Role of probiotics in rumen fermentation and animal performance: A review

Kassa Shawle Retta

Department of Animal and Range Sciences, Wolaita Sodo University, P. O. Box 138, Wolaita Sodo, Ethiopia.

Received 5 January, 2016; Accepted 15 March, 2016

Probiotics, live cells with different beneficial characteristics have been extensively studied and explored commercially in many different products in the world. Their benefits to human and animal have been supported in hundreds of scientific papers. Ruminant animals principally depend on microbial degradation of their feed rather than on direct enzyme degradation as in most non-ruminants. Microbial feed additives used in ruminant feeds are mainly for stabilization of the intestinal flora, enhance the development of the adult rumen microflora, improve digestion and nitrogen flow towards lower digestive tract, and improve meat and milk production. Beneficial microorganisms supply protein, vitamins and short-chain organic acids for the animal host. In a normally functioning ruminant, little or none of the sugars and proteins originally present in the feed are directly incorporated into the animal: they are first processed by bacterial fermentation in the rumen. Given the importance of the microbial population in feed conversion, it is also important in manipulating rumen fermentation to boost animal productivity and reduce the productivity loss that is associated with rumen acidosis. Probiotics administration improves the health status of the animal by competing the nutrient utilization of the pathogenic microbes by having a positive influence on gut microflora. Furthermore, their anti-pathogenic activity may reduce the stress on animal. Microorganisms that are used in direct fed microorganisms for ruminants may be classified as lactic acid producing bacteria, lactic acid utilizing bacteria, or other microorganisms and yeasts. However, numerous contradictory reports, such as dosages, dietary and management constraints, and effects on different animal conditions have been shown to markedly affect the structure and activities of gut microbial communities in ruminant animals. Therefore, this review article is an attempt to summarize the mode of actions and the effects of feeding probiotics on different aspects of health and productivity of ruminant animals.

Key words: Bacteria, fiber degradation, probiotics, ruminant, yeast

INTRODUCTION

Probiotics are live microorganisms that may beneficially affect the host upon ingestion by improving the balance of the intestinal microflora (Fuller, 1989). They are non-pathogenic microbes that occur in nature and the gastrointestinal tract of ruminants (Dunne et al., 1999). Currently, the use of probiotic additives has been
developed as alternatives to antibiotics to improve animal health and productivity (Allen et al., 2013). This appears to be strongly driven by the ban of most of the antibiotic feed additives within the European Union, because of speculated risk for generating antibiotic resistance in pathogenic microbiota (Windisch et al., 2008), chemical residues in animal products, release of antibiotics into the environment (Yamamoto et al., 2014; Martínez-Vaz et al., 2014) and also the advent of present day organic agriculture.

Ruminants rely on a symbiosis between the host and the rumen microbes, with the microorganisms supplying protein, vitamins and short-chain organic acids for the animal host (Pinloche et al., 2013). The energy absorbed, glucose formed in the liver, and the protein digested in the abomasum are all mainly derived from microbial origins. In a normally functioning ruminant, in fact, as much as 90% of the protein that reaches the small intestine and up to 50% of the host energy requirement is provided by the microbial cells of the reticulo-rumen (Russell, 2002). The microbial communities are involved in the digestion and fermentation of plant polymers, which is of particular importance in mature herbivorous animals (Uyeno et al., 2015).

Probiotics, in general as reported by different authors, have the ability to enhance intestinal health by stimulating the development of a healthy microbial ecosystem (Uyeno et al., 2015; Musa et al., 2009), increase digestive capacity and their bio-availability (Oyetayo and Oyetayo, 2005), prevent enteric pathogens from colonizing the intestine (Casas and Dobrogosz, 2000), restore the gut microflora (Musa et al., 2009), lower pH, and improve mucosal immunity and nutrient absorption (Timmerman et al., 2005; Uyeno et al., 2015). As a result they are supposed to improve the productivity and the general health of ruminants. Therefore, this review briefly elaborates the effects of probiotics feeding on nutrient intake, digestibility, health and growth performance of ruminant animals.

