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## Effect of Feeding a Viable Yeast Culture on Ruminal Fermentation Characteristics, Milk Production Response and Apparent Nutrient Digestibility in Holstein Cattle

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EFFECT OF FEEDING A VIABLE YEAST CULTURE ON  
RUMINAL FERMENTATION CHARACTERISTICS, MILK  
PRODUCTION RESPONSE AND APPARENT NUTRIENT  
DIGESTIBILITY IN HOLSTEIN CATTLE

by

Mohamed H. Shokair

A dissertation submitted in partial fulfillment  
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Animal Science

Approved:

UTAH STATE UNIVERSITY  
Logan, Utah

1988

## ACKNOWLEDGEMENTS

Special appreciation and gratitude go to many people who have contributed to the successful completion of this work. I am particularly indebted to my major advisor, Dr. Michael Arambel, for his unlimited advice, encouragement and patience through the course of this study. Thanks also to other members of the committee; Dr. George Stoddard, Dr. LeGrande Ellis, Dr. Ronald Canfield and Dr. Randall Wiedmeier for their helpful suggestions and advice.

Special appreciation and thanks goes to Dr. Jeffrey Walters for helping with the statistical analysis.

I would like to thank my friend Dr. Ali Chamam for his encouragement, assistance, and friendship. A special thanks goes to Barb Kent for her friendship and assistance when needed.

My deepest appreciation goes to my wife and children for their unselfish sacrifice, patience and encouragement during the course of my studies.

Mohamed H. Shokair

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## ABSTRACT

Effect of Feeding a Viable Yeast Culture on  
Ruminal Fermentation Characteristics, Milk  
Production Response and Apparent Nutrient  
Digestibility in Holstein Cows

by

Mohamed H. Shokair, Doctor of Philosophy  
Utah State University, 1988

Major Professor: Dr. Michael Arambel  
Department: Animal, Dairy and Veterinary Sciences

Four barren Holstein cows fitted with ruminal fistulas were assigned to each of two dietary treatments in a replicated 2 x 2 Latin square design. Treatments consisted of a basal ration and a basal ration plus 10g/d of a viable yeast culture (Saccharomyces cerevisiae). Cows were fed treatments for a 21-day adaptation followed by a 7-day collection period. Total ruminal bacteria, cellulolytic bacteria and protozoa were unaffected by treatment. Feeding the viable yeast culture significantly increased ruminal acetic acid and acetic/propionic ratio. Molar percentage of propionic, isobutyric, isovaleric and valeric acids and rumen ammonia-N levels were significantly reduced in cattle fed

added yeast culture. Liquid dilution and particulate rate of passage and total tract apparent nutrient digestibility were unaffected by treatment.

Eighteen Holstein cows in mid-lactation were allocated equally to one of two treatments based on stage of lactation and previous mean daily 2-week milk yield. Therefore, nine cows were allocated to each treatment. Treatments consisted of a basal ration and a basal ration plus 10g/d of yeast culture (Saccharomyces cerevisiae). Cows were fed total mixed rations for a 10-week period. In week 8, feed and fecal samples were collected twice daily for 3 days. Acid detergent fiber insoluble ash was used to determine total tract apparent nutrient digestibility.

Feeding mid-lactation dairy cows the viable yeast culture had no effect on mean daily dry matter intake. However, it tended to improve mean daily 3.5% FCM. Milk production efficiency was higher in lactating dairy cows supplemented with the viable yeast culture when compared to the nonsupplemented cows. Milk composition and overall mean body weights were unaffected by treatment. Total tract apparent nutrient digestibilities also were unaffected by treatment.

## INTRODUCTION

Highly productive ruminants, such as feedlot and lactating cattle in peak lactation are usually fed rations containing large amounts of cereal grains (40-80%) to increase the energy available for production (Clark et al., 1980). However, the structural carbohydrate portion of the ration is an important source of energy for the animal. Feeding high levels of grain results in decreased ruminal pH, decreased fiber digestibility, increased propionate production, decreased acetate propionate ratio and marked depression in milk fat content (Bauman et al., 1971; Stewart, 1977; Davis, 1979).

Feeding microbial cultures to ruminants appears to be useful in improving dry matter digestibility and structural carbohydrate digestion, milk production and increasing milk fat content. Phillips and Von Tungen (1984) reported improved rate of gain and feed efficiency in calves fed yeast culture. Hoyos et al. (1987) reported increased milk production and milk fat content in cows supplemented with a viable yeast containing Saccharomyces cerevisiae.

## OBJECTIVES

The objectives of this study were to: 1) determine the effect of supplemental viable yeast culture on apparent total tract digestibility and rumen fermentation characteristics of mature ruminants and 2) evaluate the effect of a supplemental viable yeast culture on DM intake milk yield, milk composition and apparent nutrient digestibility of lactating dairy cows.

## REVIEW OF LITERATURE

Most rations for highly productive ruminants, such as feedlot and peak lactation dairy cattle, contain large amounts of cereal grains (40-80%) to derive energy. However, digestion of the structural carbohydrate portion of the ration also is an important source of energy for the animal. Ruminants can utilize energy contained in the fibrous portion of the ration through the hydrolysis and metabolism of these compounds by the microorganisms inhabiting the rumen and lower part of the gastrointestinal tract. The main bacterial species inhabiting the rumen and capable of utilizing the structural carbohydrate (cellulose, hemicellulose) portion of the diet are Ruminococcus flavefaciens, Ruminococcus albus, Butyrivibrio fibrisolvens and Bacteroides rumenicola (Yokoyama and Johnson, 1988).

Ruminal digestion of feedstuffs differs from gastrointestinal digestion in three important aspects: (1) the quantity of structural carbohydrate (fiber) enzymes present, which in turn depends on the type of microbial population present in the rumen, (2) the action of the fiber-digesting enzymes depends upon the attachment of the enzyme to fiber particles or the closeness of the ruminal microbe to the fiber particle, and (3) the rate of fiber digestion is slower than the



rate of starch digestion by amylases of the small intestine (Mertens, 1979).

Characteristics of the digestive mechanisms of fibrous carbohydrates result in a reaction or series of reactions which proceed at a much slower rate and are affected by factors other than those involved in simple enzyme kinetics (Mertens, 1979). Factors such as low ruminal pH not only affect the cellulase kinetics but also alter cellulolysis by altering the rumen microbial populations sequential microbial digestion. Immediately after feeding, inoculating bacteria rapidly colonize the new feed particles. Presence of competing substrates such as starch or soluble carbohydrates can delay or reduce adherence of bacteria to the plant fibrous structure. Cell contents are rapidly solubilized and attacked (Owens and Goetsch, 1988; Cheng and Costerton, 1980).

Many bacteria adhere only to specific plant structures. Rapidly and easily digested mesophyll and phloem tissues are digested first, leaving the more resistant sclernchyma and xylem tissue (Akin, 1979; Akin, 1986; Akin and Amos, 1975).

The rate of nutrient solubilization and release varies with the chemical composition and physical structure of the plant. The digestion of starch by the digestive enzymes of the small intestine is simpler than

the digestion of fiber in the rumen, because the rate of hydrolysis of starch depends mainly on the concentration of the amylase enzyme and the substrate (starch).

Factors influencing fiber digestion can be divided into dietary and ruminal environment characteristics: dietary factors affecting fiber digestion, include chemical characteristics associated with the fiber itself such as lignin content and physical form associated with the major fiber components (Van Soest, 1982; Hoover, 1986). The physical form of fiber can be changed by processing and grinding, which affect digestibility. In addition to dietary factors, characteristics of the rumen environment affect fiber digestion (Mertens, 1979). Ruminal pH has one of the most profound effects upon fiber digestion. Salivation, rumination, feeding level and feeding of cereal grain all influence ruminal pH and thereby affect fiber digestion. The ruminal passage rate of feedstuff influences fiber digestion, especially at a higher feed intake, because there is competition between particulate rate of passage and fiber digestion (Van Soest, 1982).

#### The Effect of Ruminal pH on Fiber Digestion

Although many factors affect ruminal pH, the effect of ruminal pH on fiber digestion has been documented. Generally, as ruminal pH decreases fiber digestion

decreases. Terry et al. (1969) observed that fiber digestion in vitro was highest at pH 6.8 and fiber digestion fell markedly as pH decreased to 5.5. Stewart (1977) observed that cellulolytic activity, as measured by digestion of cotton yarn, was highest at pH 7.0 and declined as pH was reduced to 6.0. Slyter et al. (1966) and Esdale and Satter (1972) observed that lowering pH below 6.2 reduced ruminal acetate production. Slyter et al. (1970) observed that cellulolytic bacterial numbers were reduced when pH was below 6 in steers fed a high concentrate diet.

Altering ruminal pH has a dramatic effect on the type of rumen microbe and its metabolic end products produced. As ruminal pH decreases below 6.2 there is a significant increase in propionic acid production, resulting in an increased molar proportion of propionic acid in the rumen (Esdale and Satter, 1972).

#### Factors Affecting Ruminal Digesta Passage Rate

Ruminal output or flow to omasum divided by ruminal volume gives the fractional passage rate. For liquids this is often called "dilution rate," and for solid particles the particulate rate of passage. Liquid dilution rate is always greater than particulate rate of passage (Owens and Goetsch, 1988).

1. Feed intake. As the dry matter intake increases ruminal liquid volume, dry matter percent in the ruminal content and particulate rate of passage all increase (Grovum and Williams, 1977; Galyean et al., 1979). Fluid passage rate is expected to increase as dry matter intake increases because water intake usually parallels dry matter intake (Evans, 1981). Increased feed intake will increase efficiency of production of ruminants by diluting maintenance costs. Dry matter intake could be increased by elevating ruminal volume or passage rate (Grovum, 1988).

