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Microbial Feed Supplements for Ruminant's Performance Enhancement

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ABSTRACT

Improved ruminant's health and its productive performance has always remained a primary goal of researchers associated with the animal production sector. Microbial feed supplements as natural growth promoters might play an important role for enhancement of health and productive performance of ruminants through prevention of disease, enhancement of desirable microbial growth in the rumen environment, stabilization of ruminal pH, altered ruminal fermentation patterns, increased nutrient digestibility and flow of nutrients to the small intestine, improved nutrient retention and reduced stress through enhanced immune response. The definition of microbial feed supplements is very broad and may include specific and nonspecific yeast, fungi, bacteria, cell fragments and filtrates. The microbial feed supplements preparations must having a beneficial effect on the host animal (non-pathogenic and non-toxic), able to produce antimicrobial agents, antagonistic toward pathogenic, have ability to adhere and colonize the epithelial cells of the rumen and the gut, capable of compete with normal microflora and metabolizing in the gut environment and genetically stable and capable of remaining viable for long periods under storage and field conditions. The use of microbial feed supplements continuously may decrease the harmful effects of the pathogenic bacterial species in the ruminant digestive system and thereby improve the animal performance.

Key words: Lactic acid bacteria, yeast culture, probiotics, ruminants, meat, milk

INTRODUCTION

Improved animal's health and its productive performance has always remained a primary goal of researchers associated with the animal production. Consequently, any feedstuff, feed additive, drug or other compound that is capable of enhancing animal health or performance will interest producers, veterinarians and animal nutritionists. Research has yet to find a sole feed supplement that can improve the rate, efficiency and quality of gain, production, reproduction, prevent certain diseases or preserve feeds (Wilks, 1997). Several feed supplements have been used to improve animal performance either by manipulation of the rumen environment or by directly altering the composition and metabolic activities of rumen microorganisms (Azzaz *et al*., 2015a). These feed supplements could be classified into two main categories as reported by Wilks (1997) as follow:

- Dietary supplements which include feed or feed mixture rich in one or more of protein, energy, vitamins or minerals combined with the other feeds to produce more complete feed. Fermentable nitrogen, by-pass nutrient and medicinal herbs can be also considered as dietary supplements

- Dietary additives which include substances used in livestock rations to: (1) Help to resist changes in the acidity of the digestive tract or certain problems in rumen fermentation (buffers) and (2) Inhibits the growth of some gram positive bacteria in the rumen like ionophores which affect the transport of ions across cellular membranes of this bacteria, anabolic hormones, feed enzymes which used to speed up the chemical reactions of digestion and metabolism processes to improve utilization of feeds, antibiotics, synthetic amino acids and microbial feed supplements

The growing societal concerns toward using of antibiotics and anabolic hormones as growth promoters for livestock animals, microbial feed supplements and their metabolites as natural, safe and effective growth promoters might play an important role for enhancing health and performance of the farm animals (Azzaz *et al*., 2012). Recent advances in fermentation technology and biotechnology have allowed for production of large quantities of microbial feed supplements and their metabolites (Azzaz *et al*., 2013b; Murad and Azzaz, 2013). The effect of microbial feed supplementation on farm animal's performance or rumen fermentation has been studied (Jouany and Morgavi, 2007; Guedes *et al*., 2007; Wallace *et al*., 2008). Although microbial feed supplementation has improved milk yield, milk composition, feed efficiency and animals health (Kholif *et al*., 2000; Raeth-Knight *et al*., 2007), animal response to microbial feed supplementation have been inconsistent. Therefore, this review will focus on the microbial feed supplements and their effects on the animal's health and productivity.

MICROBIAL FEED SUPPLEMENTS CHARACTERIZATION AND MODE OF ACTION

The definition of microbial feed supplements, Direct-Fed Microbials (DFM), or probiotics as they traditionally have been called is very broad and may include specific and nonspecific yeast, fungi, bacteria, cell fragments and filtrates (Knowlton *et al*., 2002). The term "probiotic" has been defined as a live microbial feed supplement, which beneficially affects the host animal by improving its intestinal microbial balance (Fuller, 1989; Ko and Yang, 2008). Also, in feed regulation, probiotics were included in the group of microbial feed supplements for stabilizing the microbial communities of the animal's digestive tract and play an important role in animal's protection against harmful microorganisms and strengthen the host's immune system (Salem *et al*., 2000). In a narrower sense, microbial feed supplements are confined to products which consist of one or a few well-defined strains of microorganisms that, when administered in adequate amounts, confer a health benefit on the host (FAO/WHO., 2001). The microbial feed supplements preparations should be met the following criteria in order to be effective: (1) The microbial strain must having a beneficial effect on the host animal (non-pathogenic and non-toxic), (2) Able to produce antimicrobial agents, antagonistic toward pathogenic (Kullen and Klaenhammer, 1999), (3) Have ability to adhere and colonize the epithelial cells of the rumen and the gut, (4) Capable of compete with normal microflora and metabolizing in the gut environment (e.g., resistant to low pH, organic acids, bile salts and digestive enzymes) (Parvez *et al*., 2006) and (5) Genetically stable and capable of remaining viable for long periods under storage and field conditions.

