FEED ADDITIVES IN DAIRY NUTRITION AND MANAGEMENT

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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 produce milk (estimated to be 35 to 50 percent). Goals of a successful feeding program are:

- Optimize milk yield
- Produce desirable milk components
- Maximize rumen microbial yield
- Stimulate dry matter intake
- Produce key nutrients for mammary gland synthesis

Table 1: Feed additives used in diets fed to high producing herds in 1992 compared to 1983.

Additive	------% Report -----	
	1992	1983
Sodium bicarbonate	75	70
Magnesium oxide	66	na
Yeast/Yeast culture	51	17
Niacin	38	16
Zinc methionine	48	na
No additives	na	10

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. A survey of 61 managers of high producing US herd in 1992 (averaging 11099 kg of milk, 396 kg of milk fat, and 347 kg of milk protein) revealed variable use of feed additives (Table 1; Jordan and Fourdraine, 1993) compared to an earlier survey of top herds. Feed additives are not a requirement or guarantee for high productivity or profitability.

Evaluating Feed Additives

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 expected performance changes the user could anticipate when a feed additive is included. They include:

- 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 (Table 2). 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 .45 kg, every cow must produce .375 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 which could minimize the anticipated response.

Table 2: Required increase in milk yield to recover various additive costs with different milk prices.

Additive Cost ($/cow/day)	Milk price ($/45 kg) 10	12	14
	Kilograms of milk / cow / day		
.02	.1	.1	.05
.06	.3	.2	.2
.10	0.5	.4	.3
.30	1.3	1.1	1.0

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, which will allow critical evaluation of a selected additive, 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.

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 verse 10 percent) in the rear lateral claw and 18 percent (20 verse 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 verse 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) percent 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 verse 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 versus 12,108 kg in biotin-supplemented cows; $P < 0.05$). In another study, biotin supplemented cows experienced fewer days to conception (116 verse 99) and services per conception (3.02 verse 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 Zimmerly, 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 problems 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, .17 percent fat, and 1.5 kg per day fat corrected milk (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. Careful handling of the product is required to avoid damage to the encapsulated product.

Anionic Salts and Products

Anionic salts and products (ammonium chloride, ammonium sulfate, aluminum sulfate, magnesium sulfate, calcium chloride, and commercial acid treated feeds) cause rations to be more acidic, increasing absorption of dietary calcium and stimulating mobilization of bone calcium due to improvement in parathyroid hormone receptor sites (NRC, 2001). When more calcium is available, the cow is able to maintain blood calcium levels caused by the calcium drain due to milk synthesis. Canadian workers (Block, 1984) reported 48 percent milk fever when cationic (control) diets were fed and no milk fever with anionic diets. Colorado researchers (Oetzel et al., 1988) reported a 13 percent decrease (from 17 to 4 percent) in milk fever when cows received anionic salts with calcium intakes as high as 150 grams per day. Feeding 100 grams of ammonium chloride and 100 grams of magnesium sulfate for 2 to 3 weeks prepartum has resulted in favorable responses reducing milk fever and hypocalemia, lowering retained placenta, and increasing dry matter intake postpartum (Beede et al., 1991). Anionic salts are unpalatable; therefore they should be mixed with 1 to 2 kg of a palatable carrier (such as distillers grain, molasses, or heated soybeans) and pelleted to avoid separation (Oetzel et al., 1988). Additional research is needed to determine optimal combinations of anionic salts, levels, and length of feeding.

Monitoring urine pH is an effective way to determine if adequate levels of anionic products are being consumed relative to dietary potassium levels (Jardon, 1995). Target values for Holsteins are a pH from 6.2 to 6.8. For Jerseys, a pH from 5.5 to 6.0 may be needed for optimal response. If urine pH is over 7, the benefit of anionic products is not occurring. If urine pH is too low, excessive metabolic acidosis is occurring which can lead to kidney and health problems.

Recently chlorine sources of anionic salts have proven to be more aggressive acidifiers compared to sulfates when monitoring urine pH. Hydrochloric acid (sprayed on feed) improves feed palatability compared to salts, while reducing urine pH. Several commercial products (Appendix 1) are available with field reports of improved palatability.

Ionophores

Monensin (common brand name is Rumensin®) and lasalocid (common 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 coccidiostats in growing heifers. The mode of action for ionophores includes:

- 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 as a coccidiostat 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). Canadian workers reported dry matter intake was modestly decreased (< 1 kg) while milk slightly increased (<1 kg of milk; Symanowski et al., 1999)

Yeast Culture

Yeast culture is a live culture of yeast (a fungi) and the media on which it was grown and dried so as to preserve the yeast's fermenting capacity. Several other types of yeast products are available from fermentation processes (such as brewer's and distiller's yeast). A summary of 7 yeast studies concluded cows fed yeast averaged 25.1 kg of 4% FCM compared to control cows at 23.5 kg (Hutjens, 1991). Early lactation cows had a significant increase in milk yield, while mid lactation cows had no response (Harris and Lobo, 1988). Milk composition (fat and protein levels) response is also variable. Illinois (Dann et al., 2000) and Canadian workers (Robinson and Garrett, 1999) have reported significant increases in dry matter intake when yeast culture was fed to transition cows, resulting in higher milk yields and less weight loss postpartum.