2. Diet type. Feeding high cereal grain diets results in lower rumen fluid dilution rate (than all-forage diets) (Evans, 1981; Rogers and Davis, 1982a). Fluid passage rate is greater for diets with high roughage levels than with high concentrate levels (Warner, 1981). The increase in dilution rate when roughages are fed reflects increased mastication and salivation (Cole et al., 1976).

#### Microbial Efficiency and Ruminal Kinetics

Efficiency of microbial protein production, expressed as grams of microbial nitrogen reaching the abomasum or duodenum per kilogram of organic matter truly digested in the rumen, can differ with a number of factors. The factors could be energy, supply or other nutrients and

rumen environmental characteristics such as passage rate, pH and microbial species (Owens and Goetsch, 1986; Czerkawski, 1978; Hespell and Bryant, 1979; Harrison and McAllan, 1980). Microbial efficiency is positively correlated to dilution rate of culture medium for both pure and mixed bacterial cultures (Isaacson et al., 1975; Harrison and McAllan, 1980). In continuous culture studies 15 to 55% of available energy are used for maintenance purposes, depending on the dilution rate of the medium (Hespell and Bryant, 1979; Isaacson et al., 1975). Substantial increases in in vivo passage rate and microbial efficiency were obtained through mineral salt infusion into the rumen (Harrison et al., 1975). Estell and Gaylean (1985) reported a positive relationship between ruminal pH and liquid dilution rate.

Harrison et al. (1976) reported an increased acetate/propionate ratio when liquid dilution rate was increased with ruminal infusion of sodium bicarbonate. Increased ruminal fluid dilution rate increases the amount of high quality protein escaping the rumen. Also, amount of soluble carbohydrate and starch escaping ruminal degradation and fermentation is increased (Harrison et al., 1975; Hemsley, 1975; Hemsley et al., 1975; Okeke et al., 1983; Rogers and Davis, 1982b). Cole et al. (1976) reported increased efficiency of microbial protein production when rumen liquid dilution rate was increased.

The quantity and the quality of protein delivered to the small intestine for absorption is the sum of microbial and dietary protein which escapes ruminal degradation by rumen microbes (Owens and Zinn, 1988). Ruminant microbes produce the required enzymes to hydrolyze protein to amino acids. The resulting amino acids are deaminated and decarboxylated. The end-product of bacterial action on amino acids is the formation of  $\text{NH}_3$ , carbon skeleton and  $\text{CO}_2$  (Blackburn, 1965). The carbon skeleton and ammonia are absorbed by rumen microorganisms and resynthesized into microbial amino acids and proteins (Allison, 1969).

Microbial action reduces the protein supply to the duodenum with natural diets containing high levels (15% or greater) of high-quality protein (Owens and Zinn, 1988) but increases the supply to the duodenum with diets low in protein. Microbial action on protein is an advantage to cattle if the dietary protein is of lower biological value than microbial protein, and it is disadvantageous to the ruminant when large amounts of high-quality protein are included in the diet because rumen microbes can degrade dietary protein faster than they can synthesize into microbial protein (Chalupa, 1982).

### Microbial Additives

Microbial additives have been produced from bacteria, yeast, fungi and algae. Microbial additives could develop into an important source of animal feed. New methods are being developed to use microbial fermentation processes to utilize vast amounts of waste materials such as straw, wood, wood-processing waste, food cannery and food-processing wastes (Church, 1982). In addition to supplying a source of high-quality protein from fermentation, these products contain enzymes and vitamins that appear to improve animal performance.

Most microorganisms reproduce at a faster rate than either plants or animals; many bacteria double their numbers in less than 1 hour. The generation time of yeasts is usually 1 to 3 hours. Microbial cells are generally rich in protein, 35-75% CP (Church, 1983). The amino acid composition of Saccharomyces cerevisiae is as follows: CP, 53.7%; lysine, 8.2%; threonine, 4.8%; cysteine, 1.6%; methionine, 2.5%; valine, 5.5%; isoleucine, 5.5%; leucine, 7.9%; phenylalanine, 4.5%; and tryptophan, 1.2% (Goldberg, 1985).

### The Effect of Forage: Concentrate Ratio on Forage Fiber Digestion

MacRae and Armstrong (1969) reported a depression in fiber digestion in sheep fed a total mixed ration consisting of roughage and cereal grains. In a study by

Miller and Muntifering (1985) the effect of concentrate on forage digestion in vivo using the nylon bag technique in steers fed 10, 20, 40, 60, or 80% cracked corn was evaluated. Fiber digestion decreased as the percentage of cracked corn in the diet was increased. Fiber digestibility depression associated with feeding high levels of concentrate appears to be caused by many factors: lag time, increased particulate rate of passage, decrease in ruminal pH, reduction of cellulolytic bacteria numbers and activity and other factors related to the characteristics of the fiber consumed.

Staples et al. (1984) evaluated the effect on digestibility of level of intake in mixed ration containing 50% cereal grain. Steers were fed the mixed diet at 100, 85, 70, or 55% of the ad libitum intake. Steers consuming 55% of the ad libitum intake consumed enough nutrient to meet maintenance requirements. Apparent dry matter, cellulose and hemicellulose digestibility decreased linearly as feed intake increased from 55 to 100% ad libitum. Dry matter digestibility decreased 8% when feed intake increased to 100% ad libitum; ADF digestibility decreased 8% when feed intake increased to 100% ad libitum; hemicellulose digestibility decreased 13% when feed intake increased to 100% ad libitum. In referring to the study of Staples et al.



(1984), rate of disappearance and extent of disappearance of ADF, cellulose and hemicellulose were evaluated in steers using the nylon bag technique. Rate of disappearance decreased as feed intake increased from 55 to 100% ad libitum, but the extent of disappearance was not affected by level of feed intake. Particulate rate of passage and liquid dilution rate were increased as feed intake increased from 55 to 100% ad libitum. The ruminal pH decreased linearly as feed intake increased from 55% to 100% ad libitum. Overall retention time in the total tract was reduced from 55.6 h to 39 h as the feed intake increased from 55 to 100% ad libitum.

#### Probiotics in Ruminants

Originally the word probiotics referred to a viable preparation of Lactobacillus acidophilus. Presently, the list of probiotics has been expanded to include viable and non-viable preparations of lactobacilli, streptococci, fungi, yeasts and molds (Zinn, 1988). Lactobacilli and streptococci are nonpathogenic bacteria found throughout the gastrointestinal tract. With normal colonization the lactobacilli appear to regulate growth of pathogenic bacteria, such as E. coli and other coliforms (Kujawa and Rocznik, 1983; Bruce et al., 1979) Both lactobacilli (Lactobacillus acidophilus) and streptococci (Streptococcus faecium) promote animal health and

performance. The improvement in animal health and performance is thought to be mediated by a more favorable intestinal bacterial balance. This favorable balance is thought to come about as a result of (1) direct competition with E. coli for binding sites in the lower part of the digestive tract, (2) production of antimicrobial substances (Kujawa and Roczniak, 1983), (3) lowering of intestinal pH and lactic acid production (Zinn, 1988), and (4) neutralization of endotoxin produced by E. coli (Underdahl, 1983).

Gill et al. (1987) reported improved feed utilization in stocker calves fed live bacteria ( $1.4 \times 10^9$  live bacteria). The improvement in feed efficiency for calves fed the bacterial additive was 9.5% higher than the control. Aldrovandi et al. (1984) also observed increased rate of gain when calves were fed Lactobacillus acidophilus (100 million cells). Calves fed lactobacillus did not demonstrate digestive disturbances. Kolar et al. (1988) reported improved feed intake, rate of gain, and feed utilization when bacterial probiotics were included in the ration of growing heifers. Braun et al. (1988) fed a bacterial additive to pregnant heifers. The birthweight of calves born to heifers supplemented with the bacterial additive was 2.7 kg higher than the birth weight of calves born to nonsupplemented heifers. Bonaldi et al. (1986) reported increased rate of gain in

calves fed 7.5 million cells of a Lactobacillus acidophilus product.

Schingoethe et al. (1984) fed 15 gm of a bacterial additive to lactating dairy cows. There were no significant differences in dry matter intake, milk yield or milk composition between the supplemented and nonsupplemented cows. Jaquette et al. (1988) reported a significant increase of milk production (29.1 vs 30.9 kg) when Lactobacillus acidophilus, strain B1386, was included in the ration of lactating cows. However, the additive had no effect on milk composition. Ware et al. (1988) supplemented the diet of lactating cows with a Lactobacillus acidophilus, strain B1386, product. The lactobacillus-supplemented cows produced significantly more milk (31.8 vs. 33.6), with no effect on feed intake or milk composition.

McCormick (1984) reported that digestibility and volatile fatty acid concentration were not affected when lambs were supplemented with a Lactobacillus acidophilus additive. Zinn et al. (1985) did not observe a treatment effect on volatile fatty acid proportions or total digestive tract digestibility of organic matter, crude protein or acid detergent fiber when calves on the high concentrate diet were supplemented with a Lactobacillus acidophilus additive.

### Feeding of Yeasts to Ruminants

The yeast Saccharomyces cerevisiae, of the fungi family, is able to ferment soluble carbohydrates to alcohol and CO<sub>2</sub>. Arambel and Tung (1987) evaluated the survival and growth of a strain of Saccharomyces cerevisiae in a simulated rumen environment. It was found that Saccharomyces cerevisiae is sensitive to a rumen temperature of 39°C, because budding did not occur at 39°C but did occur when Saccharomyces cerevisiae was incubated at 25°C.

Dyer (1960) reported increased gain in steers and lambs when yeast preparation was added to the diet. Phillips and Von Tungeln (1985) reported that inclusion of yeast culture in the receiving ration of beef calves tended to increase dry matter intake. The weight gain was not consistently increased by the addition of yeast culture to the diet. Phillips and Von Tungeln (1984) added yeast culture at 1 and 2% to stock-calf diets. Calves that received the yeast culture tended to have increased dry matter intake, increased gain and improved feed efficiency over calves not receiving the yeast supplement. Adams et al. (1981) included viable yeast in the ration of growing lambs. Lambs fed the yeast culture had an increase in dry matter intake, weight gain and improved feed efficiency. Fallon and Harte (1987) observed that dry matter intake and live weight

gain of calves were increased when barley/soya diet including yeast culture was given to the calves. Bonaldi et al. (1986) noted an increased rate of gain in calves supplemented with viable yeast (Saccharomyces cerevisiae). Calves supplemented with yeast did not experience digestive disturbances.