Most of bacterial feed supplements are Gram-positive like lactic acid bacteria *Lactobacillus*, *Streptococcus*, *Bifidobacterium*, *Bacillus* spp. and *Propionibacterium* spp. (Marco *et al*., 2006). However, some Gram-negatives are also used as probiotics like *Escherichia coli* Nissle 1917 (EcN) (Nissle, 1959). In addition, the most common fungal feed supplements are *Aspergillus oryzae* and *Saccharomyces cerevisiae*. The bacterial feed supplements have been effective in monogastric

animals and pre-ruminant calves; whereas fungal feed supplements have given better results in adult ruminants (Fuller, 1999). The combinations of microbial feed supplement strains could increase the beneficial health effects compared with the individual strains, depending on their synergistic adhesion effects (Collado *et al*., 2007). The direct mode of action of microbial feed supplements for ruminants has not been fully determined. Yoon and Stern (1995) listed several possible modes of action for microbial feed supplements including enhancement of desirable microbial growth in the rumen environment, stabilization of ruminal pH, altered ruminal fermentation patterns, increased nutrient digestibility and flow of nutrients to the small intestine, improved nutrient retention and reduced stress through enhanced immune response. Also there are many mechanisms have been proposed to explain the positive effects of microbial feed supplements can be summarized as follow: (1) Antagonism through production of antibacterial compounds (e.g., acids, bacteriocins, antibiotics) (Vandenbergh, 1993), (2) Competition with the undesirable organisms for adhesion sites and/or nutrients resources (Guillot, 2003), (3) Stimulation of immune response by the host animal through enhanced phagocytosis and natural killer cell activity (Isolauri *et al*., 2001), (4) Metabolism and detoxification of bacterial toxins (Brandao *et al*., 1998) and (5) Production or stimulation of enzymes secretion (Azzaz *et al*., 2015b). These mechanisms could benefit ruminants by promoting nutrient uptake through decrease the thickness of the inflamed intestinal wall. If the thickness of the intestinal wall is decreased, bacterial feed supplements could improve the efficiency of energy utilization by diminish the amount of energy used for tissue turnover in the gastrointestinal tract (Elam *et al*., 2003). The microbial feed supplements have generally been supplemented to animals during periods of stress with the assumption that establishment of a beneficial microorganism population in the digestive tract will decrease or prevent pathogenic organism establishment. However, when an animal stressed, the intestinal microflora will be change. Often this is characterized by an increase in the number of coliform and other enterotoxigenic bacteria. Unfortunately, the definition of stress is not clear and any animal can be stressed as a result of any of the following causes: (1) Nutritional stress (deficiency or excess of a nutrient and the antagonism between levels of two or more nutrients), (2) Environmental stress (thermal, moisture, crowding and sanitary conditions, e.g., manure accumulation), (3) Emotional stress (e.g., handling or shipping, changes in pen-mates and weaning) and (4) Disease stress (infectious and metabolic, e.g., milk fever or ketosis), therefore the microbial feed supplements should be fed continuously to attempt to enhance production performance, alter ruminal fermentation, or improve nutrient utilization.

BACTERIAL FEED SUPPLEMENTS

The increased interest in the use of bacterial feed supplements in the ruminant feeding has resulted from societal concerns with the using of antibiotics as growth promoters by the animal feed manufacturers. Bacterial feed supplements as natural growth promoters might play an important role for prevention of disease and thereby diminution need of animal producer for the antibiotics. In addition, the growing concern about pathogen contamination of meat and meat products and the extensive experiments which have been made to evaluate the efficacy of probiotics, the bacterial feed supplements became major tool for reducing fecal shedding of harmful bacteria, such as *Escherichia coli* 0157:H7.

Ruminal effects: Feeding bacterial feed preparations to ruminants is depending primarily on potential beneficial postruminal effects; however, there are some evidences that certain bacterial

strains might have beneficial effects for manipulating ruminal fermentation, which would help for prevention of metabolic disorder "Ruminal acidosis" (Krehbiel *et al*., 2003). Lactic acid producing bacteria (e.g., *Lactobacillus* and *Enterococcus* species) might help for prevention of ruminal acidosis, by allowing the ruminal microflora to adapt to the presence of lactate in the rumen (Yoon and Stern, 1995; Nocek *et al*., 2002). The bacterial feed supplements that produce lactate (e.g., *Lactobacillus acidophilus*) sustain a tonic level of lactic acid in the rumen, which could potentially stimulate lactic acid-utilizing microorganisms (Nocek *et al*., 2002). Furthermore, inclusion of lactic acid-utilizing bacteria might help for preventing production of excess amount of lactic acid in the rumen (Nisbet and Martin, 1994; Kung and Hession, 1995). In this concern, some researchers reported positive effects of supplemented dairy and beef cattle rations with *Lactobacillus* species and suggested reduced ruminal acidosis risk (Huffman *et al*., 1992; Lodge *et al*., 1996; Nocek *et al*., 2002; Azzaz *et al*., 2015a), while the others, found no effect of bacterial feed supplementation for prevention of ruminal acidosis (Ghorbani *et al*., 2002; Beauchemin *et al*., 2003; Yang *et al*., 2004). Beauchemin *et al*. (2003) noted that when the rumen of the animal is adapted to a high-grain diet, the bacterial feed supplements was not effective. However, in some feeding cases in which lactate might accumulate in the rumen, providing bacterial feed supplements might give beneficial effects.