**MICROORGANISMS USED AS PROBIOTICS**

The major and frequently studied bacterial microorganisms used as probiotics in ruminant production include those derived from *Lactobacillus*, *Streptococcus*, *Entrococcus*, *Bacillus*, *Clostridium*, *Bifidobacterium* species, *Propionibacterium*, *E.coli Nissle 1917* (Kruis et al., 2004), *Megasphaera elsdenii* and *Prevotella bryantii* (Seo et al., 2010). The bacterial probiotic strains can be classified as lactic acid producing (LAB) and lactic acid utilizing bacteria (LUB). Lactic acid production and utilization in the rumen is related to feed efficiency and animal health (Seo et al., 2010). Yeasts and fungal probiotics such as *Saccharomyces* and *Asperillus* respectively have given better results in adult ruminants (Fuller, 1999; Seo et al., 2010).

The combinations of probiotics strains could increase the beneficial health effects compared with individual strains, because of their synergetic adhesion effects (Collado et al., 2007).

**CHARACTERISTICS OF A GOOD PROBIOTIC**

According to the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) (2002), probiotics are defined as live microorganisms, which when administered in adequate amounts, confer a health benefit on the host. This definition of probiotics is also adopted by the International Scientific Association for Probiotics and Prebiotics and is used in most scientific publications. A number of criteria are used to select probiotic strains. According to Fuller (1989) an effective probiotic should be a strain that is capable of exerting a beneficial effect on the host animal, increased growth or resistance to disease, non-pathogenic and non-toxic, should be present as viable cells, and capable of surviving and metabolizing in the gut environment (resistant to low pH and organic acids). Moreover, they should compete along with a highly-diverse and competitive environment presented by the gut microflora (Bezkorovainy, 2001); adhere to the intestinal epithelial cell lining (Guarner and Schaffaaf, 1998); produce antimicrobial substances towards pathogens; remain viable during storage and use; have good sensory properties; be isolated from the same species as it is intended to use (Collins and Gibson, 1999). However, the results obtained in field trials have been variable.

**PROBIOTICS MECHANISM OF ACTION**

Some proposed mechanisms of probiotics when fed to the host animals were:

(i) Production of a wide variety of antimicrobial substances (Vandenbergh, 1993) and inhibitory metabolites such as organic acids, bacteriocins, diacetyl, antibiotics and H$_2$O$_2$ (Rolfe, 2002);

(ii) Competition with the pathogen for adhesion sites or nutritional sources (Guillot, 2003); the presence of some bacteria in the intestinal tract is dependent on their ability to adhere to the gut epithelium, such that they become immobilized on the gut wall and resist being flushed out by peristalsis, as well as occupying a niche at the expense of potentially harmful organisms (Fuller, 1992; Fooks and Gibson, 2002);

(iii) Production of nutrients (e.g. amino acids, vitamins) or other growth factors stimulatory to other microorganisms in the digestive tract and the host animal;

(iv) Immunomodulation of the host (Isolauri et al., 2001);

(v) Production and stimulation of enzymes.
(vi) Metabolism and/or detoxification of undesirable compounds.

There are marked differences between the various probiotic groups regarding their properties and mode of action. Lactic acid producing bacteria (LAB) (e.g. Lactobacilli and Enterococci) provide a constant lactic acid supply in the rumen, helps the overall microflora to adapt the lactic acid accumulation, stimulate lactate utilizing bacteria (LUB) (Yoon and Stern, 1995) and stabilize ruminal pH (Seo et al., 2010). Whereas, LUB (e.g. M. elsdonii) has been used to decrease concentration of lactate by converting to volatile fatty acids (VFA) and maintain ruminal pH when fed a highly fermentable diet in transition animals (Kung and Hession, 1995). Propionibacteria ferments lactate to propionate, and an increase of propionate production in the rumen results in increases of glucose production (Stein et al., 2006), providing more substrates for lactose synthesis, improving energetic efficiency and reducing ketosis (Weiss et al., 2008).