The main effect of yeast culture is to stabilize the rumen environment. Concentrations of cellulolytic and anaerobic bacteria were higher in *in vitro* and *in vivo* systems. Rumen pH has been elevated in some studies with yeast cultures, but pH changes are not consistent. A reduction in rumen lactic acid concentrations has been reported (Williams, 1989). Yeast cultures are being studied to determine mode of action, optimum level, and correct stage of lactation to feed. Early lactation (2 weeks prepartum to 4 weeks postpartum) appears to be an optimum time to feed yeast culture to stabilize the rumen environment as cows are shifted from dry cow to high-energy diets. Various forms and concentrations of yeast culture products are commercially available.

Zinc Methionine

Zinc methinione is a compound composed of zinc and methinione. The additive is resistant to degradation by rumen microbes. Zinc methionine was absorbed to a similar extent as zinc oxide, but zinc methionine appears to be metabolized differently after absorption with lower urinary excretion and slower rate of decline in plasma zinc (Spears, 1989). In eight lactation studies, somatic cell counts averaged 320,000 and 217,000; and milk yield was 30.3 and 31.9 kg for control and zinc supplemented cows, respectively (Kellogg, 1990). However, Ohio researchers found zinc methinione supplementation did not have an effect on wound healing, mastitis, immune response, or plasma zinc levels (Heinrichs et al., 1984). Zinc methinione has been reported in the field to harden hoof surfaces and reduce foot disorders. Several concentrations of zinc methionine are commercially available (feed labels must be checked to avoid excessive consumption).

Conclusions

Interest in feed additives will continue and will be influenced by new research results, advertising, and profit margins. Appendix 1 outlines additives in six categories to 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

Literature Cited

Beede, D. K., C. Wang, G. A. Donovan, L. F. Archbald, and W. K. Sanchez. 1991. Dietary cation-anion difference (electrolyte balance) in late pregnancy. *In* Proc. FL Dairy Prod. Conf. p. 1.

Block, E. 1984. Manipulating dietary anion and cation for prepartum dairy cost to reduce incidences of milk fever. J.Dairy Sci. 67:2939.

Dann, H.M., J.KI. Drackley, G.C. McCoy, M.F. Hutjens, and J.E. Garrett. 2000. Effects of yeast culture on prepartum intake and postpartum intake and milk production of Jersey cows. J. Dairy Sci. 83: 123.

Drackley, J.K. 1999. Biology of dairy cows during the transition period: the new frontier? J. Dairy Sci. 82:2259.

Downer, J. F, and K. R. Cummings. 1987. A ten-year review of lactation studies with sodium bicarbonate. J. Dairy Sci. 70 (Suppl 1): 198.

Duffield, T.F., D. Sandals, K.E. Leslie, K Lissemore, B.W. McBride, J.H. Lumsden, P. Dick, and R. Bagg. 1998. Efficacy of monensin for the prevention of subclinical ketosis in lactating cows. J. Dairy Sci. 81:2866

Erdman, R. A. 1988. Dietary buffering requirements of the lactating dairy cow. J. Dairy Sci. 71:3246.

Erdman, R. A. 1990. Choline nutrition in dairy cattle. *In* NFIA Nut. Inst. Proc. Kansas City, MO.

Grummer, R. R., L. E. Armentano, and M. S. Marcus. 1987. Lactation response to short-term abomasal infusion of choline, inositol, and soy lecithin. J. Dairy Sci. 70:2518.

Harris, B. Jr. and R. Lobo. 1988. Feeding yeast culture to lactating cows. J.Dairy Sci. 71 (Suppl 1):276.

Heinrichs, A. J., D. A. Todhunter, F. A. Murray, A. P. Grifo, Jr., J. H. Harrison, and H. R. Conrad. 1984. Zinc-methionine supplementation for dairy cows--a study of effects on plasma zinc, wound healing, mammary health, and immune response. Ohio State Res. Circ. 231.

Hutjens, M. F. 1991. Feed additives. Vet Clinics North Am.: Food Animal Practice. 7(2):525.

Jardon, P.W. 1995. Using urine pH to monitor anionic salt programs. Compend. Contin. Educ. Pract. Vet. 17:860.

Jaster, E. H. 1988. Nicotinic acid or nicotinamide for lactating dairy cows. *In* Proc. Degussa Tech. Symp. Atlanta, GA. p. 3.