Postruminal effects: Although, it has been well established that the use of bacterial feed supplements can improve animal health by altering the composition (Jonsson and Olsson, 1985) and enzymatic activities (Goldin and Gorbach, 1977) of the *Microflora* in the gastrointestinal tract, there is a little direct evidence that lactic acid-producing bacteria can alter the major fermentation activities in the gastrointestinal tract. The major end product of most of the bacterial feed supplements is lactic acid. In most feeding situations this compound is considered to be a transient intermediate in rumen metabolism and is converted to propionate and acetate by active anaerobic populations of lactate-utilizing bacteria in the rumen. In addition, there are some researchers demonstrated that bacterial feed preparations for ruminants possess some beneficial effects in the gastrointestinal tract including antidiarrheal and antitumor effects (Gilliland *et al*., 1985; Dawson, 1988). Furthermore, some bacterial feed preparations have the ability to produce lactic acid along the intestinal wall and thereby maintain healthy environment for the intestine. The produced lactic acid reduces the pH of the intestinal environment which became unfavorable for certain pathogenic bacteria such as coliforms, particularly *E. coli*. This acidic environment is also conductive to increased enzymatic activity with the digestive system (Azzaz *et al*., 2015a).

The ability of some strains of lactic acid producing bacteria for preventing coliforms, particularly *E. coli* to attachment to the intestinal wall is well studied (Fuller, 1989; Yoon and Stem, 1995). Jones and Rutter (1972) indicated that attachment of *E. coli* to intestinal epithelial mucosa is necessary for enterotoxin-production and subsequently causing diarrhea. In addition, Reiter and Hfunulv (1984) reported that *Lactobacillus lactis* may possess an antimicrobial activity as a result of its ability to excretion of hydrogen peroxide in the intestinal environment through the lactoperoxidase-thiocyanate system. In support, Walter *et al*. (1992) reported that bacterial feed preparation which based on lactobacilli spp may have ability to produce antimicrobial substances such as bacteriocins, acidophilin and lactocidin, which are broad-spectrum antibiotic-like substances. These antimicrobial substances may facilitate antagonism by *L. acidophilus*. Therefore, the use of bacterial feed supplements continuously may decrease the harmful effects of the pathogenic bacterial species in the ruminant digestive system and thereby improve the animal performance.

FUNGAL FEED SUPPLEMENTS

Yeast and yeast culture have been used as supplements in animal feed for more than six decades (Dawson, 1992; Kholif *et al*., 2000). The early usage of fungal feed supplements was based on empirical observations which suggested that improvements in animal performance could be obtained by adding small amount of it to animal diets. By the way, not all yeast or *A. oryzae* preparations show the same effects on animal's performance as others and therefore not all yeasts or fungi would be expected to have similar nutritional effects. Yeast products are mixtures of live and dead yeast cells together with some nutrients of the medium in which the yeast was grown. Because the medium component is claimed to be important in the products' activity, the accepted terminology for the supplement is "Yeast Culture" (YC) rather than simply yeast. On the other hand, *A. oryzae* fermentation extract (AO) consists of fungal spores and mycelium dried on a base of lignocellulytic material such as wheat bran. The fungal feed supplements can be used either by sprinkling on the feed or by incorporation into a compound of the diet. Dawson (1992) reported a number of features which make the use of supplemental yeast culture in ruminants feeding be attractive. These features can be summarized in the following points: (1) Safe, wholesome and have long history in human and animal feeding, (2) Rich sources of vitamins, enzymes, nutrients and other important co-factors, (3) Appetite enhancer and thereby increase the dry matter intake and reduce the animal production losses, (4) Rumen environment stabilizer, preventer for acidosis, twisted gut problems and consequently maintain the general herd health and (5) Assist the liver for fat metabolizing by increasing the supply of B complex vitamin.

Moreover, stimulation of the growth and activities of both total and certain specific groups of ruminal bacteria have been the most consistent reproducible modes of action for fungal feed supplements (Yoon and Stern, 1995; Beharka and Nagaraja, 1998; Newbold *et al*., 1996). Cellulose digesting and lactic acid utilizing bacteria are the most commonly enhanced ruminal bacteria groups by fungal supplementation (Callaway and Martin, 1997). Why and how fungal feed supplements increase bacterial numbers is not understood but one proposed mechanism is that the respiratory activity of yeast protects anaerobic rumen bacteria from damage by oxygen (Newbold *et al*., 1996). It seems likely that yeast culture stimulates the initial colonization on the plant fragments in the rumen allowing a more rapid commencement of fibre breakdown. A large increase in cellulolytic organisms has been found when yeast culture has been added to the diet (Harrison *et al*., 1988). In addition the possibility that yeast cells interact in the rumen with anaerobic fungi should not be ignored as these have been shown preferentially to colonize cellulose and hemicellulose, making the fibre more accessible to bacteria (Akin *et al*., 1983). It seems that changes in the rumen microbial numbers and activity are responsible for the beneficial effects on fibre digestion. Yeast culture supplementation has been shown to cause small increases in rumen pH but the response is not always statistically significant for its probable short-lived. However, the effect of yeast culture on pH become greatest at 4 h post feeding when it is associated with lower concentration of lactic acid. The better control of rumen pH when yeast culture is fed may result from the inherent buffering capacity of yeast cells (Cartwright *et al*., 1986) or from reduced lactate accumulation (Williams *et al*., 1990) because of utilization lactate precursor by yeast or to indirect stimulation of lactate utilizing microorganisms (since lactate is not a substrate used by *Saccharomyces cerevisiae*). Yeast cells have been shown to reduce the concentration of starch degradation products (Panchal *et al*., 1984) which would also decrease lactate production as well as reducing the inhibition of cellulolytic organisms. Yeast cells also may act as acceptors of metabolic hydrogen which depresses methane production (Offer and Cruive, 1991). Yeast cells in