Enterotoxin-producing strains of E. coli attach to intestinal epithelial cells and mucus to induce diarrhea. Lee et al. (2003) discovered that L. rhamnosus GG could attach to epithelial cells via hydrophobic interactions and limit pathogens from attaching to the enterocytic receptor. Lactate produced by LAB also has critical roles in penetrating microbial cells and interfering with essential cell function to reduce intracellular pH (Holzapfel et al., 1995). Hydrogen peroxide produced by LAB can oxidize on the bacterial cell, on sulfhydryl groups of cell proteins and on membrane lipids (Dicks and Botes, 2010); thereby blocking glycolysis due to the oxidation of sulfhydryl groups in metabolic enzymes (Carlsson et al., 1983). Holzapfel et al. (1995) suggested that LAB produced hydrogen peroxide, which effectively inhibited S. aureus and Pseudomonas spp. Various strains of LAB also activate macrophages to produce cytokines that stimulate immune response (Dicks and Botes, 2010).

Increases in bacterial numbers recovered from the rumen are the most reproducible effects of dietary yeast supplementation. Yeasts remove oxygen in the rumen (Newbold et al., 1996). Yeast cells in the rumen use available oxygen on the surfaces of freshly ingested feed to maintain metabolic activity (Newbold et al., 1996). This creates better conditions for the growth of strict anaerobic cellulolytic bacteria, stimulates their attachment to forage particles, and increases the initial rate of cellulolysis (Seo et al., 2010). In addition, Saccharomyces cerevisiae is able to compete with other starch utilizing bacteria for fermentation of starch (Lynch and Martin, 2002) leading to the prevention of lactate accumulation in the rumen and had the ability to provide growth factors, such as organic acids or vitamins, thereby stimulating ruminal populations of cellulolytic bacteria and LUB (Chaucheyras et al., 1995). As a result they can improve the ruminal end products (VFA, rumen microbial protein), increase ruminal digestibility and reduce excess lactic acid in the rumen.

**PRACTICAL EFFECTS OF PROBIOTICS IN ANIMAL PERFORMANCE AND HEALTH**

**Nutrient intake**

The more feed an animal consumes each day, the greater will be the opportunity for increasing its daily production. Probiotic supplementation has been found to increase feed intake (Chiofalo et al., 2004; Antunovic et al., 2006; Desnoyers et al., 2009) and is known to influence the performance of ruminants. The reason for increased feed intake and performance is due to improved cellulolytic bacteria in the rumen-fed probiotics fortified diets (Wallace and Newbold, 1993) and their positive effect on ruminal pH, leading to improved fiber degradation and dry matter intake (Umberger and Notter, 1989). For instance, Lactobacillus plantarum splits certain carbohydrates into simpler substances like glucose, which provides energy and Aspergillus oryzae helps in producing enzymes that are involved in carbohydrate/fiber digestion leading to improved animal performance (Khalid et al., 2011). The increase in productivity is often associated with an increase in feed intake (Fiems, 1994).

**Nutrient digestibility**

Probiotics for ruminants have mainly been selected to improve various ruminal digestion by increasing pH in the rumen (Mohamed et al., 2009), fiber digestion (El-Waziry and Ibrahim, 2007) and the synthesis of microbial proteins (Uyeno et al., 2015). Probiotics enhance growth and/or cellulolytic activity by rumen bacteria and prevent ruminal acidosis by balancing the VFAs ratios in the rumen (Arcos-Garcia et al., 2000). Supplementation of yeast culture in the diets of Awassi lambs resulted in higher dry matter (DM), organic matter (OM), apparent crude protein (CP) and neutral detergent fiber (NDF) digestibility (Haddad and Guossous, 2005). Whitley et al. (2009) also reported improved apparent DM, CP, NDF and ADF digestibility in meat goats fed diet supplemented with commercial probiotics than control group. Abd El-Ghany (2004) observed that bucks fed a diet containing yeast culture supplements had higher nutrient digestion compared to those fed a concentrate and roughage diet. The positive effect and mode of actions of yeast products are generally considered to involve changes in rumen fermentation rates and patterns. Certain strains of active dry yeast are particularly effective at raising and stabilizing ruminal pH by stimulating certain populations of ciliate protozoa, which rapidly engulf starch and, thus, effectively compete with amylolytic lactate-producing bacteria.
bacteria (Thrune et al., 2009; Nocek, and Kautz, 2006). A less acidic ruminal environment has been shown to benefit the growth and fiber-degrading activities of cellulolytic microorganisms (Mosoni et al., 2007; Chung et al., 2011). Yeast also has the potential to alter the fermentation process in the rumen in a manner that reduces the formation of methane (\(\text{CH}_4\)) gas (Chung et al., 2011). Therefore, it is concluded that probiotic supplementation in the diet may result in improved nutrient digestibility.

