistency, milk components, and milk curves), reproductive summaries, somatic cell count data, dry matter intake, heifer growth charts, body condition graphs, and herd health profiles that will allow critical evaluation of a selected additive.

■ **Evaluating Feed Additives at the Industry Level (7 R's)**

Feed industry personnel and consultants may evaluate feed additives using a slightly different approach; the seven “R’s including the basic four R’s as listed above plus reliability, repeatability, and relativity. Reliability is based on the research data base that has been published on a feed additive.

- ▶ the ability to predict that the product can have a positive response in a wide range of feeding conditions
- ▶ establish a normal curve of response in various studies
- ▶ minimize the risk of not obtaining a positive benefit to cost ratio.

Repeatability represents the statistical data results (mean and standard deviation). Each feed consultant must determine what level of risk she or he will assume when selecting each feed additive. The bottom line is the probability of a profitable response. Relativity refers to other products, management changes, or on-farm practices that could replace the feed additive being used. For example, an anionic product could be removed if the nutritionist could reduce close-up ration levels of potassium to less than one percent, adapt a “no dry period” for third and over lactation cows, and/or drench each third lactation cow with a calcium gel product.

A second aspect of industry selection of a feed additive is which commercial product should be purchased. “Me too syndrome” is a term referring to products that have limited research and results, but are marketed on the concept that their products are identical to the industry-base standard. One example is sodium bicarbonate, a chemical defined product that has no unique processing to make it more soluble or rumen active vs. inert.

■ **A Look at New Research and Products**

Direct Fed Microbial Products (DFM)

The concept of DFM involves the feeding of beneficial microbes to dairy cattle when they are under stress (disease, ration changes, environmental, or production challenges). Probiotics is another term for this category of feed additives used as a means to reduce the need and role of antibiotics for improved animal performance. In this section, we will evaluate bacterial additives (not fungal or yeast-based products).

The proposed mechanisms for improvement in dairy cattle performance when feeding DFM are outlined below:

- ▶ Production of antibacterial compounds (acids, bacteriocins, or antibiotics)
- ▶ Compete against undesirable organisms for nutrients or colonization of the digestive tract (competitive exclusion)
- ▶ Nutrient production or other growth factors
- ▶ Stimulate production of enzymes or natural bacteria
- ▶ Metabolize or detoxify undesirable compounds (lactic acid)
- ▶ Stimulate the immune system

Several studies that have reported positive effects used a combination of several microbial species (Table 1). The mode of action and dosage are listed in Table 2. *Lactobacillus acidophilus* produces lactic acid that may lower the pH in the small intestine inhibiting undesirable microbes. Calves that have been stressed (weaning, scouring, and shipping challenges) have responded to large doses of *Bifidobacterium*, *Enterococcus*, *Bacillus*, and *Lactobacillus*. *Megasphaera elsdenii* is a major lactate utilizing organism in cattle fed high grain diets. Feedlot producers have used DFM to adapt cattle to high energy diets reducing lactic acidosis. Applications in high producing cows are being explored in the field. *Propionibacteria* have the ability to convert lactic acid and glucose to acetic and propionic acid improving the energy status of early lactation cows. Similar results have been reported in beef cattle with improved feed efficiency. This group of bacteria can reduce nitrate levels as they are nitrate users.

DFM products must be live to impact rumen or lower gut fermentation. Thus, viability and number must be guaranteed at the time of feeding along with the desired organism. DNA figure printing continues to offer an approach to select the optimal strain of organism based on controlled research results. Some products guarantee levels as cfu (colony forming units) per gram.

The method of delivery also varies from powders, pastes, boluses, and capsules using feed or water as carriers. If water is used, chlorination, temperature, minerals, flow rates, and antibiotics must be considered to avoid killing or reducing the effectiveness of the DFM. With the approved use of monensin, gram positive DFM products may be less effective. Producers and nutritionists need to ask for controlled studies with DFM and monensin. Other products require a higher dosage to “seed down” the digestive tract for several days followed by a maintenance daily feeding rate.

The ability of DFM to survive feed processing, especially pelleting, must be determined, as well as viability during prolonged feed storage, and impact when mixed with low pH silages for several hours. Viability of DFM products has improved by following directions from the manufacturer concerning heat, oxygen exposure, and moisture.