the rumen might supply a chemical growth factor to the cellulolytic microorganisms. Weidmir and Arambel (1985) suggested that B Vitamins or branched-chain fatty acids may be involved although there is no definite evidence for a particular stimulatory factor. Some effects of yeast culture supplements on the activities of mixed populations or ruminal bacteria can be summarized as follows (Williams, 1989), (1) Decreased ammonia concentration, (2) Altered VFA production, (3) Increased ethanol concentration, (4) Moderated effect on ruminal pH, (5) Decreased lactic acid concentration, (6) Decreased soluble sugar concentrations, (7) decreased methane production, (8) Altered digestive pattern, (9) Stabilized fermentation and (10) Increased concentration of anaerobic bacteria, cellulolytic bacteria and yeast in the population. Some consideration should be accounted for describing the effect of yeast supplementation on ruminal bacteria (Dawson *et al*., 1990), (1) Yeast supplementation increased the growth and concentration of certain type of anaerobic bacteria particularly cellulolytic bacteria, (2) Cellulose degradation enhanced by yeast supplementation appears to be related to a decrease in the amount of time required to initiate the digestion process (lag time) which was 50% longer in cultures that did not receive the yeast supplement. Stimulatory effects of the yeast were dependent upon the presence of low concentration (10^4 mL^{-1} approx.) of metabolically active yeast cells and not to their water soluble extracts, (3) Not all strains of yeast stimulate cellulolytic organisms in the same way and also not all strains of cellulolytic bacteria are influenced by yeast in the same way. Such differences may explain some of the variations observed in different studies and give opportunities to further improve in animal responses by including different yeast strains in the supplement, (4) Yeast cells also appear to affect the metabolic activities of some strains of bacteria. The relative amount of acetate produced from cellulose was found to be greater in cultures containing the yeast. Succinate production was not significantly influenced by the yeast supplementation. Such shifts in metabolic activities suggest that the yeast can serve as a mediator of metabolic activities of the cellulolytic bacteria and may enhance the energy producing mechanisms in the bacterial cells. Also, the particular strains ability to grow within the rumen, to remove sugar and avoid the typical lactate peak could have major implications for diets containing high levels of starch (Lyons, 1990). On the other hand, the strain's ability to stimulate cellulose lysis by certain rumen microorganisms could be the reason of better fibre digestion. Yeast culture supplements can significantly influence digestive process in the rumen (DM, CP, hemicellulose, cellulose and nitrogen retention) due to enhanced microbial activity (Kholif *et al*., 2000). The effects of processing procedures on the viability of yeast cells in processed feeds must be considered. There is evidence that the viability of yeast cells can be decreased by heat processing techniques (i.e., pelleting). To overcome this problem is to provide an excess of live yeast to ensure that appropriate levels of viable cells are present in the feed after processing. The development or improvement of yeast strains which can better withstand processing techniques and long term storage could allow for more uniform application of yeast cultures in processed feeds and provide for the delivery of more viable yeast cells to the site of action in the digestive tract. Pagan (1990) has provided evidence for improved phytate phosphorus digestion and that might be related to the ability of yeast culture supplements to increase phytase activity by the microbial populations and mineral absorption in the hindgut. On the other hand, the experiments which have been done on *A. oryzae* was administered as an inoculant to silage (Harris *et al*., 1983). The precise mode of action of *A. oryzae* has received less attention than yeast culture. Substantial growth of *A. oryzae* does not occur in the rumen and autoclaving destroys the stimulation (Newbold *et al*., 1991). The dicarboxylic acids present in the extract stimulate lactate production by *Selenomonas ruminantium* (Nisbet and Martin, 1990) and *Megasphaera elsdenii* (Waldrip and Martin, 1993) but

once more the quantity of dicarboxylic acids present does not seem to be sufficient to have a major effect on lactate metabolism by the mixed rumen population (Varel *et al*., 1993). It is much more likely that it is the enzymes present in the extract that are responsible for the activity of *Aspergillus oryzae* in the rumen. *Aspergillus oryzae* contains enzymes capable of the digestion of plant cell wall material. These are believed to include cellulase, xylanase and phenolic acid esterases (Varel *et al*., 1993). Identification of these enzyme activities would be an important step forward in understanding and manipulating rumen fermentation. Furthermore, *Aspergillus oryzae* play an important role for increasing the population of cellulolytic bacteria, shifting VFA fermentation patterns in the rumen by reducing the proportion of propionate relative to acetate and increase production of butyrate and stabilizing rumen pH. In addition, Arambel and Kent (1990) reported that if supplemented yeast not survives in the rumen, their lysis would provide protoplasm which in turn represent a source of nutrients for the rumen microbes and subsequently faster ruminal microbial colonization and fermentation.