Teh et al. (1987) supplemented the diet of lactating goats with viable yeast culture. Yeast-supplemented goats produced more milk, milk production efficiency was increased, and percent fat in the milk was increased. Hoyos et al. (1987) fed a viable yeast culture to lactating cows at the rate of 3 gm/d. The addition of a yeast culture to the diet of high-producing cows significantly increased milk yield (30.9 kg/day, control vs. 32.8 kg/day, treatment). The addition of yeast to the diet of low producers (cows producing 22 kg/day or less) did not increase milk production. The percent fat in the high-producing group supplemented with yeast was increased 19.4% and in the low producing group increased 14%. Arambel and Kent (1987) found no difference in dry matter intake, milk yield or milk composition between lactating cows supplemented with 90 gm/day Saccharomyces cerevisiae and unsupplemented cows. Quinonez et al. (1988) fed a viable yeast to lactating cows at the rate of 3 lb/ton. There were no differences in dry matter intake, milk yield, percent milk crude protein, SNF and

lactose. Percent milk was slightly increased in cows supplemented with yeast (3.36, control vs. 3.48).

The Effect of Yeast on Feed  
Utilization and Rumen Fermentation  
Characteristics

Ruf et al. (1953), using an artificial rumen technique, found that yeasts had a stimulatory effect on cellulose digestion. Teh et al. (1987) found that yeast addition to the diet of lactating goats increased the ruminal pH, acetate and acetate/propionate ratio. Dawson and Newman (1987) evaluated the effect of yeast supplementation on bacterial growth and activities using a continuous fermenter technique. They found that fermenters supplemented with yeast had consistently higher pH, lower ammonia nitrogen, higher anaerobic bacteria and higher cellulolytic bacteria ( $1.58 \times 10^9$  for the treatment vs.  $1.23 \times 10^8$  for the control).

Wiedmeier et al. (1987) found that cows supplemented with a yeast culture (Saccharomyces cerevisiae) tended to have more cellulolytic bacteria, increased dry matter, crude protein and hemicellulose digestibility. The ruminal volatile fatty acids were not affected by the addition of a yeast culture. However, Quinonez et al. (1988) did not observe a difference in volatile fatty acids and digestibility when yeast was added to the ration of lactating dairy cows. LeGendre et al. (1957) found that supplementing the diet of steers with yeast

had no effect on nitrogen retention and digestibility. Sniffen (1986) suggested that yeast products could provide the necessary amino acids to provide adequate isoacids for bacterial growth and action. However, no evidence was presented.

#### Fungi Additives for Lactating Cows

The role and importance of fungi in rumen fermentation is virtually unknown. However, anaerobic fungi have been observed in the rumen of sheep and cattle attached to and within plant fragments (Bauchop, 1979). The rumen fungi may contribute up to 8% of the microbial mass. The importance of fungi in the rumen has not been totally evaluated, but they have been shown to degrade cellulose which is probably why they improve fiber digestion (Yokoyama and Johnson, 1988). During recent years several fungal extracts have been marketed as feed supplements for livestock. Aspergillus oryzae is the main fungi that is being used as a feed additive to improve fiber digestion and milk yield.

Huber and Higginbotham (1985) fed lactating cows a commercial additive (Vitaferm) that contained Aspergillus oryzae culture that was fortified with vitamins and minerals. Cows fed the additive produced significantly more milk than the control. The milk composition was not affected by the addition of Aspergillus oryzae culture.

Kellems et al. (1987) supplemented the ration of lactating cows with 3 gm/day of Aspergillus oryzae extract. Cows fed the extract produced significantly more milk than the control. The response was different when cows were grouped according to days in milk: 40-90 days, 35.6 kg/d control vs. 38.9 kg/d treatment; 91-120 days, 36.1 kg/d control vs. 38.2 kg/d treatment; 120-150 days, 33.3 kg/d control vs. 34.7 kg/d treatment. Huber et al. (1986) evaluated the effect of supplementing 3 g/day Aspergillus oryzae in lactating dairy cows during hot weather. The cows supplemented with Aspergillus oryzae produced more milk than the control (23.5 vs. 22.6 kg) and consumed more feed than the control (19.9 vs. 19.01 kg).

Gomez et al. (1986) studied the effect of an Aspergillus oryzae culture on lactating cows. Supplementation increased ruminal cellulose digestion and ruminal nitrogen output. Total tract dry matter and cell wall constituent were similar between supplemented and non-supplemented cows. Gomez-Alarcon et al. (1987) reported increased rumen digestibility of dry matter and fiber, although total tract apparent digestibility was similar between treatment cows. The addition of Aspergillus oryzae increased microbial protein synthesis in the rumen and increased the protein delivered to the duodenum. Wiedmeier (1986) observed increased



total tract apparent dry matter and acid detergent fiber digestibility from Aspergillus oryzae feeding. Wiedmeier (1986) also noticed increased ruminal cellulolytic bacteria in cows fed the Aspergillus oryzae extract. Harris (1987), after reviewing experiments concerned with feeding an Aspergillus oryzae fermentation extract, concluded that Aspergillus oryzae appears to be active in the synthesis of cellulolytic and proteolytic enzymes.

In general, feeding an Aspergillus oryzae culture has demonstrated increased cellulose digestion, protein utilization, improved feed intake and increases in milk yield of up to 8 pounds per day.

EFFECT OF FEEDING A VIABLE YEAST CULTURE  
ON RUMINAL FERMENTATION CHARACTERISTICS  
AND NUTRIENT DIGESTIBILITY

Introduction

Intensive livestock production has resulted in the feeding of high energy, low fiber diets. Changing the composition and physical form of the diet as well as the amount fed alters rumen pH, rumen fluid and particulate turnover rate and microbial activity in the rumen (Davis, 1979; Mertens, 1979). Feeding high-grain, low-fiber diets results in decreased ruminal pH, fiber digestion, increased propionate production and decreased acetate to propionate ratio. When ruminants are fed high levels of concentrate in the diet, ruminal pH drops below the optimum pH range (6.7-7.0) for maximum rumen cellulolytic ruminal bacterial activity (Stewart, 1977). Since all cellulolytic ruminal bacteria are sensitive to a modest decline in pH (Russell and Dombrowski, 1980; Stewart, 1977), digestibility of the structural carbohydrates and eventually the net energy available for production are reduced when cattle are fed diets containing a high proportion of concentrate.

Several methods have been used to increase structural carbohydrate digestibility with variable results.

Feeding buffers, such as sodium bicarbonate, have been useful in improving structural carbohydrate digestion by maintaining a more favorable ruminal pH for bacterial cellulolytic activity (Erdman et al., 1982). Another method of improving structural carbohydrate digestion is supplying growth factors, such as isoacids, for the cellulolytic bacteria inhabiting the rumen (Gorosito et al., 1985), or daily feeding of microorganisms that are capable of maintaining cellulolytic activity in the rumen.

Huber and Higginbotham (1985) supplemented rations of lactating dairy cows with an Aspergillus oryzae fermentation extract fortified with vitamins and minerals. Cows fed the fermentation extract produced more milk when compared to the controls. Wiedmeier et al. (1987) noted that addition of yeast culture and Aspergillus oryzae fermentation extract increased the percentage of cellulolytic bacteria found in the rumen. The digestibility of crude protein and hemicellulose also was increased. Gomez-Alarcon et al. (1987) observed an increase in milk yield and feed intake when rations fed to lactating cows were supplemented with Aspergillus oryzae fermentation extract. However, Adams et al. (1981) fed steers a viable yeast culture but did not observe an effect on dilution rate or nutrient digestibility.

The purpose of this study was to determine the effect of supplemental viable yeast culture on apparent total tract nutrient digestibility and rumen fermentation characteristics of mature ruminants.

#### Materials and Methods

Four barren Holstein cows, averaging 750 kg. and fitted with ruminal cannulae, were fed each of two treatments in a replicated Latin square design. Treatments consisted of (1) basal ration and (2) basal ration plus 10 gm of viable yeast culture (YC) Saccharomyces cerevisiae) (provided by Chr. Hansen Laboratory) per head per day (Tables 1 and 2). Basal ration was fed at the rate of 10.0 kg/d. Cows were fed individually, twice daily at 0700 and 1900 h and had free access to clear water. Cows were fed for a 21-day adaptation period followed by a 7-day collection period. Yeast culture was topdressed on the basal ration.

On day 1 of the collection period, cows received a 500 ml intra-ruminal dose of Cobalt and Ethylenediaminetetraacetic acid (Co-EDTA) as prescribed by Uden et al. (1980). Subsequently, ruminal liquid samples were withdrawn from each animal at 0, 1, 2, 3, 5, 8, 17, and 23 h post-dosing. Ruminal samples were centrifuged at  $10,000 \times g$  for 10 min., and cobalt concentration was determined on the supernatant portion by atomic absorption spectroscopy (Instrumentation Lab. no. 11,

TABLE 1. COMPOSITION OF BASAL RATION

Item	%
Chopped alfalfa hay	33.50
Rolled barley	36.25
Wheat bran	15.00
Chopped barley straw	15.00
Trace mineralized salt <sup>a</sup>	.25

<sup>a</sup>Consisted of 99.445% salt, .2% manganese, .3% iron, .033% copper, .01% zinc, .007% iodine, and .005% cobalt.

