African Journal of Agricultural Research Vol. 6(23), pp. 5198-5203, 19 October, 2011
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1134
ISSN 1991-637X ©2011 Academic Journals

Review

Probiotics and lamb performance: A review

Khalid, M. F.[1]*, Shahzad, M. A.[2], Sarwar, M.[2], Rehman, A. U.[2], Sharif, M.[2] and Mukhtar, N.[3]

[1]University of Agriculture, Faisalabad, Toba Tek Singh Campus-Pakistan.
[2]Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad-Pakistan.
[3]Department of Poultry Science, University of Arid Agriculture, Rawalpindi-Pakistan.

Accepted 11 October, 2011

Probiotics are naturally occurring microbes, which upon administration improve the health status of the animal by competing with the pathogenic microbes and nutrient utilization by having a positive influence on gut microflora. Addition of probiotics in the lamb's diet has been reported to improve feed utilization and growth performance of the animals. The exact mechanism through which they affect the animal performance is not well known. However, it is stated that they work synergistically with the ruminal microbes. They also increase the ruminal pH, which favours the growth of cellulolytic bacteria. Improvement in the colonization of cellulolytic bacteria may result in improved digestion process and nitrogen flow towards lower digestive tract. Furthermore, their anti-pathogenic activity may reduce the stress on animal. Because of higher profit margin in intensive small ruminant production, farmers are shifting from tradition to high input feeding systems. In order to harvest, real benefits from small ruminants which are raised on nutrient rich diet, feed additives like probiotics are used to enhance the efficiency of nutrient utilization in growing ruminants. However, reports regarding the effect of probiotics administration on growing and fattening performance and carcass characteristics of the lambs are inconsistent. This might be related to the type and level of probiotics used and ingredient composition of the experimental diet. Thus, further research to understand the interaction of direct fed microbials with ruminal microbes is to have better understanding about adequate dose level at particular stage of lamb growth. This short review article is an attempt to recapitulate the effects of feeding probiotics on different aspects of lamb production which directly or indirectly influence the productivity and hence profitability associated with this enterprise.

Key words: Probiotics, lambs performance, microbial growth.

INTRODUCTION

Probiotics are non-pathogenic microbes which occur in nature and the gastrointestinal tract of ruminants, where they exert a positive influence on the host physiology (Dunne et al., 1999). Probiotics improve microbial ecosystem (Sandine, 1979; Musa et al., 2009), nutrient synthesis and their bio-availability resulting in better growth performance in farm animals (Oyetayo and Oyetayo, 2005). In addition to that probiotics also improve nutrient absorption (Teeler and Vanabelle, 1991), reduce the incidence of intestinal infection (Casas and Dobrogosz, 2000) and restore the gut microflora in case of diarrhoea (Musa et al., 2009). They are also known to increase ruminal pH (Umberger and Notter, 1989), total volatile fatty acids (VFAs) and ruminal biomass (Newbold et al., 1996) and thus influence the cellulolytic activity and microbial protein synthesis and fiber degradation (Martin and Nisbet, 1990; Yoon and Stern, 1996). It is also considered that they compete with other pathogenic micro-organisms for the provision of nutrients and other growth factors (Rolfe, 2000).

They enhance immunity (Aattouri et al., 2001) by promoting the antibodies, IgA and cytokines production (Trebichavsky and Splichal, 2006). A positive impact of probiotics supplementation on nutrient intake, weight gain and feed conversion ratio (FCR) in ruminants has been reported by many workers (Chiofalo et al., 2004; Antunovic et al., 2006; Whitley et al., 2009). However, the actual mechanism through which probiotics improve animal performance is not known (Koop-Hoolihan, 2001).

*Corresponding author. farooq325@uaf.edu.pk. Tel: +92 300 6562494.

However, different environmental factors may affect the gut microbial ecology; they include diet, medication, stress, age and general living conditions (Vlková et al., 2009). Positive effects of probiotics on the rumen environment and performance of ruminants have been intensively studied because they can beneficially modify microbial activities, fermentative and digestive functions in the rumen. It is further stated that probiotics can stimulate specific groups of beneficial bacteria in the rumen, and has provided mechanistic models that can explain their effects on animal performance (Dutta et al., 2009).

This short review article briefly elaborate the effects of probiotics feeding on nutrients intake, digestibilities, nitrogen balance, blood metabolites and growth performance in growing lambs.