### Improved growth rate

Probiotic strains administered separately, or in combination, significantly improved feed intake, feed conversion rate, daily weight gain and total body weight in sheep, goat and cattle (Casey et al., 2007; Stein et al., 2006) (Table 1). Probiotics improve microbial ecology (Musa et al., 2009), nutrient synthesis and absorption, nutrient bioavailability and stabilized ruminal pH and lactate resulting in better weight gain in farm animals (Mountzouris et al., 2007; Oyetayo and Oyetayo, 2005). Probiotic supplementation in lambs resulted increased weight gain (Jang et al., 2009). Higher weight gain as compared to the control could be due to improved microbial protein synthesis leading to more amino acids supply at post-ruminal level (Erasmus et al., 1992) or it might be related to higher consumption and better feed efficiency in the probiotics supplemented group (Antunovic et al., 2006). Better weight gain in ruminants might be also due to more cellulolytic activity resulting in improved fiber degradation (Russell and Wilson, 1996) because of reduced activity of more ammonia producing microbes that made the protein available for absorption at the postruminal level. *Bacillus licheniformis* and *Bacillus subtilis* fed cows showed a higher average daily gain and final live weight gain (Kowalski et al., 2009). Fiems (1994) also reported that on average the addition of *S. cerevisiae* to the diet lead to a 9.5 and 7.8% increase in live weight gain in calves and growing adult cattle, respectively, and these were often associated with an increase in feed intake.

### Milk yield and composition

Probiotics supplemented animals have a beneficial effect on subsequent milk yields, fat and protein content (Kritas et al., 2006) (Table 1). Fiems (1994) reported that on average the addition of *S. cerevisiae* to the diet lead to a 3.9% response in milk yield in lactating cattle. The review of Williams and Newbold (1990) noted that 8 trials with *A. oryzae* produced an average 4.3% improvement in milk yield and a similar analysis of yeast culture trials resulted in an average improvement of 5.1%. Wallace and Newbold (1993) summarized 19 results from different lactation studies with yeast and concluded that the response ranged from a 6.8% decrease to a 17.4% increase in milk yield. The increase in milk production, milk Solids-Not-Fat and milk protein percentages in dairy cows were associated with the numbers of cellulolytic bacteria, fiber degradation and changes in volatile fatty acid in the rumen (Martin and Nisbet, 1990). Gomez-Basauri et al. (2001) observed an increase in milk production when feeding cows a mixture of *Lactobacillus acidophilus*, *Lactobacillus casei* and *Enterococcus faecium*. Stein et al. (2006) also reported an 8.5% increase in 4% fat corrected milk in cows receiving 6 x 10^{10} *Propionibacterium* /day from 2 weeks pre-partum to 30 weeks post-partum (Table 1). Nocek et al. (2003) observed an increased dry matter intake (2.6 kg/day) and increased milk yield (2.3 kg/day). According to Lehoeny et al. (2007), a 9% increase in milk yield was observed when a mixture of yeast and *Propionibacterium* was fed to dairy cows from 2 weeks pre-partum to 30 weeks post-partum. However, according to Putnam et al. (1997) milk yield of dairy cows was increased with addition of yeast but only when protein content was deficient in the diet.

### Meat production

Probiotic supplements were also shown to increase carcass output and water holding capacity, and decrease cooking loss and meat hardness (Ceslovas et al., 2005). Abdelrahman and Hunaite (2008) noticed higher dressing percentage by lambs fed diets supplemented with probiotics. Lactate-utilizing or lactate-producing bacteria did not affect the marbling and dressing percentage (Ware et al., 1988). However, higher (2%) values for back fat thickness in response to probiotics supplementation in goats, as compared to control, were reported by Whitley et al. (2009). Similarly, Pelicano et al. (2005) reported 11.6% higher values for fat in animals supplemented with probiotics. This change in body fat may be because of changes in relative concentration of VFAs resulting in more lipogenesis and fat distribution in different tissues of the body (Elam et al., 2003). 