Table 1. Effects of bacterial DFM on dry matter intake, milk yield, and milk composition in lactating dairy cows in five studies (Krehbiel et al. 2003).

Treatment	number	Milk (kg/day)	Fat (%)	Protein (%)	DMI (kg)
Control	16	29.1a	3.81	3.34	na
<i>L. acidophilis</i> (BT1386)	16	30.9b	3.75	3.36	na
Control	550	31.8a	3.64	na	21.2
<i>L. acidophilis</i> (BT1386)	550	33.6b	3.63	na	21.4
Control**	6	8.2 a	3.30a	3.09	na
Yeast culture	6	9.34b	3.96b	3.15	na
<i>L. acidophilis</i> + yeast culture	6	9.28b	3.57b	3.13	na
Control	32	48.2	na	3.01a	24.6
Yeast + <i>L. plantarum</i> and <i>E. faecium</i>	32	49.1	na	3.27b	25.1
Control	100	38.8	4.24	3.02	25.0a
<i>L. acidophilis</i> , <i>L. casei</i> , <i>E. faecium</i> + Mannanoligosaccharide	100	39.6	4.34	3.04	24.6b

ab means in columns differ (P , 0.05)

** Tropical feeding conditions

At this time, most nutritionists are “cautious” when adding DFM. The success in the field with milk fed calves seems to warrant the addition of DFM until dry matter intake of starter is over two pounds per calf per day. The addition of DFM to drench products, fed to cows off-feed, animals that received high levels of antibiotics to treat a disease, and dairy cattle under stress may be warranted. At this point, ask for controlled data on the response to DFM products, evaluate the type and number of microbes added, and follow handling guidelines.

Table 2. Bacteria with potential use as DFM (Kung, 2001).

Source	Strain	Dose	Effect
<i>Megasharera elsdenii</i>	B159 407A	8.7x 10 ⁶	Prevent lactic acidosis when diets change to higher fermented CHO
<i>Lactobacillus acidophilus</i>	na	1 x 10 ⁹	Increase milk yield when feed intake depressed and under Stress
<i>Propionibacteria</i> P-63 and <i>L. acidophilus</i> 5345	na	1 x 10 ⁹ 1 x 10 ⁸	Improve feed efficiency during adaptation to higher CHO diets
<i>Propionibacterium Freudenreichii</i> and <i>L. Acidophilus</i> (B2FFO4)	na	1 x 10 ⁹ 1 x 10 ⁸	Improve feed efficiency
<i>Propionibacterium acidipropionici</i>	DH42	1 x 10 ⁹	Increase propionic acid
<i>Propionibacterium freudenreichii</i> plus lactobacilli	na	na	Improve weight gain in calves

Biotin

Biotin has been associated with formation of hoof horn. Deficiency signs in calves include soft hooves, skin lesions, and hair loss. In swine and horses, a deficiency has resulted in cracks and fissures in the foot and toe. Biotin is required by ruminants and is synthesized by rumen bacteria. If rations are high in concentrate, the synthesis of biotin in the rumen is reduced due to the acid environment and shift in rumen microbes. Recent studies with beef and dairy cattle fed supplemental biotin are summarized below (Seymour, 1998).

- ▶ White line separation was reduced by 17 percent (27 vs. 10 percent) in the rear lateral claw and 18 percent (20 vs. 2 percent) in the rear medial claw when 20 mg of biotin was fed to first lactation Holstein cows after 100 days of supplementation.
- ▶ Sole ulcers were reduced in 180 dairy cows receiving 10 mg per day of

biotin by 2.6 percent (3.3 vs. 0.7 percent) compared to unsupplemented cows after 24 months of supplementation.

- ▶ Heel warts were reduced 20.2% (after 11 months) to 37.3% (after 4 months) in 56 dairy cows fed 20 mg of supplemental biotin per head per day during an 11 month study.
- ▶ Claw lesions (236 claws in 160 cows in 82 dairy herds) were improved and short term healing was enhanced when 20 mg of biotin were fed per day. Plasma biotin concentrations were correlated with faster new horn formation over lesions in biotin-supplemented cows.
- ▶ Vertical fissures or sand cracks were reduced 15.1 percent (29.4 verses 14.3) in 265 Hereford cows fed 10 mg per cow per day. Biotin-supplemented cows were 2.5 times less likely to develop sand cracks compared to unsupplemented cows.