Nutrient intake

Diet composition and probiotics supplementation are known to influence the performance of ruminants. Probiotics supplementation has been found to increase feed intake (Chiofalo et al., 2004; Antunovic et al., 2005, 2006; Desnoyers et al., 2009). Similarly, Chademana and Offer (1990) reported a promoting role of probiotics on dry matter intake (DMI) and fiber degradability. This might be because of improved cellulolytic bacteria in the rumen of lambs fed probiotics supplemented diets (Wallace and Newbold, 1993). Other possible reason for increased DMI in response to probiotics supplementation may be their positive effect on ruminal pH, leading to improved fiber degradation and DMI (Umberger and Notter, 1989). *Lactobacillus plantarum* splits certain carbohydrates into simpler substances like glucose, which provides energy. *Apergillus oryzae* helps in producing enzymes that are involved in carbohydrate/fiber digestion leading to improved animal performance.

Titi et al. (2008) observed that supplementation of yeast culture in the diets of lambs and kids had no effect on DMI.

Likewise, Hernandez et al. (2009) noticed no change in DMI of lambs fed grass diets which contain probiotics. Haddad and Goussous (2005) also reported similar findings. Kiesling et al. (1982) added lactobacillus culture to the diet of steers for a 209 day finishing period and found no difference in DMI among the treated and controlled group. In the same way, Swinney-Floyd et al. (1999) fed *Propionibacterium* and *Lactobacillus* spp. independently or in a combination and found that treatments did not influence DMI in calves. The DMI was not affected in feed lot cattle fed high concentrate diets; however supplementation with *Propionibacterium* P15 resulted in an increase in protozoal numbers with associated increase in ruminal ammonia concentration and a decrease in the number of amylolytic bacteria compared with the un-supplemented group (Ghorbani et al., 2002). In conclusion, supplementation of probiotics may influence DMI by affecting ruminal pH and digestion of the nutrients.

Nutrient digestibility

Probiotics improve nutrient digestibility (Abd El-Ghani, 2004), degradation of fiber (El-Waziry and Ibrahim, 2007) and ruminal digestion (Kamel et al., 2004) more likely fiber degradation (Dawson and Tricarico, 2002) by increasing pH in the rumen (Mohamed et al., 2009; Paryad and Rashidi, 2009), enhancing growth and/or cellulolytic activity by rumen bacteria (Dawson and Tricarico, 2002) and preventing ruminal acidosis by balancing the VFAs ratios in the rumen (Arcos-Garcia et al., 2000). Haddad and Goussous (2005) reported that the supplementation of yeast culture (YC; Diamond V® YC) in the diets of *Awassi* lambs resulted in higher dry matter (DM), organic matter (OM) and apparent crude protein (CP) digestibility (678, 683 and 653 g/kg, respectively) compared to control (632, 645 and 589 g/kg, respectively).

Similarly, neutral detergent fiber (NDF) digestibility was also higher in the yeast culture supplemented group. Abd El-Ghani (2004) observed that bucks fed diet containing yeast culture supplements had higher nutrient digestion compared to those fed a concentrate and roughage diet. Krehbiel et al. (2003) reported that feed additives and direct-fed microbes improved digestibility of the diet. In contrast, Titi et al. (2008) reported that addition of probiotics (yeast culture) had no effect on DM, CP and NDF digestibility. However, in the same study, digestibility of OM and acid detergent fiber (ADF) increased in lambs and kids supplemented with yeast culture in the diet. 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. In conclusion, supplementation of probiotics in the diet may result in improved nutrient digestibility.

Blood metabolites

Blood urea nitrogen (BUN) concentration is indicative of renal function (Oltner and Wiktorson, 1983). Weaned lambs (60 days old) supplemented with 0.1% probiotics (PDFM®) had statistically lower concentration of glucose and BUN (Antunovic et al., 2005). Antunovic et al. (2006) also examined lower concentration of urea (5.51:7.97 mmol/l) in the blood serum of lambs fed diets with probiotics as compared to the control diets. Lower BUN in lambs containing probiotics could be due to improved utility of N in the rumen (Bruno et al., 2009) and lower blood glucose might be attributed to higher fiber digestion leading to more production of ketogenic moieties.