### Reduction in the pathogens load and enhance the immune response

The indigenous intestinal bacteria inhibit pathogens by competing for colonization sites (Chaucheys-Durand et al., 2008) and nutritional sources, and production of toxic compounds or stimulation of the immune system (Paravez et al., 2006). These mechanisms are not mutually exclusive and inhibition may comprise one or all of these mechanisms (Chaucheys-Durand et al., 2008; Chiquette, 2009). The protection included a ten-fold increase in survival rate, significantly higher post-challenge feed intake and weight gain and reduced
Table 1. Effect of some direct fed microbial probiotics in ruminants.

<table>
<thead>
<tr>
<th>Microbial probiotics</th>
<th>Ruminant</th>
<th>Effect</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-species probiotic</td>
<td>Young cattle</td>
<td>Improved weight gain</td>
<td>Bayatkoushar et al. (2013)</td>
</tr>
<tr>
<td>Yeast culture</td>
<td>Holstein heifers</td>
<td>Improved health</td>
<td>Moya et al. (2009)</td>
</tr>
<tr>
<td>Enterococcus faecium Yeast</td>
<td>Cow</td>
<td>Consumed more DM, and produced 2.3 kg more milk/cow per day.</td>
<td>Nocek and Kautz (2006)</td>
</tr>
<tr>
<td>Enterococcus faecium</td>
<td>Cow</td>
<td>First lactation cows produced more milk fat % and second lactation cows received fewer antibiotic treatments.</td>
<td>Oetzel et al. (2007)</td>
</tr>
<tr>
<td>Saccharomyces cerevisiae</td>
<td>Cow</td>
<td>Increased milk fat %, concentration of acetate, butyrate, and decreased lactate conc. 2 to 3 h after feeding.</td>
<td>Chiquette et al. (2008)</td>
</tr>
<tr>
<td>Prevotella bryantii</td>
<td>Cow</td>
<td>Feeding P169 tended increased molar proportions of propionate, however did not affect ruminal digestibility, microbial N synthesis, or particulate passage rates.</td>
<td>Lehoeyna et al. (2008)</td>
</tr>
<tr>
<td>Propionibacterium strain P169 Yeast</td>
<td>Cow</td>
<td>Milk yield and protein were increased by supplementation of bacilli.</td>
<td>Qiao et al. (2009)</td>
</tr>
<tr>
<td>Bacillus licheniformis</td>
<td>Holstein cows</td>
<td>Both probiotics enhanced humoral immunity.</td>
<td>Roos et al. (2010)</td>
</tr>
<tr>
<td>Bacillus subtilis</td>
<td>Sheep</td>
<td>Both probiotics enhanced humoral immunity.</td>
<td></td>
</tr>
<tr>
<td>Lactobacillus spp.</td>
<td>Calves</td>
<td>Reduced scouring</td>
<td>Beeman (1985)</td>
</tr>
<tr>
<td></td>
<td>Lambs</td>
<td>Improved feed intake/Live weight gain</td>
<td>Lee and Batts (1988)</td>
</tr>
<tr>
<td>Lactobacillus acidophilus</td>
<td>Calves</td>
<td>Lower mortality</td>
<td>Umberger et al. (1989)</td>
</tr>
<tr>
<td></td>
<td>Calves</td>
<td>Improved feed intake/Live weight gain</td>
<td>Cruywagen et al. (1996)</td>
</tr>
<tr>
<td>Bifidobacterium pseudolongum</td>
<td>Calves</td>
<td>Both strains improved ADG, feed efficiency and reduced diarrhea incidence.</td>
<td>Abe et al. (1995)</td>
</tr>
<tr>
<td>Lactobacillus acidophilus</td>
<td>Calves</td>
<td>Improved feed intake/Reduced scouring</td>
<td>Tournut (1989)</td>
</tr>
<tr>
<td>Streptococcus faecium</td>
<td>Calves</td>
<td>Improved feed intake/Live weight gain</td>
<td>Hughes (1988)</td>
</tr>
<tr>
<td>Saccharomyces cerevisiae</td>
<td>Calves</td>
<td>Improved feed intake/Live weight gain</td>
<td>Jordan and Johnston (1990)</td>
</tr>
<tr>
<td></td>
<td>Lambs</td>
<td>Improved feed intake/Live weight gain</td>
<td></td>
</tr>
<tr>
<td>Aspergillus oryzyae</td>
<td>Calves</td>
<td>Decreased effects of transport stress</td>
<td>Phillips and von Tungeln (1985)</td>
</tr>
<tr>
<td></td>
<td>Calves</td>
<td>Improved feed intake/Live weight gain</td>
<td>Beharka et al. (1991)</td>
</tr>
<tr>
<td>Bacillus licheniformis</td>
<td>Holstein calves</td>
<td>Higher ADG, final live weight.</td>
<td>Kowalski et al. (2009)</td>
</tr>
<tr>
<td>Bacillus subtilis</td>
<td>Sheep and lambs</td>
<td>Treated group have lower mortality and produced significantly more milk.</td>
<td>Kritas et al. (2006)</td>
</tr>
</tbody>
</table>