Besides the improvement in foot health, an Ohio study reported 314 kilograms more milk (11,794 kg in control cows vs. 12,108 kg in biotin-supplemented cows) ($P < 0.05$). In another study, biotin supplemented cows experienced fewer days to conception (116 vs. 99) and services per conception (3.02 vs. 2.69). In a second Ohio State study, a milk increase of 2.3 kilograms of milk per day was reported suggesting the role of biotin may enhance a metabolic route mediated by enzymes, increased glucose synthesis, and/or improved fiber digestion (Weiss and Zimmerman, 2000).

The recommended level for biotin supplementation is 10-20 mg per day starting at 15 months of age for heifers. Cows should be supplemented with 20 mg per day throughout lactation and 10 mg per day during the dry period. Target animals include chronic hoof problem cows, high producing cows, cows fed high grain rations, and heifers from breeding to calving. The cost is typically 8 to 10 cents per cow per day. The benefit to cost ratio is 3:1 based on a milk yield increase of two kilograms. The economics is more favorable if reproduction improves and lameness is reduced. Foot-related response to biotin supplementation may take several months before changes and improvements occur.

Protected Choline

Choline is usually classified as a B vitamin, but does not fit in the traditional role of a vitamin. Its roles in dairy nutrition include minimizing fatty liver formation, improving neurotransmission, and serving as a methyl donor. The lack of response to dietary choline is due to extensive rumen degradation estimated to be 85 to 95 percent of supplemental choline. When choline was infused postruminally (15 to 90 grams per day), the average milk response to choline was 1 kg milk per day, 0.17 percent fat, and 1.5 kg fat corrected milk per day (Erdman, 1990). The primary mechanism of interest in dairy cows is choline's effect on triglyceride transfer from the liver, especially in early

lactation when free fatty acids from adipose tissue are mobilized and formed into lipoproteins requiring a methyl donor (Erdman, 1990). Choline could also spare methionine (10g of choline would provide the equivalent methyl groups found in 44g of methionine). Diets low in methionine may be improved by adding 30g of rumen-protected choline (Grummer et al, 1987). Choline is more difficult to protect in the rumen than amino acids because it is extremely hygroscopic.

Recently sources of rumen-protected choline have been manufactured by encapsulation and fat coating. Cornell workers have reported rumen-protected choline significantly reduced NEFA conversion to stored triglyceride and increased glycogen in livers of dairy cows at calving and in early lactation (Overton et al, 2000). These metabolic changes can reduce the risk of clinical ketosis. New York field studies have also measured an average increase of 2.2 kg of milk per cow per day during the postpartum feeding period. One commercial product is fed at the rate of 15 gram of protected choline (in a 60 gram encapsulated product) starting 21 days prepartum to 50 days postpartum at a cost of 30 cents per cow per day. Improved encapsulation allows protected choline to be mixed with dry feed ingredients without loss of protection.

Ionophores

Monensin (brand name is Rumensin) and lasalocid (brand name of Bovatec) are antibiotics that can change rumen fermentation patterns (higher propionic acid and less methane) by reducing gram positive bacteria. The initial research was conducted with beef cattle. In trials with monensin involving dairy animals, growth improvement ranged from 6 to 14 percent with no negative effects on reproduction, calving ease, or calf size. Pennsylvania data indicated heifers calved 38 days earlier due to improved growth and feed efficiency resulting in a savings of \$62. The cost of monensin was 1.2¢ per day or \$5 per animal resulting in a benefit to cost ratio of 12:1 (Hutjens, 1991). Both ionophores are labeled as a coccidiostats in growing heifers. The mode of action for ionophores includes a shifting of VFA and methane production in the rumen favoring growth and feed efficiency, sparing dietary protein, and changing rumen fill and rate of passage. The benefit of ionophores as a coccidiostat would improve growth and health in young animals. In Canada, monensin has been cleared for lactating and dry cows and a 50 percent decrease in subclinical ketosis has been reported (Duffield et al, 1998). Levels varied from 8 to 24 mg per kg of dry matter (300 to 350 milligrams per cow per day). Dry matter intake is modestly decreased (< 1 kg) with milk slightly increased (<1 kg of milk) as reported by Canadian workers (Symanowski et al, 1999).