EFFECTS OF MICROBIAL FEED SUPPLEMENTS ON RUMINANT'S HEALTH AND PERFORMANCE

Pre-ruminant calves: The efficacy of microbial feed supplements, such as *Lactobacillus, Bifidobacterium, Enterococcus* and *Streptococcus* species has been extensively studied in neonatal ruminants (Newman and Jacques, 1995). At birth, the digestive system of newborn calves is initially colonized by species of coliforms and clostridium but colonization by lactobacilli occurs rapidly, resulting in a decrease in coliforms and clostridial species (Smith, 1971). However, during stress conditions, the numbers of lactobacilli decrease, whereas coliforms increase in the gastrointestinal tract (Fuller, 1989). Therefore, bacterial feed supplements might be beneficial for preruminants to establish and maintain normal intestinal microorganisms. Kilmer (2000) demonstrated that most of the research on the effects of bacterial feed supplements for young ruminants has involved the addition of various lactic acid producing bacteria, primarily *Lactobacillus* and *Streptococcus*, as intestinal inoculants to suppress neonatal diarrhea and to improve the growth rate of young or stressed calves. The primary action of bacterial feed supplements appears to be related to enhanced development of rumen function by minimizing growth of pathogenic bacteria, increasing desirable microbial populations in the gut and facilitating fiber digestion. In this concern, many studies indicated that preparation of lactic acid bacteria could regulate diarrhea incidence as well as improve weight gain and feed efficiency for tested newborn calves. Abe *et al*. (1995) found that oral administration of *Bifidobacterium pseudolongum* or *L. acidophilus* improved body weigh gain and feed efficiency of newborn calves and reduced frequencies of diarrhea occurrence compared calves that did not receive the two bacterial supplements. Abu-Tarboush *et al*. (1996) reported similar results with calves that were given lactobacilli supplementation. In addition, Frizzo *et al*. (2010) reported that the young calves which were fed a large quantity of milk replacer and spray-dried whey powder had imbalanced intestinal microflora. Under these conditions, calves which give bacterial feed supplements had higher daily gain and total feed intake as well as lower fecal consistency index, indicating that diarrhea incidence was reduced. Moreover, Adams *et al*. (2008) reported that calves received *Propionibacterium jensenii* 702 exhibited higher weight gain during preweaning and postweaning periods. Dicks and Botes (2010) suggested that bifidobacteria produce acetic and lactic acids and these acids may negatively affect the growth of gram-negative pathogens in the gastrointestinal tract of preruminants.

Adult ruminants: More recent research and development efforts have identified specific microbial strains that stimulate ruminal bacteria more than others and these have been selected and targeted for use with particular diets to enhance production of either meat or milk. Yoon and Stern (1995) reported that microbial feed supplements have a positive effect on various digestive processes, especially cellulolysis and synthesis of microbial protein in adult ruminants. Swinney-Floyd *et al*. (1999) reported that feedlot calves which treated with *Propionibacterium* P-63 alone or in combination with *L. acidophilus* LA53545 had higher average daily gain than those of the control. Also, McPeake *et al*. (2002) found that steers fed a various combinations and concentrations of *Lactobacillus acidophilus* strains and *Propionibacterium freudenreichii* PF-24 had greater final weight, average daily gain, dry matter intake, hot carcass weight and carcass-adjusted ADG (final weights were calculated as hot carcass weight/average dressing percent) compared with control steers. In addition, Gomez-Basauri *et al*. (2001) found that cows fed mixture of *L. acidophilus, L. casei, E. faecium* and mannan oligosaccharide consumed 0.42 kg d^{-1} less DM and produced 0.73 kg d^{-1} more milk. Moreover, Krehbiel *et al*. (2003) reported a summary of results of several studies which showed that feeding a microbial feed supplements (combination of live cultures of *L. acidophilus. L. plantarum, L. casei* and *S. faecium*) at processing, throughout the receiving period resulted in a 13.2% increase in daily gain, 2.5% increase in feed consumption and a 6.3% improvement in feed gain. Moreover, Lehloenya *et al.* (2008a) found that the total tract digestibility of OM, NDF and ADF tended to increase when Yeast Culture (YC) *Saccharomyces cerevisiae* or *Propionibacterium freudenreichii* strain169 (P169) were fed to steers. In addition, Gaafar *et al.* (2009) demonstrated that digestibility coefficients of all nutrients and nutritive values of experimental rations increased significantly by buffaloes treated with baker's yeast. Also, lactating buffaloes fed *Aspergillus awamori* supplemented rations showed higher DM, OM, CF, NFE digestibility and TDN value compared to those fed the control ration (Azzaz *et al*., 2013a). Farahat (2014) stated that supplemented lactating goat's diets with *Lactobacillus acidophilus* significantly improved all nutrients digestibility and nutritive values compared with those of control. In addition, Azzaz *et al*. (2015a) found that apparent total tract digestibilities of DM, OM, CP, CF and NFE for goats fed supplemented rations with *Aspergillus awamori* and *Lactobacillus acidophilus* showed significant improvement compared with those fed the control ration. Azzaz *et al*. (2015b) Also found that all nutrients digestibility coefficients increased by buffaloes fed rations supplemented with YC or YC+P169 compared with those fed the control ration and no significant differences were detected in all nutrients digestibility coefficients among YC or YC+P169 treated buffaloes. In another study, Stein *et al.* (2006) reported that feeding of early lactating cows *Propionibacterium* strain P169 at concentration of 6×10^{10} or 6×10^{11} CFU d^{-1} led to increase their production of fat corrected milk 8% more than did the control cows. Lehloenya *et al.* (2008b) Also found that feeding P169+yeast to cows increased production of actual milk and 4% FCM yield by 8.5-16.6% above control cows and this overall increase in milk yield was due to increased milk production during mid lactation (9-30 weeks). In contrast, Azzaz *et al*. (2013a) found no significant differences among control and *Aspergillus awamori* supplemented buffaloes groups in milk composition and milk component's yields. Also, Morsy *et al.* (2014) found that supplementing dairy buffalo's rations with *Propionibacterium* strain P169 did not affect milk yield or milk components. Farahat (2014) reported that although, *Lactobacillus acidophilus* supplemented goats showed significant increase in actual milk, 4% fat corrected milk, milk total solids, milk fat, milk solids not fat and milk lactose yields, there is no effect of *Lactobacillus acidophilus* supplementation on milk composition. Azzaz *et al*. (2015a) also, found that milk, 4%