However, Abo El-Nor and Kholif (1998) reported higher BUN values in response to probiotics supplementation. This higher BUN concentration may be due to incapacity of ruminal microflora to detain the ammonia optimally (Butler, 1998). Whereas, other researchers reported no differences in BUN concentration when probiotics supplemented groups were compared with the control (Masek et al., 2008; Bruno et al., 2009).

Gluconeogenesis is a major source of glucose in lambs (Huntington and Eisemann, 1988) as it is responsible for the satisfaction of 75% of the total glucose needs in ruminants (Donkin and Hammon, 2005). Antunovic et al. (2006) reported unaltered blood glucose levels in the diets of lambs containing probiotics. While, Abo El-Nor and Kholif (1998) reported higher blood glucose concentration in cows fed diets containing probiotics. This increase in glucose concentration in the probiotics supplemented group might be related to a temperate improvement in gluconeogenesis and increased lactose absorption (de Valdez et al., 1997). However, no differences were noticed in blood glucose concentration in lambs fed diets with or without probiotics (Ding et al., 2008). Creatinine is produced in the muscle tissue and its normal concentration indicates the optimal physical activity. Belewu et al. (2008) noticed no change in creatinine in goats fed diets supplemented with probiotics. Likewise, Antunovicc et al. (2006) found similar results in growing lambs. Galip (2006) also found no difference in blood creatinine level in rams supplemented with probiotics.

Nitrogen balance

Probiotics supplementation improves the microbial activities in rumen resulting in enhanced NH_3 capture to synthesize microbial protein (Erasmus et al., 1992) and have profound influence in lambs (Jouany et al., 1998a). Probiotics alone or in combination increase the N-intake (Mohamed et al., 2009) and ruminal N pool (Jouany et al., 1998a). Probiotics have been reported to enhance the N-retention (Paryad and Rashidi, 2009) by enhancing microbial peptidolytic and proteolytic activities in the rumen (Cole et al., 1992), and post-ruminal amino acid flow (Enjalbert et al., 1999; Erasmus et al., 1992). This augmentation in post-ruminal amino acid flow has also been reported by other researchers (Putnam et al., 1997; Doreau and Jouany, 1998). However, Hernandez et al. (2009) reported no effect of probiotics supplementation on N-retention, N-intake and fecal and urinary N in lambs fed mature orchard grass. Jouany et al. (1998b) also reported no change in urinary N excretion in response to probiotics supplementation.

It is well documented that probiotics impart their favorable effects to ruminants even at post ruminal level. Positive effects of probiotics on nutrients intake may be attributed to numerous factors like they attach to the intestinal mucosa and prevents potential pathogen establishment leading to improved nutrient digestion which enhances dry matter intake (Seo et al., 2010). Furthermore, it is also stated that probiotics also help to maintain lower pH in the GIT, thereby inhibiting growth of pathogens and modulate microbial balance in the GIT and prevent illness caused by intestinal pathogens or stress (Dicks and Botes, 2010). Production of anti-bacterial compounds such as bacteriocin and hydrogen peroxide have also been reported to favour animal fed on diets containing probiotics (Frizzo et al., 2010). It has also been reported that probiotics may also help in reducing the load of undesirable microbes which may cause diseases in human being (Arthur et al., 2010). Favorable effects of probiotics on rumen fermentation which may ultimately improve the utilization of feed and thereby animal performance has also been observed in buffaloes (Malik and Bandla, 2010).

Growth performance

Feed additives like probiotics have been reported to improve FCR in ruminants (Robinson, 2002). Probiotics supplementation improves feed efficiency (Abdelrahman and Hunaiti, 2008). Probiotics improve microbial ecology (Sandine, 1979; Musa et al., 2009), nutrient synthesis and their bio-availability resulting in better weight gain in farm animals (Oyetayo and Oyetayo, 2005). Haddad and Goussous (2005) observed that the supplementation of yeast culture (YC; Diamond V® YC) in the diets of *Awassi* lambs resulted in higher weight gain (266 g/day) as compared to control (212 g/day). Similarly, Jang et al. (2009) found that the probiotics supplementation tended to increase weight gain in lambs. Higher weight gain in lambs fed diets containing probiotics could be due to augmented microbial protein synthesis leading to more amino acids supply at post-ruminal level (Erasmus et al., 1992). Body weight gain improved by 1.90% and daily gain by 2.50% in lambs fed diets with probiotics Bioplus 2B compared to the control group. Better weight gain may also be related to higher consumption and better efficiency of feed utilization in the probiotics-supplemented group (Antonovic et al., 2006). Lambs fed diets with Probios® had improved weight gain (24.7 and 6.4%) during the first two weeks and from the 2nd to 4th week (Pond and Goode, 1985).