With the FDA clearance to use monensin for dry and lactating dairy cows, dairy managers have a new tool to improve feed efficiency and herd health.

Table 3 is a summary of nine studies in the U.S. and Canada including 357 first lactation cows (primiparous) and 609 second and great lactation cows (multiparous) starting 21 days prepartum through the entire lactation. The following points should be considered by dairy managers, nutritionists, and veterinarians.

- Efficiency of milk production increased 2 to 4 percent with recommended level of 11 grams to 22 grams per ton of total ration dry matter (TMR) on a dry matter basis.
- With higher milk yield and lower components at higher levels, the amount of solids-corrected milk did not change.
- Dry matter intake did not change in early lactation and dropped in the later stages of lactation.
- Body weight was not different between controls and supplemented cows.
- The benefit to cost ratio for monensin for lactating cows was 5 to 1.

Table 3. Summary of effectiveness of monensin by level (nine studies).

Level of monensin (g/ton)	Control	11	15	22
Dry matter intake (kg/day)	19.9	19.8	19.4	19.2
Milk yield (kg/day)	29.5	30.3	30.4	30.7
Milk fat (%)	3.65	3.53	3.49	3.38
Milk protein (%)	3.15	3.13	3.13	3.10
Solids corrected milk (kg)	26.5	26.6	26.4	26.4
3.5% FC milk (kg)	30.0	30.4	30.3	30.0
Imp milk efficiency (%)	control	+ 2.0	+2.5	+4.0

Based on these data and Canadian research results, monensin should be fed to dry cows (250 mg per day) reducing displaced abomasum, increasing glucose precursors that lower ketosis risk, and allowing better transition of dry cows. Lactating cows should receive monensin to increase feed efficiency, reduce methane losses, improve protein status, and reduce bloat risk for cows on pasture. Growing heifers should be fed 60 to 200 mg per day (depending on body weight) to improve feed efficiency and reduce the risk of coccidiosis.

■ Conclusions

Interest in feed additives will continue and will be influenced by new research results, advertising, and profit margins. Table 4 outlines additives in six categories that will assist dairy farmers, consultants, feed company nutritionists, and veterinarians in deciding if an additive should be included. Current status is classified in the following ways:

- ▶ Recommended: Include as needed
- ▶ Experimental: Additional research and study are needed
- ▶ Evaluative: Monitor on individual and specific situations
- ▶ Not recommended: Lacks economic responses to currently use.

Table 4. Feed additive guidelines for dairy cows.

Anionic salts and products

1. Function: Cause the diet to be more acidic increasing blood calcium levels by stimulating bone mobilization of calcium and calcium absorption from the small intestine
2. Level: Reduce DCAD to -50 meq/kg using chloride sources (calcium chloride, ammonium chloride, Bio Chor, Animate, Soy Chor 44, Soy Chor 16, Nutro Clor, and hydrochloric acid treated feeds)
3. Cost: 40 to 75 cents per dry cow per day depending on product used
4. Benefit to Cost Ratio: 10:1
5. Feeding strategy: Feed to dry cows two to three weeks before calving. Adjust dietary calcium levels to 150 g per day (50 g inorganic). Raise dietary magnesium levels to 0.4 percent.
6. Status: Recommended

Aspergillus oryzae

1. Function: Stimulate fiber-digesting bacteria, stabilize rumen pH, and reduce heat stress.
2. Level: 3 g per day
3. Cost: 3 cents per cow per day
4. Benefit to Cost Ratio: 6:1
5. Feeding Strategy: High grain diets, low rumen pH conditions, and under heat stress (cows) and calves receiving a liquid diet
6. Status: Evaluative