fat corrected milk and the other components yields were higher for goats fed *Lactobacillus acidophilus* and *Aspergillus awamori* supplemented rations than those of control, while milk composition was not affected by microbial feed supplementation while, Azzaz *et al*. (2015b) reported that milk yield and 4% Fat Corrected Milk (FCM) yield were higher for YC or YC+P169 treated buffaloes than untreated one and the percentages and yields of milk fat, protein, lactose, Total Solids (TS) and Solid Not Fat (SNF) take the same trend of milk productivity. Azzaz *et al*. (2015b) reported that, the inconsistently of animal responses to microbial feed supplementation may be attributed to several factors concerning with the viability of the microbial strains, inclusion level in the diet, diet composition, feed intake, feeding frequency, animal age, type, health and the physiological and stress status of treated animals. Therefore, there are need for conducting more research on microbial feed supplements and their effects on the animal's health and productivity.

CONCLUSION

The main activity of microbial feed supplements is the maintenance and reconstitution of the equilibrium of the rumen Microflora which is achieved by various modes of action. So, microbial feed supplements are evaluated especially regarding their quality, efficacy and safety for humans, animals and the environment. Therefore, only well-defined and safe microorganisms are used, for which the bio regulative properties have been validated under conditions of common feeding practice.

REFERENCES

Abe, F., N. Ishibashi and S. Shimamura, 1995. Effect of administration of Bifidobacteria and lactic acid bacteria to newborn calves and piglets. J. Dairy Sci., 78: 2838-2846.

Abu-Tarboush, H.M., M.Y. Al-Saiady and A.H.K. El-Din, 1996. Evaluation of diet containing lactobacilli on performance, fecal coliform and lactobacilli of young dairy calves. Anim. Feed Sci. Technol., 57: 39-49.

Adams, M.C., J. Luo, D. Rayward, S. King, R. Gibson and G.H. Moghaddam, 2008. Selection of a novel direct-fed microbial to enhance weight gain in intensively reared calves. Anim. Feed Sci. Technol., 145: 41-52.

Akin, D.E., G.L. Gordon and J.P. Hogan, 1983. Rumen bacterial and fungal degradation of *Digitaria pentzii* grown with or without sulfur. Applied Environ. Microbiol., 46: 738-748.

Arambel, M.J. and B.A. Kent, 1990. Effect of yeast culture on nutrient digestibility and milk yield response in early- to midlactation dairy cows. J. Dairy Sci., 73: 1560-1563.

Azzaz, H.H., A.M. Kholif, H.A. Murad, M.A. Hanfy and M.H. Abdel Gawad, 2012. Utilization of cellulolytic enzymes to improve the nutritive value of banana wastes and performance of lactating goats. Asian J. Anim. Vet. Adv., 7: 664-673.

Azzaz, H.H., H.A. Murad, A.M. Kholif, T.A. Morsy, A.M. Mansour and H.M. El-Sayed, 2013a. Increasing nutrients bioavailability by using fibrolytic enzymes in dairy buffaloes feeding. J. Biol. Sci., 13: 234-241.

Azzaz, H.H., H.A. Murad, A.M. Kholif, T.A. Morsy, A.M. Mansour and H.M. El-Sayed, 2013b. Pectinase production optimization and its application in banana fiber degradation. Egypt. J. Nutr. Feeds, 16: 117-125.

Azzaz, H.H., H.A. Aziz, E.S.A. Farahat and H.A. Murad, 2015a. Impact of microbial feed supplements on the productive performance of lactating nubian goats. Global Vet., 14: 567-575.

Azzaz, H.H., H.M. Ebeid, T.A. Morsy and S.M. Kholif, 2015b. Impact of feeding yeast culture or yeast culture and propionibacteria 169 on the productive performance of lactating buffaloes. Int. J. Dairy Sci., 10: 107-116.

Beauchemin, K.A., W.Z. Yang, D.P. Morgavi, G.R. Ghorbani, W. Kautz and J.A. Leedle, 2003. Effects of bacterial direct-fed microbials and yeast on site and extent of digestion, blood chemistry and subclinical ruminal acidosis in feedlot cattle. J. Anim. Sci., 81: 1628-1640.

