Feed Enzyme and Direct Fed Microbial Workshop
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Introduction

- Generally these products are rumen stabilizers and enhancers
- Ruminal digestion declines about 4% with each incremental increase in intake above maintenance (NRC 1989). Thus, in high producing dairy cows, digestible energy of feeds is lower than observed in vitro. Rumen stabilizers help capture some of the potential energy that is lost due to rapid turnover rate, lower pH, and unstable ruminal populations.
- Many different products on the market
- With biological processes there will always be variability in response
- Improved rumen (and G.I.T.) function may or may not translate into increased productivity
- Some overlap in mode of action among these products. Questionable whether responses are additive.
- Key in selecting a product is to review the research results (make sure diet composition and animals are relevant)

Objective of Workshop

- Discuss the various types of products and identify when and if they are most likely to be effective (not to recommend individual products)

Feed Enzymes

What are ruminant feed enzymes?

- Concentrated sources of enzymes (enzymes are catalysts involved in biochemical processes)
- Source organisms usually fungi (mostly *Trichoderma longibrachiatum, Aspergillus niger, A. oryzae)* and bacterial (*Bacillus* spp.) origin
- Do not contain microbial cells, cells are removed from the fermentation and the enzymes are concentrated and purified
- Enzyme technology well accepted for poultry applications
- For ruminants, mainly concerned with fiber-degrading enzymes

Activity

- Enzyme units are measured as hydrolase activity (amylase, protease, cellulase, hemicellulase, xylanase, etc.)
- Enzyme activities are generally determined by measuring the rate of release of reducing sugars from pure substrates, with enzyme units expressed as the quantity of reducing sugars released per unit time per unit enzyme (i.e., :mol glucose min^{-1} ml^{-1}).
- No standardization among companies
- No minimum level of enzyme required to register product
- Relationship between enzyme activity and effectiveness of product poor

Delivery system/application method

- Product can be in liquid or granular form
- Most effective when diluted and applied (sprayed) onto the diet or component of the diet
- Least effective when provided as a granular topdress
- Enzymes are susceptible to heating (i.e, post-pelleting applications only)
- Typically more costly than other microbials ($0.05 to -$0.15/head/day?)
- Not many true enzyme products on the market for ruminants
- Many direct-fed microbials with residual enzyme activity are confused with enzymes

Mode of action

- Increase energy content of the diet by increasing fiber digestion
- Increase in the hydrolytic capacity of the rumen, act synergistically with rumen microbes
- Increased bacterial attachment, increased bacterial numbers
- Improve performance

When best to use

- Ruminant adult cows
- Cows in early lactation

- Cows in negative energy balance
- Poor forage quality
- Permits higher forage in the diet
- Cows in heat stress
- Still somewhat experimental, but tremendous potential benefits. Results product dependant and diet dependant. Need to use products that have been scientifically developed with in vivo testing.

Bacterial Direct-Fed Microbials (Probiotics)

What are bacterial DFMs?

- Sources of viable (live) bacteria
- From a range of source organisms including *Lactobacillus, Enterococcus, Streptocossus, Bifidobacterium, Propionibacterium, etc.*
- Bacterial cells that are removed from the fermentation

Activity

- Activity measured as microbial counts, colony forming units (cfu) per gram

Delivery system/application method

- Usually diluted with carrier
- Granular form, used as topdress or added to the diet daily
- Pastes and gels
- Little information comparing one-time dosing vs daily supplementation
- Heat susceptible (although *Bacillus* more stable)
- Dose: 10^6 to 10^{10}/head/day

Mode of action

- Original concept of DFM based on intestinal effects
- Help establish and maintain normal intestinal microorganisms
- Reduces establishment of enteropathogens, which cause diarrhea
- Compete with pathogens for sites of adherence on the intestinal surface
- Antibacterial effect (eg. lactobacilli produce hydrogen peroxide)
- Some evidence for immune response
- Some limited evidence for ruminal effects (reduce acidosis)
- *Propionibacterium* ferments lactate and glucose to acetate and propionate
- *Enterococcus* and *Lactobacillus* produce lactic acid

When best to use

- Reduce scours in neonatal calves (non-ruminant)
- Reduce morbidity in newly weaned calves in the feedlot
- During dietary transitions (close-up cows)

- Assist with adaptations
- During periods of stress
- After antibiotic therapy
- Less effective in adapted animals
- Limited research conducted with lactating dairy cows

Yeast

What is yeast?

- Yeast belongs to the plant group fungi
- Source organism mainly *Saccharomyces cerevisiae* (baker's yeast)
- Can survive and grow with and without oxygen
- Most commercial feed yeast products are either a) active dry yeast products, or b) yeast culture
- Active dry yeast products consist of dried yeast cells whish are extracted from the fermentation. The yeast is then blended with carriers.
- Yeast cultures contains both the residual yeast cells used in the fermentation, as well as the metabolites (ex. peptides, organic acids, etc.) the yeast produce. The entire fermented media is dried.

Activity

- Activity measured as microbial counts, colony forming units (cfu) per gram
- Pure (undiluted) yeast contains about 15 to 25 billion cells or colony forming units (cfu) per gram (1.5×10^{10}).
- Some debate over whether the yeast need to be live or just metabolically active.

Delivery system/application method

- Active dried yeast typically fed in lower amounts than yeast culture (i.e., 1-4 g/hd/d vs 20-60 g hd/d).
- Increased stability when vacuum packed to limit oxygen.
- Yeast cultures are less susceptible to heat and pelleting because they are fed mainly for their fermentation factors, not the yeast.

Mode of Action

- Mainly ruminal effects
- Increased fiber digestion
- Decreased lactate production, improved pH stability, reduced acidosis
- Changed VFA proportions (reduces methane)
- Removal of oxygen (toxic to cellulolytic organisms)
- Increased bacterial numbers
- Some post-ruminal effects that include binding of pathogenic bacteria (yeast cell membranes are a source of mannanoligosaccharides)

When best to use

- For adult ruminants
- During dietary transitions
- During periods of off-feed and stress
- In transition cows and early lactation cows
- Variability in response expected, but substantial body of research conducted indicating benefits of feeding yeast to lactating dairy cows

Fungal Extracts

What are fungal extracts?

- Fermentation extract, do not contain live cells
- Mainly produced from *Aspergillus oryzae*
- Are often by-products of another manufacturing processes

Activity

- No specific activities or activity measurements

Delivery system/application method

- Usually as dried fermentation extract on carrier (ie., wheat bran or wheat middlings)

Mode of Action

- Some studies show increased milk yield, increased rumen microbial growth, mode of action not clear

When best to use

- Lactating dairy cows in early lactation
- When not using yeast culture