Biotin

1. Function: Improve hooves by reducing heel warts, claw lesions, white line separations, sand cracks, and sole ulcers and increase milk yield through a metabolic route
2. Level: 10 to 20 milligrams per cow per day for 6 months to one year
3. Cost: 8 to 10 cents per cow per day
4. Benefit to Cost Ratio: 4:1
5. Feeding Strategy: Herds with chronic foot problems may require supplementation for 6 months before evaluation, and company recommends beginning supplementation at 15 months of age.
6. Status: Recommended

Beta-carotene

1. Function: Improve reproductive performance, immune response, and mastitis control
2. Level: 200 to 300 mg per day
3. Cost: 30 cents per cow per day
4. Benefit to Cost Ratio: Not available
5. Feeding Strategy: In early lactation and during mastitis-prone time periods
6. Status: Not recommended

Calcium propionate

1. Function: Increase blood glucose and calcium levels
2. Level: 120 to 225 grams
3. Cost: 80 cents per 454 grams
4. Benefit to cost ratio: Not available
5. Feeding Strategy: Feed 7 days prepartum to 7 days postpartum or until appetite responds; unpalatable
6. Status: Recommended

Protected choline

1. Function: A methyl donor used to minimize fatty liver formation and to improve fat mobilization
2. Level: 15g per day
3. Cost: 30 cents
4. Benefit to Cost Ratio: 2:1 (when protected)
5. Feeding Strategy: Feed two weeks prepartum to eight weeks postpartum to cows experiencing ketosis, weight loss, and high milk yield
6. Status: Recommended (rumen protected)

Enzymes

1. Function: Increase fiber digestibility by reducing fiber (cellulase and xylanase enzymes) and DM intake
2. Level: Not clearly defined (enzymatic units per unit of feed dry matter)
3. Cost: 15 to 25 cents per cow per day
4. Benefit to Cost Ratio: 2 to 3:1 (Canadian data)
5. Feeding Strategy: Increase fiber digestibility, treated 12 hours before feeding, spray on product more effective when applied to dry diets, and may be diet specific
6. Status: Experimental

Magnesium oxide

1. Function: Alkalinizer (raises rumen pH) and increases uptake of blood metabolites by the mammary gland raising fat test
2. Level: 45 to 90 g per day

3. Cost: 21 cents per pound
4. Benefit to Cost Ratio: Not available
5. Feeding Strategy: With sodium-based buffers (ratio of 2 to 3 parts sodium bicarbonate to 1 part magnesium oxide)
6. Status: Recommended

Methionine hydroxy analog

1. Function: Minimize fatty liver formation, control ketosis, and improve milk fat test
2. Level: 30 g per cow per day
3. Cost: \$1.60 per 454 grams
4. Benefit to Cost Ratio: 2:1
5. Feeding Strategy: Feed to cows in early lactation receiving high levels of concentrate and limited dietary protein
6. Status: Evaluative

Monensin

1. Function: Improve feed efficiency for lactating cow, reduce ketosis and displaced abomasums in transition cows by shifting rumen fermentation and microbial selection
2. Level: 11 g to 22 g per ton of total ration dry matter consumed (250 to 400 mg / cow / day)
3. Cost: 3 cents per cow per day
4. Benefit to Cost Ratio: 5 to 1
5. Feeding Strategy: Feed to dry cows (reduce metabolic disorders) and lactating cow (feed efficiency) while monitoring milk components to evaluate optimal levels of monensin.
6. Status: Recommended

Niacin (B₃, nicotinic acid, and nicotinamide)

7. Function: Coenzyme systems in biological reactions, improve energy balance in early lactation cows, control ketosis, and stimulate rumen protozoa
8. Level: 6 g per cow (preventive and prepartum) and 12 g per cow (treatment and postpartum) unprotected, 2 to 3 grams protected
9. Cost: One cent per gram (6 to 12 cents per cow per day) unprotected, 10 to 12 cents protected
10. Benefit to Cost Ratio: 6:1 (6 grams level)
11. Feeding Strategy: High producing cows in negative energy balance, heavy dry cows, and ketotic-prone cows fed two weeks prepartum to peak dry matter intake (10-12 weeks postpartum)
12. Status: Evaluative

Probiotics (Bacterial direct-fed microbes)