Beharka, A.A. and T.G. Nagaraja, 1998. Effect of *Aspergillus oryzae* extract alone or in combination with antimicrobial compounds on ruminal bacteria. J. Dairy Sci., 81: 1591-1598.

Brandao, R.L., I.M. Castro, E.A. Bambirra, S.C. Amaral and L.G. Fietto *et al*., 1998. Intracellular signal triggered by cholera toxin in *Saccharomyces boulardii* and *Saccharomyces cerevisiae*. Applied Environ. Microbiol., 64: 564-568.

Callaway, E.S. and S.A. Martin, 1997. Effects of a *Saccharomyces cerevisiae* culture on ruminal bacteria that utilize lactate and digest cellulose. J. Dairy Sci., 80: 2035-2044.

Cartwright, C.P., J.R. Juroszek, M.J. Beavan, F.M.S. Ruby, S.M.F. de Morais and A.H. Rose, 1986. Ethanol dissipates the proton-motive force across the plasma membrane of *Saccharomyces cerevisiae*. J. Gen. Microbiol., 132: 369-377.

Collado, M.C., J. Meriluoto and S. Salminen, 2007. Measurement of aggregation properties between probiotics and pathogens: *In vitro* evaluation of different methods. J. Microbiol. Methods, 71: 71-74.

Dawson, K.A., 1988. Manipulating Ruminal Fermentations. Are there Natural Alternatives to Ionophores for Beef Production? In: Biotechnology in Feed Industry, Lyons, T.P. (Ed.). Alltech Technical Publications, Nicholasville, KY., USA., pp: 101.

Dawson, K.A., K.E. Neuman and J.A. Boling, 1990. Effects of microbial supplements containing yeast and lactobacilli on roughage-fed ruminal microbial activities. J. Anim. Sci., 68: 3392-3398.

Dawson, K.A., 1992. Current and Future Role of Yeast Cultures in Animal Production: A Review of Research over the Last Six Years. In: Biotechnology in the Feed Industry, Lyons, T.P. (Ed.). Alltech Technical Publications, Nicholasville, KY., USA., pp: 1-23.

Dicks, L. and M. Botes, 2009. Probiotic lactic acid bacteria in the gastro-intestinal tract: Health benefits, safety and mode of action. Beneficial Microbes, 1: 11-29.

Elam, N.A., J.F. Gleghorn, J.D. Rivera, M.L. Galyean, P.J. Defoor, M.M. Brashears and S.M.Y. Dahl, 2003. Effects of live cultures of *Lactobacillus acidophilus* (strains NP45 and NP51) and *Ropionibacterium freudenreichii* on performance, carcass and intestinal characteristics and *Escherichia coli* strain O157 shedding of finishing beef steers. J. Anim. Sci., 81: 2686-2698.

FAO/WHO., 2001. Health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria. Report of a Joint FAO/WHO Expert Consultation, October 1-4, Cordoba, Argentina. http://www.who.int/foodsafety/publications/fs_management/en/probiotics.pdf

Farahat, E.S.A., 2014. Using biologically treated date kernels in lactating rations. Ph.D. Thesis, Faculty of Agriculture, Cairo University, Egypt.

Frizzo, L.S., L.P. Sotto, M.V. Zbrun, E. Bertozzi, G. Sequeira, R.R. Armesto and M.R. Rosmini, 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.

Fuller, R., 1989. Probiotics in man and animals. J. Applied Bacteriol., 66: 365-378.

Fuller, R., 1999. Probiotics for Farm Animals. In: Probiotics: A Critical Review, Tannock, G.W. (Ed.). Horizon Scientific Press, New York, pp: 15-22.

Gaafar, H.M.A., A.M.A. Mohi El-Din, M.I. Basiuoni and K.F.A. El-Riedy, 2009. Effect of concentrate to roughage ratio and baker's yeast supplementation during hot season on performance of lactating buffaloes. Slovak J. Anim. Sci., 42: 188-195.

Ghorbani, G.R., D.P. Morgavi, K.A. Beauchemin and J.A.Z. Leedle, 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.

Gilliland, S.E., C.R. Nelson and C. Maxwell, 1985. Assimilation of cholesterol by *Lactobacillus acidophilus*. Applied Environ. Microbiol., 49: 377-381.

Goldin, B. and S.L. Gorbach, 1977. Alterations in fecal microflora enzymes related to diet, age, lactobacillus supplements and dimethylhydrazine. Cancer, 40: 2421-2426.

Gomez-Basauri, J., M.B. de Ondarza and J. Siciliano-Jones, 2001. Intake and milk production of dairy cows fed lactic acid bacteria and mannanoligosaccharide. J. Dairy Sci., 84: 283-283.

Guedes, C.M., D. Goncalves, M.A.M. Rodrigues and A. Dias-da-Silva, 2007. Effects of a *Saccharomyces cerevisiae* yeast on ruminal fermentation and fibre degradation of maize silages in cows. Anim. Feed Sci. Technol., 145: 27-40.

Guillot, J.F., 2003. Probiotic feed additives. J. Vet. Pharmacol. Ther., 26: 52-55.

Harris, Jr. B., H.H. Van Horn, S.P. Marshall, M.J. Taylor and C.J. Wilcox, 1983. Sugarcane silage, sodium hydroxide- and steam pressure-treated sugarcane bagasse, corn silage, cottonseed hulls, sodium bicarbonate and *Aspergillis oryzae* product in complete rations for lactating cows. J. Dairy Sci., 66: 1474-1485.