In contrast, Titi et al. (2008) reported that yeast supplementation had no effect on growth rate in lambs and kids. Baranowski et al. (2007) also observed no difference in the mean daily live weight gain (238 g versus 225 g) in lambs fed diet supplemented with linseed and mineral bioplex than lambs fed control diet only. Feed conversion ratio also remained unchanged across the treatments. Whitley et al. (2009) found that growth performance of goats remained unaltered with probiotics supplementation, except in one growth trial in

which weight gain and FCR was higher in probiotics supplemented group compared with the control. Antunovic et al. (2005) reported that probiotics feeding improved daily gains and average body weights. Similarly, Abas et al. (2007) reported higher body weight gain in *Kivircik* male yearling lambs supplemented with direct feed microbial culture (Cylactin® LBC ME 10) than the control group. Mutassim et al. (2008) reported that supplementation of 2 g cyc-methionine/d resulted in significantly higher total body gain and average daily gain compared to control. Anandan et al. (1999) found significantly higher weight gain in the Cheghu crossbred kids fed the probiotics supplement (curds) orally @ 15 ml/day compared to the control (4.37 versus 3.15 kg and 44.6 versus 32.1 g/day) indicating that curds as probiotics may be supplemented for the improvement of growth performance of kids. Probiotics enhanced digestion and feed FCR and improved weight gain in small ruminants (Robinson, 2002). Higher weight gain in ruminants might be 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 post-ruminal level (Chaucheyras-Durand et al., 2008).

Adequate data on lamb production support that, supplementation of probiotics to the basal diet is effective and may be helpful to improve growth performance of the ruminants. Efficiency of feed utilization improved in growing lambs fed diets supplemented with probiotics (pioneer PDFM®) which indicated the biological changes in rumen (Antunovic et al., 2005). Antunovic et al. (2006) also reported better efficiency of feed utilization in lambs fed diets with probiotics compared to the diets without probiotics but the differences were statistically non-significant. Better efficiency of feed utilization was also noted in lambs fed diets containing Probios® during the 1st two weeks and from 2nd to 4th week (Pond and Goode, 1985).

Haddad and Goussous (2005) found that the supplementation of yeast culture (YC; Diamond V® YC) in *Awassi* lambs resulted in better FCR. Jang et al. (2009) noticed that the probiotics supplementation to the basal diet tended to improve FCR. Mutassim et al. (2008) found that supplementation of 2 g cyc-methionine/lamb/day showed better FCR compared to control, indicating that feeding *Awassi* lambs yeast and methionine in the form of cyc-methionine with low level of 2 g/day improves the efficiency of feed utilization. Swinney-Floyd et al. (1999) fed *Propionibacterium* and *Lactobacillus spp.* independently or in a combination and reported that FCR did not differ among various treatments.Above studies indicated that, supplementation of probiotics in the diet of ruminant animals improved FCR resulting in better gain.

Carcass characteristics

Reports regarding the effect of probiotic supplementation on carcass characteristics are inconsistent. Cassava waste diets treated with probiotics resulted in higher carcass weight as compared to the placebo (Belewu and Jimoh, 2005). However, no changes were observed in weights and proportions of carcass cuts in response to probiotics supplementation (Titi et al., 2008). Similarly, Whitley et al. (2009) reported that carcass weight and weights of various cuts (shoulder, loin, leg etc.) remained unaltered by probiotics supplementation in meat of goat. Probiotics supplementation to finishing diets did not influence carcass characteristics of ruminants (Kiesling et al., 1982). Belewu and Jimoh (2005) found no effect of probiotics supplementation on the weights of lungs, heart and kidney.

Mutassim et al. (2008) reported that supplementation of 2 g cyc-methionine/ lamb/day showed significantly higher dressing percentage (DP) compared to the control diet. Similar findings were reported by Belewu and Belewu (2005) in goats supplemented with probiotics. Likewise, Abdelrahman and Hunaiti (2008) noticed higher DP by lambs fed diets supplemented with probiotics. In ruminants lactate-utilizing or lactate-producing bacteria did not affect the marbling and DP (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 because of changes in relative concentration of volatile fatty acids (VFAs) resulting in more lipogenesis and fat distribution in different tissues of the body (Elam et al., 2003).