1. Function: Produce metabolic compounds that destroy undesirable organism, provide enzymes improving nutrient availability, or detoxify harmful metabolites
2. Level: Not clearly defined
3. Cost: 5 to 15 cents per cow per day
4. Benefit to Cost Ratio: Not available
5. Feeding Strategy: Feed to calves on liquid diet, transition cows, and during stress conditions
6. Status: Evaluative for cows; recommended for milk fed calves

Propylene glycol

1. Function: Source of blood glucose, stimulate an insulin response, and reducing fat mobilization
2. Level: 225 to 454 grams per cow per day
3. Cost: \$1.25 per 454 grams
4. Benefit to Cost Ratio: Not available
5. Feeding Strategy: Drench cow starting at one week prepartum (preventative role) or after calving when signs of ketosis are observed (treatment role). Feeding is not as effective as drenching.
6. Status: Recommended

Silage bacterial inoculants

1. Function: To stimulate silage fermentation, reduce dry matter loss, decrease ensiling temperature, increase feed digestibility, improve forage surface stability, and increase VFA (lactate) production
2. Level: 100,000 colony forming units (CFU) per gram of wet silage. Recommended bacteria include *Lactobacillus plantarium*, *Lactobacillus buchneri*, *Lactobacillus acidilacti*, *Pediococcus cereviseai*, *Pediococcus pentacoccus*, and/or *Streptococcus faecium*.
3. Cost: \$0.60 to \$2.00 per treated ton of silage
4. Benefit to Cost Ratio: 3:1 (feed recovery) to 7:1 (milk improvement)
5. Feeding Strategy: Apply to wet silage (over 60 percent moisture); corn silage, haylage, and high moisture corn; low natural bacteria counts (first and last legume/grass silage and frost damaged corn silage); and under poor fermentation situations
6. Status: Recommended

Sodium bentonite

1. Function: A clay mineral used as a binder, shifts VFA patterns, slows rate of passage, and exchanges mineral ions. Field claims to tie up mycotoxins have been reported
2. Level: 450 to 700 g per day (rumen effect), 110 grams for mycotoxin effect
3. Cost: 15 cents per 454 grams
4. Benefit to Cost Ratio: Not available

5. Feeding Strategy: With high grain diets, loose stool conditions, presence of mold, low fat test, and dirt eating
6. Status: Evaluative

Sodium bicarbonate/sodium sesquicarbonate (buffer)

1. Function: Increase dry matter intake and stabilize rumen pH.
2. Level: .75 percent of total ration dry matter intake
3. Cost: 6¢ per cow per day (bicarb = \$0.19/454 grams; S Carb = \$0.18/454 grams)
4. Benefit to Cost Ratio: 4:1 to 12:1
5. Feeding Strategy: Feed 120 days postpartum with diets that are high in corn silage (over 50%), wet rations (over 55% moisture), lower fiber ration (<19% ADF), little hay (<2.2 kg), finely chopped forage, pelleted grain, slug feeding, and heat stress conditions.
6. Status: Recommended

Yeast culture and yeast

1. Function: Stimulate fiber-digesting bacteria, stabilize rumen environment, and utilize lactic acid.
2. Level: 10 to 120 g depending on yeast culture concentration
3. Cost: 4 to 6 cents per cow per day
4. Benefit to Cost Ratio: 4:1
5. Feeding Strategy: Two weeks prepartum to ten weeks postpartum and during off-feed conditions and stress
6. Status: Recommended

Yucca extract

1. Function: Decrease urea nitrogen in plasma and milk by binding ammonia to the glycofraction extract of Yucca shidigera plant improving nitrogen efficiency in ruminant animals.
2. Level: 800 milligrams to 9 grams per day (depending on source)
3. Cost: 2 to 4 cents per cow per day (\$1.28/ 454 grams for Micro Aid 1X)
4. Benefit to Cost Ratio: Not available
5. Feeding strategy: To cows with high BUN and MUN levels
6. Status: Evaluative

Zinc methionine

1. Function: Improve immune response, harden hooves, and lower somatic cell counts.
2. Level: 9 g per day (Zinpro 40 trademark product)
3. Cost: 2 to 3 cents per cow per day
4. Benefit to Cost Ratio: 14:1
5. Feeding Strategy: To cows experiencing foot disorders, high somatic cell counts, and wet environment
6. Status: Recommended

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