TABLE 2. NUTRIENT COMPOSITION OF BASAL RATION

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Nutrient (DM basis)	
<hr/>	
Crude protein, %	14.08
Neutral detergent fiber, %	41.60
Acid detergent fiber, %	23.80
Calcium, %	.64
Phosphorus, %	.45
Potassium, %	1.92
Magnesium, %	.30
Sodium, %	.11
Sulfur, %	.19
Zinc, mg/kg	45.50
Manganese, mg/kg	50.00
Copper, mg/kg	40.90
Iron, mg/kg	286.40

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Lexington, MA) with an air/acetylene flame. Slope of the natural log of cobalt concentration versus time was defined as the ruminal liquid dilution rate.

On day 3 of the collection period, 150 g of chromium mordant fiber (Haaland and Tyrell, 1982) was mixed with the 0700 h ration. Rumen samples (300 ml) were collected at 0, 2, 3, 6, 7, 8, 9, 10, 12, 15, 18, 24, 30, 34, 36, and 48 h post-feeding to determine particulate rate of passage. Rumen samples were centrifuged at 25,000 x g for 10 min. The supernatant was aspirated away, and the remaining solid particulates were dried, ground, and analyzed for chromium by atomic absorption spectroscopy with an air/acetylene flame. Rate of passage was determined by the slope of the natural log of chromium concentration versus time.

Rumen fluid pH was measured using a combination electrode at 0, 2, 4, 7, 8, 9, and 12 h post- 0700-h feeding. A portion of the filtrate was acidified by placing nine parts filtrate with one part 6 N HCL. The mixture was clarified through a 0.2 um membrane filter and analyzed for VFA with a gas chromatograph (Hewlett Packard 5890, Avondale, PA) with a carbowax 20 M capillary column with a 10 M x 0.53 mm x 1.33 um film thickness and ammonia nitrogen ( $\text{NH}_3$  - N) using Nessler's reagent (A.O.A.C., 1985).

On day 7 of the collection period, rumen samples (300 ml) were collected 3 h after the 0700-h feeding and evaluated for total bacteria and cellulolytic bacteria using habitat-stimulating media as described by Leedle and Hespell (1980). The anaerobic roll tube technique for Hungate (1966) was used to identify bacterial colonies. Four replicate samples at four dilutions were used for bacterial evaluations. Total viable and cellulolytic bacteria were counted based on visual identification of colonies formed in the anaerobic growth media. Total protozoa were counted by diluting rumen samples 1:1 with a 50% formalin solution and placed in a scintillation vial. A one ml aliquot of the preserved sample was pipetted into a test tube and mixed with two drops of 2% brilliant green. Samples were then allowed to stand for at least 4 h. Nine ml of a 30% glycerol solution was added (1:20 dilution). If further dilutions were necessary to facilitate counting of protozoa, a 30% glycerol solution was used. A 1-ml aliquot was pipetted into a Sedgwick-Rafter counting chamber. After 5 min. total protozoa were counted.

On days 1-3 of the collection period, fecal grab samples were removed from each cow at 0700 h and 1700 h. Rations were sampled at each feeding but started 48 h prior to the first day of fecal collections. Fecal samples were dried initially for 72 h in a forced air



oven at 60°C, and complete dry matter (DM) was determined in a forced-air oven at 100°C for 24 h. Fecal samples were ground through a 2-mm screen using a Wiley mill (Philadelphia, PA). Feed samples were ground through a 2-mm screen. Fecal and feed samples were analyzed for CP (Hach et al., 1985), ADF and NDF (Van Soest, 1967) and acid detergent fiber insoluble ash (ADFIA) (Undersander et al., 1987). Acid detergent fiber insoluble ash was used as the internal marker to determine apparent nutrient digestibility.

Data were analyzed using a model for the Latin square design. The model included dietary treatments, cows and time periods (SAS, 1982; Steel and Torrie, 1980).

### Results and Discussion

Treatment effects on ruminal fermentation characteristics are shown in Table 3. Cows fed the added yeast culture tended to have a higher ruminal pH. Quinonez et al. (1988) reported similar increases in ruminal pH when yeast culture was included in the rations of lactating cows. Ruminal ammonia-nitrogen ( $\text{NH}_3$  -N) was significantly ( $P < .01$ ) lower in cows fed the yeast culture (20.87 and 25.48 mg/dl  $\text{NH}_3$  -N/dl for treatment and control, respectively). Decreases in ruminal  $\text{NH}_3$  -N were reported by Adams et al. (1981) when steers were fed a viable yeast culture. The reason for this decrease in ruminal ammonia-nitrogen is not clear, but it could be

TABLE 3. EFFECT OF TREATMENT ON RUMINAL FERMENTATION CHARACTERISTICS

Item	Treatment		SEM <sup>1</sup>
	Control	Yeast	
NH <sub>3</sub> -N (mg/dl)	25.38 <sup>b</sup>	20.77 <sup>a</sup>	1.33
pH	6.49	6.54	.02
Total VFA, mmole/L	74.9	73.4	1.81
Acetic (molar %)	66.29 <sup>a</sup>	67.63 <sup>b</sup>	.36
Propionic	15.70 <sup>b</sup>	14.43 <sup>a</sup>	.21
Isobutyric	1.15 <sup>d</sup>	1.09 <sup>c</sup>	.02
Butyric	13.67	13.93	.23
Isovaleric	1.61 <sup>b</sup>	1.44 <sup>a</sup>	.04
Valeric	1.57 <sup>b</sup>	1.47 <sup>a</sup>	.03
Acetic/propionic ratio	4.33 <sup>a</sup>	4.73 <sup>b</sup>	.08

<sup>a, b</sup>Means in the same row with different superscripts differ (P < .01).

<sup>c, d</sup>Means in the same row with different superscripts differ (P < .05).

<sup>1</sup>Standard error of the mean.

that feeding yeast contributed to the supply of pre-essential isoacids for the bacteria.

Total volatile fatty acids were unaffected by the treatment, which agrees with results reported by Wiedmeier et al. (1987) and Quinonez et al. (1988). The ruminal molar percent of acetate was significantly ( $P < .01$ ) higher in cows supplemented with the yeast culture, while molar % of propionate was significantly ( $P < .01$ ) lower. The increase in acetate and decrease in propionate would aid in correcting the milk fat depression that is normally associated with cows receiving high levels of grain. Bauman et al. (1971) observed that milk fat depression in lactating dairy cows is associated with a reduction of ruminal acetate/propionate ratio from increased propionate production. In this study the acetate/propionate ratio was significantly ( $P < .01$ ) higher for the cows receiving the added yeast culture in the diet. The ruminal volatile fatty acids (valeric, isovaleric and isobutyric) were significantly lower in the cows fed the yeast culture. The effects of yeast culture on ruminal flow kinetics and microbial numbers are shown in Table 4. Total viable bacterial numbers tended to be higher for cows supplemented with yeast. Total cellulolytic bacteria and percent cellulolytic bacteria tended to be higher in cows fed yeast culture ( $P < .26$

TABLE 4. EFFECT OF TREATMENT ON RUMINAL DIGESTA FLOW KINETICS AND MICROBIAL NUMBERS

Item	Treatment		SEM <sup>1</sup>
	Control	Yeast	
Liquid dilution rate, %/h	5.92	5.36	.59
Particulate rate of passage, %/h	2.44	3.02	.55
Bacteria			
Total, x 10 <sup>10</sup> /ml	11.85	40.20	18.40
Cellulolytic, x 10 <sup>9</sup> /ml	5.09	65.30	27.67
Percent cellulolytic	6.90	22.50	5.73
Protozoa, x 10 <sup>3</sup> /ml	5.37	5.44	2.61

and  $P < .19$ , respectively). Wiedmeier et al. (1987) reported a significant increase in ruminal cellulolytic bacteria when cows were supplemented with yeast culture. The reason for this increase is not clear. However, yeast culture could be supplying vitamin-B complexes or unidentified growth factors such as the branched-chained VFA and peptides, which are required by most cellulolytic bacteria. Total rumen protozoa were not significantly ( $p < .05$ ) affected by the treatment. The definitive role rumen protozoa play in the ruminal ecosystem is not clear. Hungate (1975) indicated that protozoa have potential for fiber digestion. However, they are not essential, and their role is small when compared with that of bacteria.

Ruminal digesta flow kinetics are presented in Table 4. Ruminal liquid dilution rate and particulate rate of passage were not affected by the treatment. These results are in agreement with Adams et al. (1981).

The effects of yeast culture on total tract apparent nutrient digestibility are presented in Table 5. Yeast culture did not improve the digestibility of the structural carbohydrate fraction of the diet. Yeasts are not capable of degrading the insoluble components of ligno-cellulose, cellulose, hemicellulose and lignin (Knowles et al., 1987).

TABLE 5. EFFECT OF TREATMENT ON TOTAL TRACT  
APPARENT NUTRIENT DIGESTIBILITY

Item	Treatment		SEM <sup>1</sup>
	Control	Yeast	
Crude protein	91.3	91.1	.58
Acid detergent fiber	75.6	73.7	1.08
Neutral detergent fiber	80.4	79.2	.81
Hemicellulose	87.6	86.9	.64

EFFECT OF A VIABLE YEAST CULTURE ON MILK  
PRODUCTION AND APPARENT NUTRIENT  
DIGESTIBILITY IN LACTATING COWS

Introduction

Feeding high-energy feeds such as cereal grains has increased during the last twenty-five years, due to their abundance and relatively low cost (Clark et al., 1980). Feeding high-cereal grain rations results in decreased fiber digestibility, increased propionate production and a decreased acetate-to-propionate ratio (Bauman et al., 1971). Bauman et al. (1971) reported that feeding high-grain low-fiber diets to lactating cows results in a marked depression in milk fat content. Feeding elevated levels of concentrate to high-producing lactating dairy cows depresses digestibility of the ration structural carbohydrates.