CONCLUSIONS

Probiotics may improve the ruminal microflora and increase the ruminal pH. So, their effect on the fiber digestion may be more intense in growing and fattening lambs receiving high concentrate diets. It is further stated that inclusion rate and level of concentrate in the total feed significantly influence rumen ecology and thereby nutrients digestion and availability in ruminants. However, more research work to study their interactions with ruminal microbes and the effect of their level and type used should be carried out.

REFERENCES

Aattouri N, Bouras M, Tome D, Marcos A, Lemonnier D (2001). Oral ingestion of lactic acid bacteria by rats increases lymphocyte proliferation and interferon production. Brit. J. Nutr., 87: 367-373.

Abas I, Kutay HC, Kahraman R, Toker NY, Ozcelik D, Ates F, Kacakci A (2007). Effects of organic acid and bacterial direct-fed microbial on fattening performance of Kivircik-Male yearling lambs. Pak. J. Nutr., 2: 149-154.

Abd El-Ghani AA (2004). Influence of diet supplementation with yeast (*Saccharomyces cerevisiae*) on performance of Zaraibi goats. Small Rumin. Res., 52:223-229.

Abdelrahman MM, Hunaiti DA (2008). The effect of dietary yeast and protected methionine on performance and trace minerals status of growing Awassi lambs. Livest. Sci., 115: 235-241.
Abo El-Nor SAH, Kholif MA (1998). Effect of supplementation of live yeast culture in the diet on the productive performance of lactating buffaloes. Milchwissenschaft, 53: 663-666.
Anandan S, Dey A, Deb SA, Kumar S, Harbola PC (1999) Effect of curds as probiotics supplement on performance of Cheghu crossbred kids. Small Rumin. Res., 32:93-96.
Antunovic Z, Speranda M, Amidzic D, Seric V, Steiner Z, Doma-Cinovic N, Boli F (2006) Probiotic application in lambs nutrition. Krmiva, 4: 175-180.
Antunovic Z, Speranda M, Liker B, Seric V, Sencic D, Domacinovic M, Sperandat T (2005). Influence of feeding the probiotic Pioneer PDFM® to growing lambs on performances and blood composition. Acta Vet., 55: 287-300.
Arcos-Garcia JL, Castrejon FA, Mendoza GD, Perez-gavilan EP (2000). Effect of two commercial yeast culture with Saccharomyces cerevisiae on ruminal fermentation and digestion in sheep fed sugar cane tops. Livest. Prod. Sci., 63:153-157.
Arthur TM, Bosilevac JM, Kalchayanand N, Wells JE, Shackelfold SD, Wheeler TL, Koohmaraie M (2010). Evaluation of a direct-fed microbial product effect on the prevalence and load of *Escherichia coli* o157:H7 in feedlot cattle. J. Food Prot., 73: 366-371.
Baranowski A, Gabryszuk M, Jozwik A, Bernatowicz E, Chylinski W (2007). Fattening performance, slaughter indicators and meat chemical composition in lambs fed the diet supplemented with linseed and mineral bioplex. Anim. Sci. Papers Rep., 25: 35-44.
Belewu MA, Belewu KY, (2005) Cultivation of mushroom (*Volvariella colvacea*) on banana leaves. Afr. J. Biotech., 12: 1401-1403.
Belewu MA, Jimoh NO (2005). Blood, carcass and organ measurements as influenced by *Aspergillus niger* treated Cassava wasre in the diets of West African dwarf goat. Glob. J. Agric. Sci., 4: 125-128.