Jordan, E. R., and R.H. Fourdraine. 1993. Characterization of the management practices of the top milk producing herds in the country. J. Dairy Sci. 76:3247.

Kellogg, D.W. 1990. Zinc methionine affects performance of lactating cows. Feedstuffs. 62:35.

Kung, L. Jr., and R.E. Muck. 1997. Animal responses to silage additives. *In* Silage: Field to Feedbunk. NRAES-99. p. 175

National Research Council. 2001. Nutrient Requirement of Dairy Cattle, 7th edition. National Academy Press. Washington, D.C. p. 192.

Oetzel, G. R., J. D. Olson, C. R. Curtis, and M. J. Fettman. 1988. Ammonium chloride and ammonium sulfate for prevention of parturient paresis in dairy cows. J. Dairy Sci. 71:3302.

Overton, T.R, M.S Piepenbrink, and M.R. Waldron. 2000. Interactions of liver metabolism and health in transition dairy cows. Cornell Nutrition Conf. Proc. Cornell Univ, p. 251.

Riddell, D., E. E. Bartley, and A. D. Dayton. 1981. Effect of nicotinic acid on microbial protein synthesis in vitro and on dairy cattle growth and milk production. J. Dairy Sci. 64:782.

Robinson, P.H., and J.E. Garrett. 1999. Effect of yeast culture on adaptation of cows to postpartum diets and on lactational performance. J. Anim. Sci. 77:988.

Rodes, L.M., and K.A. Beauchemin. 1998. Enzymes to enhance utilization of feed in dairy cows. Western Canadian Dairy Seminar Proc. Vol. 10. p. 167

Seymour, W.M. 1998. Role of biotin in ruminant nutrition examined. Feedstuffs. 70(19):14.

Schwab, C. G. 1983. Supplemental niacin for lactating dairy cows. *In* Proc. 24th New England Dairy Feed Conf. Concord, NH.

Sharma, B. K., and R. A. Erdman. 1984. In vitro degradation of choline from selected feedstuffs and choline supplements. J. Dairy Sci. 72:2772.

Skaar, T. C., R. R. Grummer, M. R. Dentine, and R. H. Stauffacher. 1989. Seasons effects on prepartum and postpartum fat and niacin feeding on lactating performance and lipid metabolism. J. Dairy Sci. 72:2028.

Spears, J.W. 1989. Zinc methionine for ruminants: relative bioavailability of zinc in labs and effect on growth and performance of growing heifers. J. Anim. Sci. 67:835.

Symanowski, J.T., H.B. Green, J.R. Wagner, J.I.D. Wilkinson, J.S. Davis, M.R. Himstedt, M.S. Allen, E. Block, J.J. Brennen, H.H. Head, J.J. Kennelly, J.N. Nielsen, J.E. Nocek, J.J. Vand Der List, and L.W. Whitlow. 1999. Milk production and efficiency of cows fed monensin. J. Dairy Sci. 82 (Suppl.1):75 (Abstr).

Weiss, W.P., and C. A. Zimmerly. 2000. Effects of biotin on metabolism and milk yield of dairy cows. Cornell Nutrition Conf. Proc. Cornell University. p. 22.

Williams, P. E. V. 1989. The mode of action of yeast culture in ruminant diets: A review of the effect on rumen fermentation patterns. *In* Biotech. Feed Ind. Alltech Tech. Fifth Proc. Lexington, KY. p. 65.

Appendix 1

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, Soy Chor 44, Soy Chor 16, Animate, 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: Not recommended

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: 3:1
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: Experimental

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 pound
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: 15 to 30 g per day
3. Cost: Not available
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: Experimental (rumen protected)

Enzymes (fibrolytic)

1. Function: Increase fiber digestibility by reducing fiber (cellulase and xylanase enzyemes) and dry matter 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 hydryoxy analog

1. Function: Minimize fatty liver formation, control ketosis, and improve milk fat test
2. Level: 30 g
3. Cost: 10 cents per cow per day ($1.60 per pound)
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 (unless protected)

Niacin (B_3, nicotinic acid, and nicotinamide)

1. Function: Coenzyme systems in biological reactions, improve energy balance in early lactation cows, control ketosis, and stimulate rumen protozoa
2. Level: 6 g per cow (preventive and prepartum) and 12 g per cow (treatment and postpartum)
3. Cost: One cent per gram (6 to 12 cents per cow per day)
4. Benefit to Cost Ratio: 6:1 (6 grams level)
5. 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)
6. Status: Recommended

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 stimulating an insulin response, reducing fat mobilization
2. Level: 8 to 16 ounces per cow per day
3. Cost: $1.25 per pint or pound
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 not as effective as drenching (does not cause insulin response)
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 pound
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/lb; S Carb = $0.18/lb)
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 45% moisture), lower fiber rations (<19% ADF), little hay (<5 lb), 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 lycofraction 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/ lb 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

7. Status: Recommended