Pathogen translocation to visceral tissues (Shu et al., 2000). Chiquette (2009) noted that lactic acid production by bacterial probiotics creates an acidic environment detrimental to pathogens. In addition, the production of bacteriocins by some probiotic strains (such as E. faecium) helps maintain intestinal health by inhibiting the growth of similar or closely related bacterial strains (Chiquette, 2009). Peterson et al. (2007) reported that L. acidophilus strains reduced the shedding of E. coli O157:H7 in cattle as sited by Chiquette, (2009). According to Chiquette (2009), in vitro studies have shown decreased growth and viability of both E. coli O157:H7 and Listeria monocytogenes when cultured in the presence of yeasts. S. boulardii was reported to be effective against Salmonella and E. coli and degrade the toxin produced by Clostridium difficile (Chiquette, 2009).

The intake of probiotics also has been associated with beneficial effects on the immune system, such as improved disease resistance and reduced risk of allergies. Probiotics in a healthy animal stimulate nonspecific immune response and enhance the system of immune protection (Ceslovas et al., 2005). The probiotics that enhance immunoglobulin levels have more positive effect on growth performance, production and ability to resist disease (Getin et al., 2005).

Stabilization of ruminal pH

According to Chiquette (2009), in adult ruminants, probiotics are recommended in situations where there is microbial imbalance, such as in the transition period.
when the diet changes from a high forage-based diet to a high concentrate-based diet. Concentrates are rapidly fermented in the rumen and they lead to a rapid accumulation of VFAs, which contribute to decrease ruminal pH if rumen buffering systems are unable to counteract their impact. Low rumen pH for prolonged periods can negatively affect feed intake, microbial metabolism, and nutrient degradation, and leads to acidosis, inflammation, laminitis, diarrhea, milk fat depression (Chaucheyras-Durand et al., 2012) and further reduce cellulolytic bacteria in the rumen. High levels of acid further reduce rumen motility and efficacy of mixing of contents, which acts to reduce the levels of VFA near the rumen wall. When ruminal pH is below 6.0, the activity of cellulolytic bacteria is seriously decreased and the number of protozoa declines. Among the microbial changes associated with low ruminal pH is an increase in the number of bacteria that are low pH-tolerant such as lactate producers and lactate users (Chiquette, 2009).

Lactate is a common product of carbohydrate fermentation, produced by bacterial lactate producer species such as *Streptococcus bovis* (Chiquette, 2009), *Selenomonas ruminantium*, *Mitsuokella multiacidus*, *Lachnospira multipara* or *Lactobacillus* sp. and *S. bovis* from high fermentable diets (Chaucheyras-Durand et al., 2012). *M. elsdenii* (Chiquette, 2009) and *Selenomonas ruminantium* sub sp (Chaucheyras-Durand et al., 2012) are considered as the predominant lactate utilizing bacterial species found in large numbers in the rumen of cereal grain-fed cattle; they can be useful to positively balance the rumen microbiota, stabilize rumen pH, and promote microbial degradation of plant cell walls. Lactate producing bacterial spp. Such as *Lactobacillus* and *Enterococcus* supplemented dairy cows showed increased mean daily pH and decreased time during which ruminal pH was below 5.5 (Nocek, 2002). The underlying principle is that by providing a constant supply of lactate in the rumen, lactate utilizing bacteria are stimulated and the overall microflora can adapt to the presence of a higher concentration of lactate (Chiquette, 2009).