Belewu MA, Yahaya AA, Adeyina AO (2008). Study on some haematological parameters of goats fed *aspergillus* treated and untreated shea-butter cake. Rev. J. Anim. Sci., 5: 154-156.
Bruno RGS, Rutigliano HM, Cerri RL, Robinson PH, Santos JEP (2009). Effect of feeding *Saccharomyces Cerevisiae* on performance of dairy cows during summer heat stress. Anim. Feed Sci. Tech., 150: 175-186.
Butler WR (1998). Review: Effect of protein nutrition on ovarian and uterine physiology in dairy cattle. J. Dairy Sci., 81: 2533-2539.
Casas IA, Dobrogosz WJ (2000). Validation of the probiotic concept: *Lactobacillus reuteri* confers broad spectrum protection against disease in humans and animals. Microb. Ecol. Health Dis., 12: 247-285.
Chademana I, Offer NW (1990). The effect of dietary inclusion of yeast culture on digestion in the sheep. J. Anim. Prod., 50: 483-489.
Chaucheyras-Durand F, Walker ND, Bach A (2008). Effect of active dry yeast on the rumen microbial ecosystem: past, Presetn and Future. Anim. Feed Sci. Tech., 145: 5-26.
Chiofalo V, Liotta L, Chiofalo B (2004). Effects of the administration of lactobacilli on body growth and on the metabolic profile in growing Maltese goat kids. Reprod. Nutr. Dev., 44: 449-457.
Cole NA (1992). Influence of postfast dietary crude protein and phosphorus content on nitrogen, phosphorus, calcium and magnesium repletion in sheep. J. Anim. Sci., 70: 2893-2900.
Dawson KA, Tricarico J (2002). The evolution of yeast cultures-20 years of research. In: Navigating from Niche Markets to Mainstream. Proceedings of Alltech's European, Middle Eastern and African Lecture Tour, pp. 26-43.
De Valdez DF, Martos G, Taranto MP, Lorca GL, Oliver G, De Ruiz Holgado AP (1997). Influence of Bile on b-Galactosidase Activity and Cell Viability of *Lactobacillus reuteri* when Subjected to Freeze-Drying. J. Dairy Sci., 80: 1955-1958.
Desnoyers M, Giger-Reverdin S, Bertin G, Duvaux-Ponter C, Sauvant D (2009). Meta-analysis of the influence of Saccharomyces cerevisiae supplementation on ruminal parameters and milk production of ruminants. J. Dairy Sci., 92:1620-1632.
Dicks LMT, Botes M (2010). Probiotic lactic acid bacteria in the gastro-intestinal tract: Health benefits, safety and mode of action. Benef. Microb., 1:11-29.
Ding J, Zhou ZM, Ren LP, Meng QX (2008). Effect of Monensin and live yeast supplementation on growth performance, Nutrient digestibility, carcass characteristics and ruminal fermentation parameters in lambs fed steam-flaked corn-based diets. Asian-Aust. J. Anim. Sci., 21: 547-554.
Donkin SS, Hammon H (2005) Hepatic gluconeogenesis in developing ruminants. In: Burrin DG, Mersmann HJ, editors. Biol. Metab. Growing Anim. London: Elsevier, pp. 375-390.
Doreau M, Jouany JP (1998). Effect of a Saccharomyces cerevisiae on nutrient digestion in lactating dairy cows. J. Dairy Sci., 81: 3214-3221.
Dunne C, O'Mahony L, Murphy L, O'Halloran S, Feeney M, Flynn S, Fitzgerald G, Daly C, Kiely B, O'Sullivan G, Shanahan F, Collins JK (1999). Probiotics; from myth to reality-Demonstration of functionality in animal models of disease and in human clinical trials. Antonie Van Leeuwenhoek, 76: 279-292.