Feeding microbial cultures to ruminants is thought to be useful in improving dry matter and structural carbohydrate digestion and increasing milk fat content. Adams et al. (1981) fed a viable yeast culture to steers and lambs and found that apparent nutrient digestibility was unaffected. However, slight increases in average daily gain and feed efficiency were noted. Phillips and Von Tungeln (1984) fed yeast culture to stressed stocker

calves at the rate of 1 or 2% of the diet. Calves fed the yeast culture tended to have better rates of gain and improved feed efficiency. Hoyos et al. (1987) fed a viable microbial additive containing Saccharomyces cerevisiae and Lactobacillus acidophilus. The treated group produced 6% more milk and 19% more milk fat. Gomez-Alarcon et al. (1987) fed an Aspergillus oryzae fermentation extract to lactating cows and observed a 1.7 kg/d improvement in milk-production response. Apparent dry matter digestibility also was improved in cows receiving the fermentation extract.

The purpose of this study was to evaluate the effect of a supplemental viable yeast culture on milk yield and composition and apparent nutrient digestibility of lactating dairy cows.

#### Materials and Methods

Eighteen lactating Holstein cows, averaging 18-weeks postpartum, were allocated to one of two treatments based on stage of lactation and previous mean daily 2-week milk yield. Treatments consisted of (1) basal ration (Tables 6 and 7) and (2) basal ration plus 10 g/d of a viable yeast culture (Saccharomyces cerevisiae) (provided by Chr. Hansen's Lab.). Therefore, nine cows were allocated to each treatment. Rations were fed ad libitum twice daily to allow for 5-10% refusal during a 10-week experimental period. Feed refusals were recorded once



TABLE 6. COMPOSITION OF TOTAL MIXED RATION

Ingredient	%
Chopped alfalfa hay	26.80
Corn silage	14.75
Whole cottonseed	11.45
Alfalfa haylage	8.45
Rolled barley	18.75
Beet pulp	9.60
Brewers dried grains	7.85
Beet molasses	.95
Vitamins/minerals premix <sup>a</sup>	1.40

<sup>a</sup>premix consists of 12.5% calcium, 5.2% phosphorus, 4.8% potassium, 4.2% sodium, 3.5% elemental sulfur, 75 ppm copper, 780 ppm manganese, 6.2 ppm selenium, 1575 ppm zinc, 270,600 I.U. vitamin A/kg and 92,400 I.U. vitamin D/kg.

TABLE 7. NUTRIENT CONTENT OF TOTAL MIXED RATION

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Nutrient (DM basis)	
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Crude protein, %	15.00
Neutral detergent fiber, %	49.70
Acid detergent fiber, %	32.50
Calcium, %	.70
Phosphorus, %	.46
Potassium, %	1.99
Magnesium, %	.31
Sodium, %	.16
Sulfur, %	.24
Zinc, mg/kg	54.50
Manganese, mg/kg	47.30
Copper, mg/kg	32.70
Iron, mg/kg	221.80

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daily. Cow weights were recorded initially and at the conclusion of the trial. Cows were housed and fed in shaded barns equipped with free stalls and individual feeding facilities and had free access to water.

Rations were sampled twice daily during the experimental period. Samples were composited and dried then ground through a Wiley mill (Philadelphia, PA) using a 1-mm mesh screen. Milk yield was recorded twice daily, sampled once weekly with an am-pm composite and analyzed for milk fat, protein, lactose and SNF using a multispec M Infrared Analyzer from Wheldrake, York, England. In week 8 fecal grab samples were collected twice daily prior to feeding for 3 days. Fecal samples were composited and initially dried at 60°C for 72 hours. Complete dry matter was determined in a forced-air oven at 100°C for 24 hours. Fecal samples were ground through a 2-mm mesh screen using a Wiley mill. Feed and fecal samples were analyzed for CP (Hach et al., 1985), ADF and NDF according to Van Soest (1967). Acid detergent fiber insoluble ash was determined according to Undersander et al. (1987) and used to determine apparent nutrient digestibility.

The data were analyzed using the model for the randomized block design (Barr et al., 1979). The model included dietary treatment, milk composition, milk yield, feed intake and cows.

## Results and Discussion

Effects of treatment on dry matter intake and milk response are shown in Table 8. Figure 1 shows the tendency for cows supplemented with viable yeast to produce more milk than control cows during all weeks of the treatment period. Figure 2 shows the tendency for cows supplemented with the viable yeast culture to produce more of 3.5% FCM over time. Adding yeast culture to rations of mid-lactation Holstein cows had no effect on mean daily dry matter intake. However, cows supplemented with viable yeast culture tended ( $P < .2$ ) to produce more 3.5% FCM than nonsupplemented cows (31.8 vs. 29.4 kg/day, respectively). Milk composition was unaffected by treatment except for the slight increase ( $P < .24$ ) in percent milk fat in cows supplemented with the viable yeast culture (3.5 vs 3.3%) (Table 8). Quinonez et al. (1988) reported that addition of yeast culture in milk cow rations improved milk fat production. Hoyos et al. (1987) reported a 19% increase in milk fat for cows fed a fungal additive containing Saccharomyces cerevisiae. Milk production efficiency was significantly ( $P < .02$ ) improved in cows fed the viable yeast culture. Table 8 and Figure 3 show the effects of treatment on milk production efficiency. The cows supplemented with the viable yeast culture tended to maintain a higher and more persistent milk production efficiency response

TABLE 8. EFFECT OF TREATMENT ON MEAN DAILY DM INTAKE, MILK YIELD, COMPOSITION AND PRODUCTION EFFICIENCY AND BODY WEIGHT GAIN

Item	Treatment		SEM <sup>1</sup>
	Control	Yeast	
DM intake, kg/d	23.43	22.75	.12
Milk yield, kg/d	30.32	31.88	.13
3.5% FCM, kg/d	29.38	31.78	.25
Milk composition, %			
Fat	3.30	3.50	.05
Protein	3.15	3.12	.01
Lactose	4.95	4.97	.03
SNF	8.70	8.77	.02
Production efficiency (3.5% FCM/DMI)	1.27 <sup>a</sup>	1.41 <sup>b</sup>	.02
Body weight gain kg/d	.78	.81	.09

<sup>a, b</sup>Means in the same row with different superscripts differ ( $P < .02$ ).

<sup>1</sup>Standard error of the mean.

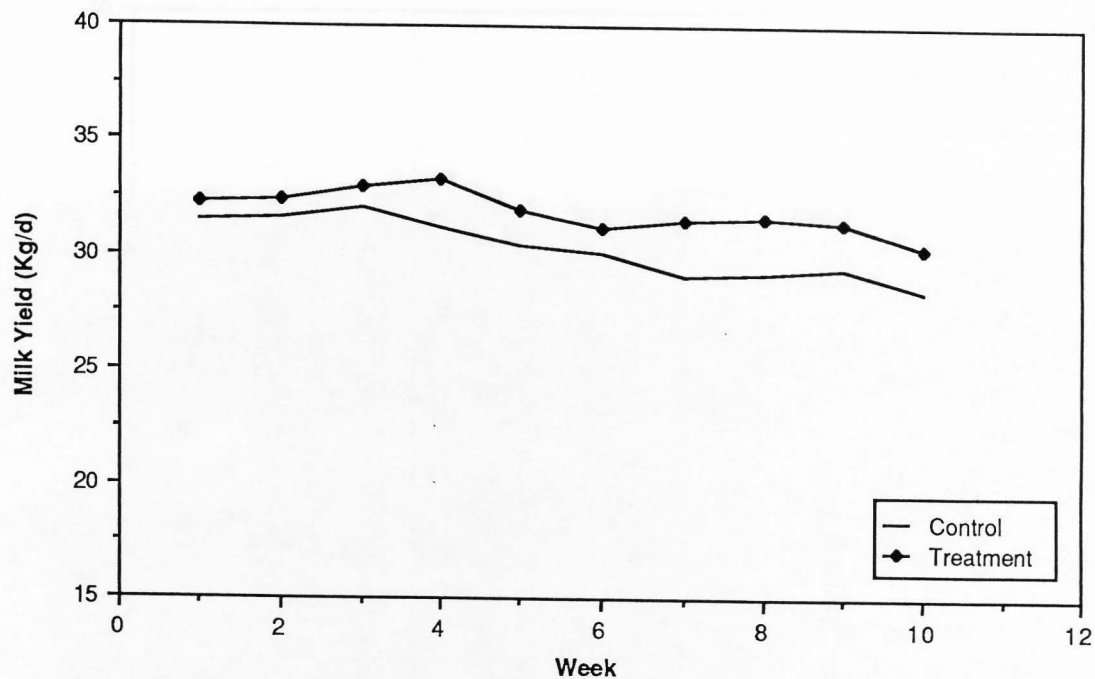


Figure 1. Effect of treatment on mean daily milk yield by week.

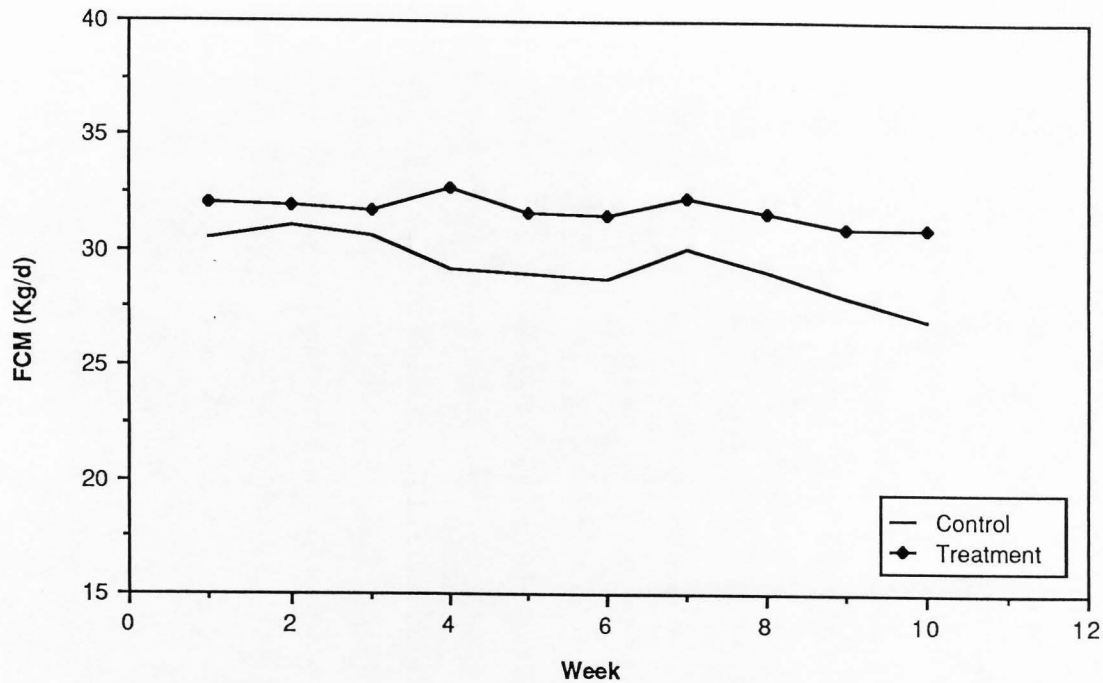


Figure 2. Effect of treatment on mean daily 3.5% FCM by week.