Yeasts have also been shown to regulate the ruminal pH and limit acidosis risks via interactions with lactate producing and lactate utilizing bacteria (Michalet-Doreau and Morand, 1996). Yeast is shown to play a role in decreasing ruminal lactate concentration in case of acidosis (Lynch and Martin, 2002) either by competing with *S. bovis* for fermentation of starch or by stimulating ruminal populations of lactate-utilizing bacteria. Certain *S. cerevisiae* strains are able to supply nutrients, that is peptides, vitamins, organic acids and cofactors which may be required by the lactate utilizing bacteria (Girard, 1996) and can utilize soluble sugars more efficiently than lactate producing bacteria. Yeasts are also able to stimulate the protozoa *Entodiniomorphs* known to engulf starch granules and delay fermentation.

**Increase the rate of establishment of cellulolytic populations in the rumen**

At birth the young ruminants acquire microflora rapidly from his mother’s saliva, feces and that of other animals (Chaucheyras-Durand et al., 2008). The prolonged contact between the mother and her young is more frequent in small size farming systems. In more intensive dairy systems the calf is rapidly separated from the mother and is often introduced to solid feed before the succession of all microbial populations is completed (Fonty et al., 1987). This situation leads to an imbalanced microbial flora making the young ruminant more prone to suffer from various infections. Gastrointestinal disorders are one of the most important sources of economic loss in pre-ruminant animals. In a study with lambs, Chaucheyras-Durand and Fonty (2001) reported that the rate of cellulolytic establishment was greater in lambs receiving *S. cerevisiae* daily compared with control lambs. The cellulolytic population was also more stable in the supplemented animals, because protozoa feed on rumen bacteria and they only appear in the rumen once the bacterial population is present. Chaucheyras-Durand and Fonty (2002) observed that protozoa appeared earlier in lambs supplemented with *S. cerevisiae* than in control lambs.

**Improve fiber degradation in the rumen**

Fibrolytic probiotics have more often been used to improve digestive function in adult ruminants (Kumar and Sirohi, 2013; Præsteng et al., 2013), as well as for pre-weaned ruminants (Sun et al., 2010). Cellulose is degraded in the rumen by a specific bacterial population because the animal host does not possess the enzymes required to breakdown cellulose. Yeasts were shown to stimulate cellulolytic populations in the rumen and increase their enzymatic activity (Chiquette, 2009). This effect on the cellulolytic population is believed to be the result of yeast scavenging ruminal O₂ which is detrimental to those populations (Newbold et al., 1996) thereby creating a more optimal environment for anaerobic bacteria. Feeding *S. cerevisiae* has increased the number of rumen protozoa in steers fed straw-based diets, which improved NDF digestibility (Plata et al., 1994). Yeasts are also reported to release vitamins and other growth factors (organic acids, B-vitamins and amino acids) that are essential for the growth of cellulolytic bacteria (Chiquette, 2009).

**CONCLUSIONS**

Probiotics have a positive effect in ruminant animal production by improving their performance and health. Probiotics may improve the ecology of ruminal microflora,
increase the ruminal pH, and decrease clinical and subacute acidosis. Probiotics enhance the growth of many domestic animals, improve the efficacy of forage digestion and quantity and quality of milk and meat. Probiotics also may protect animals against pathogens, enhance immune response, reduce antibiotic use and morbidity or mortality and increase benefits for the consumer through improved product quality. However, probiotics used as feed additives may differ from one another in their effects, properties, origin and mode of actions. A combination of probiotics with different mechanisms of action could provide better result and the potentiated probiotics are more effective than their components separately. Undesirable microorganisms are thus reduced and protection is given against colonization or attachment of harmful microorganisms. Probiotics therefore contribute to averting any disruption of the intestinal microflora as may occur during specific growing periods and situations of specific stress for the animals. However, their mode of action, their environment, their biological requirement and their interactions and competition needs more knowledge to identify new and more efficient probiotics.

Conflict of Interests

The author has not declared any conflict of interests.

REFERENCES


Elam NA (2003). Effects of live cultures of Lactobacillus acidophilus
(strains NP45 and NP51) and Propionibacterium freudenreichii on performance, carcass, and intestinal characteristics, and Escherichia coli O157 shedding of finishing beefs. J. Anim. Sci. 81:2686-2692.