Dutta TK, Kundu SS, Kumar M (2009). Potential of direct-fed-microbials on lactation performance in ruminants - A critical review. Livest. Res. Rural Dev., 10: 219-227.
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 beef steers. J. Anim. Sci., 81: 2686-2698.
El-Waziry AM, Ibrahim HR (2007). Effect of saccharomyces cerevisiae of yeast on fiber digestion sheep fed berseem (*trifolium alexandrinum*) hay and cellulose activity. Aust. J. Basic Appl. Sci., 1:379-385.
Erasmus LJ, Botha PM, Kistner A (1992). Effect of yeast culture supplement on production, rumen fermentation and duodenal nitrogen flow in dairy cows. J. Dairy Sci., 75: 3056-3065.
Frizzo LS, Sotto LP, Zbrun MV, Bertozzi E, Sequeira G, Armesto RR, Rosmini MR (2010). Lactic acid bacteria to improve growth performance in young calves fed milk replacer and spray-dried whey powder. Anim. Feed Sci. Technol., 157: 159-167.
Galip N (2006) Effect of supplemental yeast culture and sodium bicarbonate on ruminal fermentation and blood variables in rams. J. Anim. Phys. Anim. Nutri., 90:446-452.
Ghorbani GR, Morgavi DP, Beauchemin KA, Leedle JAZ (2002). Effects of bacterial direct fed microbials on ruminal fermentation, blood variables, and the microbial populations of feedlot cattle. J. Anim. Sci., 80: 1977-1985.
Haddad SG, Goussous SN (2005) Effect of yeast culture supplementation on nutrient intake, digestibility and growth performance of Awassi lambs. J. Anim. Feed Sci. Tech., 118: 343-348.
Hernandez R, Gonzalez SS, Pinos-Rodrigues JM, Ortega MA, Hernandez A, Bueno G, Cobos M (2009). Effect of yeast culture on nitrogen balance and digestion in lambs fed early, and mature orchard grass. J. Appl. Anim. Res., 32: 53-56.
Huntington GB, Eisemann JH (1988). Regulation of nutrient supply by gut und liver tissues, J. Anim. Sci., 66: 35-48.
Jang D, Oh Y, KyongPiao H, GuoChoi L, BongYun H, HyeonKim J, Yong Y (2009). Evaluation of Probiotics as an Alternative to Antibiotic on Growth Performance, Nutrient Digestibility, Occurrence of Diarrhea and Immune Response in Weaning Pigs. J. Anim. Sci. Tech., 51: 751-759.
Jouany JP, Mathieu F, Bohatier J, Bertin G, Mercier M (1998b). The effect of Saccharomyces cerevisiae and *Aspergilus oryzae* on the digestion of cell wall fraction of a mixed diet in defaunated sheep rumen. Repeod. Nutr. Dev., 38: 401-416.
Jouany JP, Mathieu F, Senaud J, Bohaitier J, Bertin G, Mercier M (1998a). The effect of Saccharomyces cerevisiae and Aspergilus oryzae on the digestion of nitrogen in rumen of defaunated and refaunated sheep. Anim. Feed Sci. Tech., 75: 1-13.
Kamel HEM, Sekine J, El-Waziry AM, Yacout MHM (2004). Effect of Saccharomyces cerevisiae on the synchronization of organic matter and nitrogen degradation and microbial nitrogen synthesis in sheep fed Barseem hay (*Trifolium alexandrium*). Small Rumin. Res., 52: 211-216.
Kiesling HE, Lofgreen GP, Thomas JD (1982). A viable lactobacillus