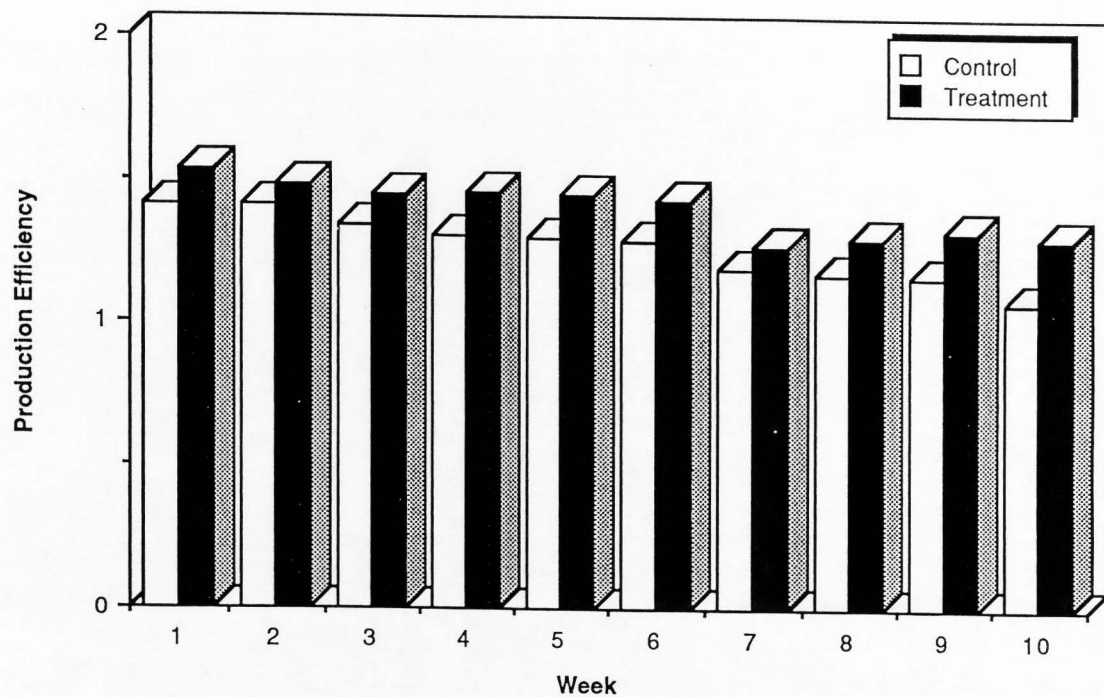


Figure 3. Effect of treatment on mean daily production efficiency by week.



during all weeks of the trial. An increase in efficiency of milk production (kg milk per kg dry matter intake) should reflect improved efficiency of nutrient utilization. An increase in feed efficiency would be expected when there is a significant increase in milk production efficiency. Apparently, the improvement in milk production efficiency cannot be accounted for by changes in body weight or nutrient digestibility, because cows supplemented with the viable yeast culture and unsupplemented cows had similar weight gains (.81 kg/d vs .78 kg/d, respectively). The reason for increased milk production in the cows supplemented with viable yeast is not clear. Increased milk production is normally associated with increased utilization and digestion of feed although no differences were noticed in apparent digestibilities between the cows supplemented with viable yeast and the nonsupplemented (Table 9). The apparent digestibility of ADF, OM, NDF and crude protein were similar between treatments. This is in agreement with the results obtained by Arambel and Kent (1987) when yeast culture was fed to cows in early lactation. Quinonez et al. (1988) likewise did not observe differences in apparent total tract digestibility in lactating cows fed a yeast culture compared to control animals. Other factors such as increased dilution rate of the rumen.

TABLE 9. EFFECT OF TREATMENT ON TOTAL TRACT  
APPARENT NUTRIENT DIGESTIBILITY

Item	Treatment		SEM <sup>1</sup>
	Control	Yeast	
Organic matter, %	70.4	70.0	.77
Crude protein, %	69.9	69.3	1.03
Acid detergent, %	56.0	56.4	1.56
Neutral detergent, %	56.7	57.8	1.16
Hemicellulose, %	58.3	60.5	1.68

<sup>1</sup>Standard error of the mean.

Increased ruminal fluid dilution rate would increase the amount of high-quality protein escaping the rumen. Increased ruminal escape of high-quality protein and soluble carbohydrates should improve milk production, due to the fact that increased degradation of protein is metabolically costly and requires energy for degradation and resynthesis into microbial protein.

Harrison et al. (1975) reported that increased LDR is associated with increased efficiency of microbial protein synthesis. Croom et al. (1982) reported increased organic matter utilization in cattle fed high levels of concentrates when the dilution rate was increased. Increased ruminal fluid dilution and rate of passage of solid digesta have been associated with increased dry matter intake (Haaland and Tyrell, 1982; Mudgal et al., 1982; Varga and Prigge, 1982). Cows supplemented with the viable yeast culture consumed slightly less feed. If viable yeast supplementation increased liquid dilution rate and particulate rate of passage as expected, we would have observed increased dry matter intake in the cows supplemented with the viable yeast culture. Therefore, the slight decrease in dry matter intake in cows supplemented with the viable yeast culture is difficult to explain. In a fermentation trial (Shokair and Arambel, 1988), a significant decrease was noted in ruminal ammonia nitrogen and the branch chain volatile

fatty acid in cows fed the viable yeast culture, which suggests less degradation of protein and amino acids which could be caused by increased liquid dilution rate or depressed protease or deaminase enzymes in the rumen (Bergen and Bates, 1984).

## CONCLUSIONS

Trial 1

Cows supplemented with the viable yeast culture had significantly lower ruminal  $\text{NH}_3$  -N than nonsupplemented. Cows supplemented with the viable yeast had significantly higher molar percentage of acetic acid than unsupplemented. Cows supplemented with viable yeast culture had significantly lower ruminal propionic, isobutyric, isovaleric and valeric acid.

Cattle supplemented with viable yeast had significantly higher acetate/propionic ratios than unsupplemented cattle. Supplementation with viable yeast culture did not affect LDR, particulate rate of passage and apparent total tract digestibility. Cattle supplemented with viable yeast culture tended to have higher rumen viable cellulolytic and total bacteria.

Trial 2

Cattle supplemented with the viable yeast Saccharomyces cerevisiae tended to produce more milk and consume less feed than the unsupplemented cows.

The percentage of milk, SNF, protein and lactose in cattle fed the viable yeast culture was unaffected.

However, cows supplemented with viable yeast culture tended to produce milk with higher fat content than cattle unsupplemented. Total tract digestibility of nutrients was not affected by feeding cattle the viable yeast culture. Production efficiency (3.5% FCM/DMI) was significantly higher in the cattle supplemented with the viable yeast. Body weight gain (kg/d) was unaffected by treatment.

#### Ideas for Further Research

1. Evaluate the effect of viable yeast culture on ruminal microbial protein production.
2. Evaluate the effect of feeding viable yeast culture on cows at lower and higher levels of production.
3. Evaluate the effect of viable yeast culture when different concentrate:roughage levels are fed.
4. Evaluate the effect of a single microbial additive or a mixture of microbial additives on ruminal fermentation characteristics and animal performance.

## LITERATURE CITED

- A.O.A.C. 1985. Official Methods of Analysis of the Association of Analytical Chemists. A.O.A.C. Washington D.C.
- Adams, D. C., M. L. Galyean, H. E. Kiesling, J. D. Wallace and M. D. Finkes. 1981. Influence of viable yeast culture, sodium bicarbonate and monensin liquid rate, rumen fermentation and feedlot performance of growing steers and digestibility in lambs. J. Animal Sci. 53:780.
- Akin, D. E. 1979. Microscopic evaluation of forage digestion by rumen microorganisms--a review. J. Animal Sci. 48:701.
- Akin, D. E. 1986. Chemical and biological structure in plants as related to microbial degradation of forage cell walls. In: L. P. Milligan, W. L. Grovum and A. Dobson (Eds.) Control of Digestion and Metabolism in Ruminants. pp 139-159. A Reston Book, Prentice-Hall, Englewood Cliffs, NJ.
- Akin, D. E. and H. E. Amos. 1975. Rumen bacterial degradation of forage cell walls investigated by electron microscopy. Appl. Microbiol. 29:692.
- Aldrovandi, V., G. Ballarini, F. Caleffi and P. G. Monetti. 1984. Use of Lactobacillus acidophilus in the rearing of veal calves. Dairy Sci. Abs. 46:786.
- Allison, M. J. 1969. Biosynthesis of amino acids by ruminal microorganisms. J. Animal Sci. 29:797.
- Arambel, M. J. and B. A. Kent. 1987. Effect of yeast culture on milk production response and apparent nutrient digestibility in early lactating dairy cows. J. Dairy Sci. 71 (Supple.1):220 (Abstr.).
- Arambel, M. J. and R. S. Tung. 1987. Evaluation of Saccharomyces cerevisiae growth in the rumen ecosystem. In: 19th Bien. Con on rumen function, Vol. 19, p 29. Chicago, Illinois.