culture for feedlot cattle. Proc. Western Sect. Am. Soc. M. Sci., 33: 53-56.
Koop-Hoolihan L (2001). Prophylactic and therapeutic uses of probiotics: A review. J. Anim. Diet Assoc., 101:229-238, 241.
Krehbiel CR, Rust SR, Zhang G, Gilliland SE (2003). Bacterial direct-fed microbials in ruminant diets: Performance response and mode of action. J. Anim Sci., 81: 120-32.
Malik R, Bandla S (2010). Effect of source and dose of probiotics and exogenous fibrolytic enzymes (EFE) on intake, feed efficiency, and growth of male buffalo (bubalus bubalis) calves. Trop. Anim. Health Prod., 42: 1263-1269.
Martin SA, Nisbet DJ (1990). Effect of Aspergillus Oryzae fermentation extract on fermentation of amino acids and starch by mixed ruminal microorganisms *in vitro*. J. Anim. Sci., 68: 2142-2149.
Masek T, Mikulec Z, Valpotić H, Kušće L, Mikulec N, Antunac N (2008). The infuence of live yeast cells (*Saccharomyces cerevisiae*) on the performance of grazing dairy sheep in late lactation Veterinarski arhi, 78: 95-104.
Mohamed MI, Maareck YA, Abdel-Magid SS, Awadalla IM (2009). Feed intake, digestibility, rumen fermentation and growth performance of camel fed diets supplemented with a yeast culture or zinc bacitracin. Anim. Feed Sci. Tech., 149:341-345.
Musa HH, We SL, Zhu CH, Seri HI, Zhu GQ (2009). The potential benefits of probiotics in animal production and health. J. Anim. Vet. Adv., 8: 313-321.
Mutassim M, Hunaiti DA (2008) The effect of dietary yeast and protected methionine on performance and trace minerals status of growing Awassi lambs. Livest. Sci., 115: 235-241.
NewBold CJ, Wallace RJ, Mcintosh FM (1996). Mode of action of yeast Saccharomyces cerevisiae as a feed additive for ruminants. Br. J. Nut., 76: 249-261.
Oltner R, Wiktorsson H (1983). Urea concentrations in milk and blood as influenced by feeding varying amounts of protein and energy to dairy cows. Livest. Prod. Sci., 10: 457-467.
Oyetayo VO, Oyetayo FL (2005). Potential of probiotics as biotherapeutic agents targeting the innate immune system. Afr. J. Biotech., 4: 123-127.
Paryad A, Rashidi M (2009). Effect of yeast (*Saccharomyces cerevisiae*) on apparent digestibility and nitrogen retention of Tomato Pomace in sheep. Pak. J. Nut., 8: 273-278.
Pelicano ERL, Souza PA, Souza, HJBA, Oba A, Boiago MM, Zeola NMBL, Scatolini AM, Bertanha VA, Lima TMA (2005). Carcass and cut yieldd and meat qualitative traits of broilers and fed doets containing probiotics and probiotics. Brazi. J. Poul. Sci., 7: 169-175.
Pond KR, Goode L (1985). The evaluation of Probios® for wean-stressed lambs. Microbial Genetics Division, Pioneer Hi-Bred International, Des Moines, Iowa.
Putnam DE, Schwab CG, Socha MT, Whitehouse NL, Kierstead NA, Garthwaite BD (1997). Effect of yeast culture in the diets of early lactation dairy cows on ruminal fermentation and passage of nitrogen fractions and amino acids to the small intestine. J. Dairy Sci., 80: 374-384.
Robinson PH (2002). Yeast products for growing and lactating dairy cattle: Impact on rumen fermentation and performance. Dairy Rev., 9: 1-4.
Rolfe RD (2000). The role of probiotic cultures in the control of gastrointestinal health. J. Nutr., 130: 396S-402S.
Russell JB, Wilson DB (1996). Why are ruminal cellulolytic bacteria unable to digest cellulose at low pH? J. Dairy Sci., 79: 1503-1510.
Sandine WE (1979). Role of lactobacillus in the intestinal tract. J. Food Prot., 42: 259-262.
Seo JK, Seon-Woo K, Kim MH, Santi D, Kam DK, Jong KH (2010). Direct-fed Microbials for Ruminant Animals. Asian-Aust. J. Anim. Sci., 12 : 1657-1667
Swinney-Floyd D, Gardner BA, Owens FN, Rehberger T, Parrot T (1999). Effect of inoculation with either Propionibacterium strain P-63 alone or combined with *Lactobacillus acidophilus* strain LA53545 on performance of feedlot cattle. J. Anim. Sci., 1: 77-87.
Teeler E, Vanabelle M (1991). Probiotics: fact and fiction, Mededelingen van de faculteit Landbouwwetenschappen, Rijksuniversitet Gent., 56: 1591-1599.
Titi HH, Dmour RO, Abdullah AY (2008). Growth performance and carcass characteristics of Awassi lambs and Shami goat kid culture in their finishing diet. J. Anim. Sci., 142: 375-383.
Trebichavsky I, Splichal I (2006). Probiotics manipulate host cytokine response and induce antimicrobial peptides. Folia Microbiol., 51: 507-510.
Umberger SH, Notter DR (1989). Evaluation of lactobacillus inoculant on feedlot lamb performance. J. Anim. Sci., 8: 40-45.
Vlková E, Grmanová M, Rada V, Homutová I, Dubná S (2009). Selection of probiotic bifidobacteria for lambs. Czech J. Anim. Sci., 54: 552–565
Wallace RJ, Newbold CJ (1993). Rumen fermentation and its manipulation: The development of yeast culture as feed additives. In: Biotechnology in the Feed Industry, Lyons, T.P. (ed.). Alltech Technical Publications, Kentucky, pp. 173-192.
Ware DR, Read PL, Manfredi ET (1988). Pooled summary of eight feedlot trials evaluating performance and carcass characteristics of steers fed Lactobacillus acidophilus strain BT1386. J. Anim. Sci., 66: 436-441.
Whitley NC, Cazac D, Rude BJ, Jackson-O'Brien D, Parveen S (2009). Use of commercial Probiotics supplement in meat goat. J. Anim. Sci., 87: 723-728.
Yoon IK, Stern MD (1996) Effects of *Saccharomyces cerevisiae* and *Aspergillus orysae* culture on ruminal fermentation in dairy cows. J. Dairy Sci., 79: 411-417.