- Barr, A. J., J. H. Goodnight and J. P. Sall. 1979. SAS User's Guide. SAS Institute, Inc. Raleigh, NC.
- Bauchop, T. 1979. Rumen anaerobic fungi of cattle and sheep. Appl. and Environ. Microbiol. 38:148.
- Bauman, D. E., E. L. Davis and H. F. Bucholtz. 1971. Propionate production in the rumen of cows fed either a control or high grain, low fiber diet. J. Dairy Sci. 54:1282.
- Bergen, W. G. and D. B. Bates. 1984. Lonaphores: Their effect on production efficiency and mode of action. J. Animal Sci. 58:1465.
- Blackburn, T. H. 1965. Nitrogen metabolism in the rumen. In: R. W. Daugherty (Ed.) Physiology of Digestion in the Ruminant. pp 322-380. Butterworths, Washington, D.C.
- Bonaldi, G., L. Buratto, G. Darsie, G. P. Didonne and S. Mondini. 1986. Use of Saccharomyces cerevisiae and Lactobacillus acidophilus in veal calves. Nutr. Abs. and Rev. 56:526.
- Braun, B., I. Kolar and J. David. 1988. Effect of probioticum S and Genium preparations on the reproduction of first-calving and dairy cows. Nutr. Abs. and Rev. 58:41.
- Bruce, S., E. Gilliland, L. J. Bush and T. E. Staley. 1979. Influence of feeding cells of Lactobacillus acidophilus on fecal flora of young dairy calves. Okla. Agric. Exp. St. MP 104:20. Stillwater, OK.
- Chalupa, W. 1982. Protein nutrition of ruminant animals. Feed Man. 33:53.
- Cheng, K. J. and J. W. Costerton. 1980. Adherent rumen bacteria--their role in the digestion of plant material, urea and epithelial cells. In: Y. Ruckebusch and P. Thivend (Eds.) Digestive Physiology and Metabolism in Ruminants. pp 227-250. AVI Publishing Company, Inc., Westport, CN.
- Church, D. C. 1982. By-product protein sources for supplementing forages. Feed Man. 33:47.
- Church, D. C. 1983. By-product protein sources for supplementing forages. Feed Man. 34:38.



- Clark, J. H., C. L. Davis and J. A. Rogers. 1980. Manipulation of rumen fermentation and its effects on performance of ruminants. In: Proc. 40th Semiannual Meeting Am. Feed Manufacturers Assoc., Arlington, VA.
- Cole, N. A., R. R. Jones, F. N. Owens and J. R. Males. 1976. Influence of roughage level and corn processing method on microbial protein synthesis by beef steers. *J. Animal Sci.* 43:497.
- Croom, W. J., Jr., R. W. Harvey, A. C. Linnerud and M. Kroetschel. 1982. High levels of sodium chloride in beef cattle diets. *Can J. Animal Sci.* 62:217.
- Czerkawski, J. W. 1978. Reassessment of efficiency of synthesis of microbial matter in the rumen. *J. Dairy Sci.* 61:1261.
- Davis, C. L. 1979. The use of buffers in the rations of lactating dairy cows. In: W. H. Hale and P. Meinhardt (Eds.) Regulation of Acid-Base Balance. Church and Dwight Co., Inc., Nutley, NJ.
- Dawson, K. A. and K. E. Newman. 1987. Effect of yeast culture supplements on the growth and activities of rumen bacteria in continuous culture. *J. Animal Sci.* 65 (Suppl. 1):452 (Abstr.).
- Dyer, I. A. 1960. Feed additives for beef cattle. Sixth Annual Beef Cattle Day Report. Washington State College, Pullman, Washington.
- Erdman, R. A., R. W. Hemken and L. S. Bull. 1982. Dietary sodium bicarbonate and magnesium oxide for early post partum lactating dairy cows: effects on production, acid-base metabolism, and digestion. *J. Dairy Sci.* 65:712.
- Esdale, W. J. and L. D. Satter. 1972. Manipulation of rumen fermentation. IV: Effects of altering ruminal pH on volatile fatty acid production. *J. Dairy Sci.* 55:964.
- Estell, R. E. and M. L. Gaylean. 1985. Relationship of rumen fluid dilution rate to rumen fermentation and dietary characteristics of beef steers. *J. Animal Sci.* 60:1061.
- Evans, E. 1981. An evaluation of the relationship between dietary parameters and rumen liquid turnover rate. *Can. J. Anim. Sci.* 61:91.

- Fallon, R. J. and F. J. Harte. 1987. The effect of yeast culture inclusion in the concentrate diet on calf performance. J. Dairy Sci. 70(Suppl. 1):143 (Abstr.).
- Galyean, M. L., D. G. Wagner and F. N. Owens. 1979. Level of feed intake and site and extent of digestion of high concentrate diets by steers. J. Animal Sci. 49:199.
- Gill, D. R., R. A. Smith and R. L. Ball. 1987. The effect of probiotic feeding on health and performance of newly arrived stocker calvs. Okla. State Univ. Anim. Sci. Res. Rept. Stillwater, OK.
- Goldberg, I. 1985. Single Cell Protein. Springer-Verlag, Berlin, Heidelberg, New York, Tokyo.p. 132.
- Gomez, R., J. T. Huber, G. E. Higginbotham and R. Wanderley. 1986. Effect of feeding a culture of A. oryzae on rumen and total tract digestion in dairy cows. J. Dairy Sci. 69 (Suppl. 1):188(Abstr.).
- Gomez-Alarcon, R., C. Dudas and J. T. Huber. 1987. Effect of Aspergillus oryzae (Amaferm) and yeast on feed utilization by Holstein cows. J. Dairy Sci. 70 (Suppl. 1):218 (Abstr.).
- Gorosito, A. R., J. B. Russell and P. J. Van Soest. 1985. Effect of carbon-4 and carbon-5 volatile fatty acids on digestion of plant cell wall in vitro. J. Dairy Sci. 68:840.
- Grovum, W. L. 1988. Appetite, palatability and control of feed intake. In: D. C. Church (Ed.) The Ruminant Animal Digestive Physiology and Nutrition. pp 202-216. Prentice-Hall, Englewood Cliffs, NJ.
- Grovum, W. L. and N. J. Williams. 1977. The effect of level of food intake on mathematical predictions of the kinetics of digesta in the reticulorumen and intestines. Bri. J. Nutr. 38:425.
- Haaland, G. L. and H. F. Tyrell. 1982. Effect of limestone and sodium bicarbonate buffers on rumen measurements and rate of passage in cattle. J. Animal Sci. 55:935.
- Hach, C. C., S. V. Brayton and A. B. Kopelove. 1985. A powerful Kjeldahl nitrogen method using peroxymonosulfuric acid. J. Agr. Food Chem. 33:1117.

- Harris, B. 1987. Review of experiments using Aspergillus oryzae fermentation products for lactating dairy cows. J. Dairy Sci. 70 (Suppl. 1):245(Abstr.).
- Harrison, D. G., D. E. Beever, D. J. Thomson and D. F. Osborn. 1975. Manipulation of rumen fermentation in sheep by increasing the rate of flow of water from the rumen. J. Agr. Sci. 85:93.
- Harrison, D. G., D. E. Beever, D. J. Thomson and D. F. Osborn. 1976. Manipulation of fermentation in the rumen. J. Sci. Food Agr. 27:617.
- Harrison, D. G. and A. B. McAllan. 1980. Factors affecting microbial growth yields in the reticulo-rumen. In: Y. Rickebusch and P. Thivend (Eds.) Digestive Physiology and Metabolism in Ruminants. pp 205-226. AVI Publishing Co., Inc. Westport, CN.
- Hemsley, J. A. 1975. Effect of high intakes of sodium chloride on the utilization of a protein concentration by sheep. 1. Wool growth. Aust. J. Agr. Res. 26:709.
- Hemsley, J. A., J. P. Hogan and R. H. Weston. 1975. Effects of high intakes of sodium chloride on the utilization of a protein concentration by sheep. II. Digestion and absorption of organic matter and electrolytes. Aust. J. Agr. Res. 26:715.
- Hespell, R. B. and M. P. Bryant. 1979. Efficiency of rumen microbial growth: Influence of some theoretical and experimental factors on YATP. J. Animal Sci. 49:1640.
- Hoover, W. H. 1986. Chemical factors involved in ruminal fiber digestion. J. Dairy Sci. 69:2755.
- Hoyos, G., L. Garcia and F. Medina. 1987. Effects of feeding viable microbial feed additives on performance of lactating cows in a large dairy herd. J. Dairy Sci. 70 (Suppl. 1):217 (Abstr.).
- Huber, J. R. and G. E. Higginbotham. 1985. Influences of feeding Vitaferm containing an enzyme-producing culture from Aspergillus oryzae on performance of lactating cows. J. Dairy Sci. 68:122(Abstr.).

- Huber, J. T., G. E. Higgingotham and R. Gomez. 1986. Influence of feeding an A. oryzae culture during hot weather on performance of lactating dairy cows. J. Dairy Sci. 69 (Suppl. 1):187(Abstr.).
- Hungate, R. E. 1966. The Rumen and Its Microbes. Academic Press, New York, NY.
- Hungate, R. E. 1975. Annual review of ecology and systematics. Vol. 6. Palo Alto: Animal Reviews, Inc. p. 39-66.
- Isaacson, H. R., F. C. Hinds, M. P. Bryant and F. N. Owens. 1975. Efficiency of energy utilization by mixed rumen bacteria in continuous culture. J. Dairy Sci. 58:1645.
- Jaquette, R. D., R. J. Dennis and J. A. Coalson. 1988. Effect of feeding viable Lactobacillus acidophilus (BT1386) on performance of lactating dairy cows. J. Dairy Sci. 71(Suppl. 1):219 (Abstr.).
- Kellems, R. O., N. P. Johnston, M. V. Wallentine, A. Lagerstedt, D. Andrus, R. Jones and J. T. Huber. 1987. Effect of feeding Aspergillus oryzae on performance of cows during early lactation. J. Dairy Sci. 70 (Suppl. 1):219(Abstr.).
- Knowles, J., M. Penttila, T. Terri, L. Andre, P. Lehtovaara and I. Salovuori. 1987. The development of cellulolytic yeasts and their possible applications. In: Biological Research on Industrial Yeasts. pp 189-198. CRC Press, Inc., Boca Raton, FL.
- Kolar, I., B. Braun and J. David. 1988. Effect of administration of probioticum N preparation on growth of heifers before reproduction. Nutr. Abs. and Rev. 58:41.
- Kujawa, K. and B. Roczniak. 1983. Antibacterial properties of lactobacilli isolated from calf intestines. Dairy Sci. Abs. 45:404.
- Leedle, J. A. and R. B. Hespell. 1980. Differential carbohydrates media and anaerobic replica plating techniques in delineating carbohydrate-utilizing subgroups in rumen bacterial populations. Appl. and Environ. Microbiol. 39:709.

- LeGendre, J. R., R. Totusek and W. D. Gallup. 1957. Effect of live cell yeast on nitrogen retention and digestibility of rations by beef cattle. *J. Animal Sci.* 16:671.
- MacRae, J. C. and D. G. Armstrong. 1969. Studies on intestinal digestion in sheep. 2. Digestion of some carbohydrate constituents in hay, cereal and hay-cereal rations. *Br. J. Nutr.* 23:377.
- McCormick, M. E. 1984. Probiotics in ruminant nutrition and health. Georgia Nutrition Conference, Atlanta, GA. pp 66-69.
- Mertens, D. R. 1979. Effects of buffers upon fiber digestion. In: W. H. Hale and P. Meinhardt (Eds.). *Regulation of Acid-Base Balance.* pp 65-81. Church and Dwight Co., Inc., Piscataway, NJ.
- Miller, B. G. and R. B. Muntifering. 1985. Effect of forage: concentrate in kinetics of forage fiber digestion in vivo. *J. Dairy Sci.* 68:40.
- Mudgal, N. D., R. M. Dixon, P. M. Kennedy and L. P. Milligan. 1982. Effect of two intake levels on retention times of liquid particle and microbial markers in the rumen of sheep. *J. Animal Sci.* 54:1051.
- Okeke, G. C., J. G. Buchanan-Smith and D. G. Grieve. 1983. Effect of sodium bicarbonate on rate of passage and degradation of soybean meal in postpartum dairy cows. *J. Dairy Sci.* 66:1023.
- Owens, F. N. and A. L. Goetsch. 1986. Digesta passage and microbial protein synthesis. In: L. P. Milligan, W. L. Grovum and A. Dobson (Eds.) *Control of Digestion and Metabolism in Ruminants.* pp 196-223. Prentice-Hall, Englewood Cliffs, NJ.
- Owens, F. N. and A. L. Goetsch. 1988. Ruminal fermentation. In: D. C. Church (Ed.) *The Ruminant Animal Digestive Physiology and Nutrition.* pp 145-171. Prentice Hall, Englewood Cliffs, NJ.
- Owens, F. N. and R. Zinn. 1988. Protein metabolism of ruminant animals. In: D. C. Church (Ed.) *The Ruminant Animal Digestive Physiology and Nutrition.* pp 227-249. Prentice-Hall, Englewood Cliffs, NJ.

- Phillips, W. A. and D. Von Tungeln. 1984. Effect of adding yeast culture to the receiving ration of stressed stocker calves. Okla. Agric. Exp. Sta. MP. 116:117. Oklahoma State Univ. and USDA-SEA-AR.
- Phillips, W. A. and D. L. Von Tungeln. 1985. The effect of yeast culture on the poststress performance of feeder calves. Nutr. Report International 32:287.
- Quinonez, J. A., L. J. Bush, T. Nelsen and G. D. Adams. 1988. Effect of yeast culture on intake and production of dairy cows fed high wheat rations. Oklahoma Agric. Exp. Sta. MP. 125:227.
- Rogers, J. A. and C. L. Davis. 1982a. Rumen volatile fatty acid production and nutrient utilization in steers fed a diet supplemented with sodium bicarbonate and monensin. J. Dairy Sci. 65:944.
- Rogers, J. A. and C. L. Davis. 1982b. Effects of intraruminal infusion of mineral salts on volatile fatty acid production in steers fed high-grain and high-roughage diets. J. Dairy Sci. 65:953.
- Ruf, E. W., W. H. Hale and W. Burroughs. 1953. Observations upon unidentified factor in feedstuffs stimulatory to cellulose digestion in the rumen and improved liveweight gains in lambs. J. Animal Sci. 12:731.
- Russell, J. B. and D. B. Dombrowski. 1980. Effect of pH on the efficiency of growth by pure cultures of rumen bacteria in continuous culture. Appl. Environ. Microbiol. 39:604.
- SAS. 1982. SAS User's Guide: Statistics. Statistical Analysis System Institute, Inc., Cary, NC.
- Schingoethe, D. J., F. C. Ludens and T. Sahlu. 1984. Lactational response to a feed supplement containing fermentation products, cobalt, dextrose, and lactose. J. Dairy Sci. 67:2460.
- Shokair, M. H. and M. J. Arambel. 1988. Effect of feeding a viable yeast culture on ruminal fermentation characteristics and nutrient digestibility. (Unpublished).
- Slyter, L. L., M. P. Bryant and M. J. Molin. 1966. Effect of pH on population and fermentation in a continuously cultured rumen ecosystem. Appl. Microbiol. 14:573.

- Slyter, L. L., R. R. Oltijen, D. L. Kern and F. C. Blank. 1970. Influence of type and level of grain and diethylstilbestrol on the rumen microbial populations of steers fed all concentrate diets. *J. Animal Sci.* 31:996.
- Sniffen, C. J. 1986. Natural growth stimulators: micronutrient requirements of the rumen--the role of yeast cultures in the rumen. *Proc. Alltech's 2nd Annual Biotechnology Symposium*. Nicholasville, KY.
- Staples, C. R., R. L. Fernando, G. C. Fahey, Jr., L. L. Berger and E. H. Haser. 1984. Effects of intake of a mixed diet by dairy steers on digestion events. *J. Dairy Sci.* 67:995.
- Steel, R. G. and J. H. Torrie. 1980. *Principles and Procedures in Statistics*. McGraw-Hill, New York.
- Stewart, C. S. 1977. Factors affecting the cellulolytic activity of rumen contents. *Appl. Environ. Microbiol.* 33:497.
- Teh, T. H., T. Sahlu, E. N. Escobar and J. L. Cutshaw. 1987. Effect of live yeast culture and sodium bicarbonate on lactating goats. *J. Dairy Sci.* 70(Suppl. 1):200 (Abstr.).
- Terry, R. A., J. M. A. Tilley and G. E. Ouen. 1969. Effect of pH on cellulose digestion under in vitro conditions. *J. Sci. Fd. Agric.* 20:317.
- Uden, P., P. E. Colucci and P. J. Van Soest. 1980. Investigation of chromium, cerium and cobalt as markers in digesta. Rate of passage studies. *J. Sci. Food Agric.* 31:625.
- Underdahl, N. R. 1983. The effect of feeding Streptococcus faecium and Escherichia coli induced diarrhea in gnotobiotic pigs. *Prog. Fd. Nutr. Sci.* 7:5.
- Undersander, D. J., N. A. Cole and C. H. Naylor. 1987. Digestibility by lambs of water-stressed alfalfa as determined by total collection or internal marker. *J. Dairy Sci.* 70:1719.
- Van Soest, P. J. 1967. Development of a comprehensive system of feed analysis and its application to forages. *J. Animal Sci.* 26:119.

- Van Soest, P. J. 1982. Nutritional ecology of the ruminant. O & B Book, Inc., Corvallis, OR.
- Varga, G. a. and E. C. Prigge. 1982. Influence of forage specie and level of intake on rumen turnover rates. J. Animal Sci. 55:1498.
- Ware, D. R., P. L. Read and E. T. Manfredi. 1988. Lactation performance of two large dairy herds fed Lactobacillus acidophilus strain BT 1386 in a switchback experiment. J. Dairy sci. 71(Suppl. 1):219 (Abstr.).
- Warner, A. C. I. 1981. Rate of passage of digesta through the gut of mammals and birds. Nutr. Abstr. Rev. 51:789.
- Wiedmeier, R. D. 1986. Manipulation of ruminal fermentation and nutrient utilization in cattle fed energy dense diets. Ph.D. Dissertation. Utah State University, Logan, Utah.
- Wiedmeier, R. D., M. J. Arambel and J. L. Walters. 1987. Effect of yeast culture on Aspergillus oryzae fermentation extract on ruminal characteristics and nutrient digestibility. J. Dairy Sci. 70:2063.
- Yokoyama, M. T. and K. A. Johnson. 1988. Microbiology of the rumen and intestine. In: D. C. Church (Ed.). The Ruminant Animal Digestive Physiology and Nutrition. pp 125-144. Prentice Hall, Englewood Cliffs, NJ.
- Zinn, R. A. 1988. Probiotics in receiving diets for feedlot cattle. Conference Proc., Southwest Nutrition and Management Conference, Univ. of Arizona, pp 98-103. Tempe, AZ.
- Zinn, R. A., D. Axe, J. R. Dunbar and B. B. Norman. 1985. Lactobacillus supplementation of receiving diets for feedlot calves. Calif. Feeders Day Report, pp 106-118.



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