Harrison, G.A., R.W. Hemken, K.A. Dawson, R.J. Harmon and K.B. Barker, 1988. Influence of addition of yeast culture supplement to diets of lactating cows on ruminal fermentation and microbial populations. J. Dairy Sci., 71: 2967-2975.

Huffman, RP., K.K. Karges, T.J. Klopfenstein, R.A. Stock, R.A. Britton and L.D. Roth, 1992. The effect of *Lactobacillus acidophilus* on subacute ruminal acidosis. J. Anim. Sci., 70: 87-87.

Isolauri, E., Y. Sutas, P. Kankaanpaa, H. Arvilommi and S. Salminen, 2001. Probiotics: Effects on immunity. Am. J. Clin. Nutr., 73: 444s-450s.

Jones, G.W. and J.M. Rutter, 1972. Role of the K88 antigen in the pathogenesis of neonatal diarrhea caused by *Escherichia coli* in piglets. Infect. Immity, 6: 918-927.

Jonsson, E. and I. Olsson, 1985. The effect on performance, health and faecal microflora of feeding *Lactobacillus* strains to neonatal calves. Swedish J. Agric. Res., 15: 71-76.

Jouany, J.P. and D.P. Morgavi, 2007. Use of natural products as alternatives to antibiotic feed additives in ruminant production. Animal, 1: 1443-1466.

Kholif, A.M., H.A. El-Alamy, M.A. El-Ashry, H.M. El-Sayed and T.A. Ali, 2000. Effect of supplementation of different types of live yeast cultures in the diet on the productive performance of lactating buffaloes. Egypt. J. Dairy Sci., 28: 281-295.

Kilmer, L., 2000. Direct-Fed Microbials and Fungal Additives for Dairy Cattle. Iowa State University Press, Ames, IA., USA.

Knowlton, K.F., J.M. McKinney and C. Cobb, 2002. Effect of a direct-fed fibrolytic enzyme formulation on nutrient intake, partitioning and excretion in early and late lactation Holstein cows. J. Dairy Sci., 85: 3328-3335.

Ko, S.Y. and C.J. Yang, 2008. Effect of green tea probiotics on the growth performance, meat quality and immune response in finishing pigs. Asian Aust. J. Anim. Sci., 21: 1339-1347.

Krehbiel, C.R., S.R. Rust, G. Zhang and S.E. Gilliland, 2003. Bacterial direct-fed Microbials in ruminant diets: Performance response and mode of action. J. Anim. Sci., 81: E120-E132.

Kullen, M.J. and T.R. Klaenhammer, 1999. Genetic Modification of Intestinal Lactobacilli and Bifidobacteria. In: Probiotics: A Critical Review, Tannock, G. (Ed.), Horizon Scientific Press, Wymondham, UK., pp: 65-83.

Kung, L. and A.O. Hession, 1995. Preventing *in vitro* lactate accumulation in ruminal fermentations by inoculation with *Megasphaera elsdenii*. J. Anim. Sci., 73: 250-256.

Lehloenya, K.V., C.R. Krehbiel, K.J. Mertz, T.G. Rehberger and L.J. Spicer, 2008a. Effects of propionibacteria and yeast culture fed to steers on nutrient intake and site and extent of digestion. J. Dairy Sci., 91: 653-662.

Lehloenya, K.V., D.R. Stein, D.T. Allen, G.E. Selk and D.A. Jones *et al*., 2008b. Effects of feeding yeast and propionibacteria to dairy cows on milk yield and components and reproduction. J. Anim. Physiol. Anim. Nutr., 92: 190-202.

Lodge, S., T. Klopfenstein, R. Stock and D. Herold, 1996. Use of direct-fed microbials to alleviate sub acute acidosis. Beef Cattle Report MP 66-A, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, pp: 66-67.

Lyons, T.P., 1990. Biotechnology: Risk or Revolution. A Review of Alltech's Position. In: Biotechnology in the Feed Industry, Lyons, T.P. (Ed.). Alltech Technical Publication, Kentucky, USA., pp: 1-9.

Marco, M.L., S. Pavan and M. Kleerebezem, 2006. Towards understanding molecular modes of probiotic action. Curr. Opin. Biotechnol., 17: 204-210.

McPeake, C.A., C.S. Abney, K. Kizilkaya, M.L. Galyean and A.H. Trenkle *et al*., 2002. Effects of direct-fed microbial products on feedlot performance and carcass characteristics of feedlot steers. Proceedings of the Plains Nutrition Council Spring Conference, April 25-26, 2002, San Antonio, Texas, pp: 133.

Morsy, T.M., H.M. Ebeid, A.E.K.M. Kholif, H.A. Murad, A.E.R.M. Abd El-Gawad and T.M. Bedawy, 2014. Influence of propionibacteria supplementation to rations on intake, milk yield, composition and plasma metabolites of lactating buffalos during early lactation. Sci. Int., 2: 13-19.

Murad, H.A. and H.E.H. Azzaz, 2013. Cellulase production from rice straw by *Aspergillus flavus* NRRL 5521. Sci. Int., 1: 103-107.

Newbold, C.J., R. Brock and R.J. Wallace, 1991. Influence of autoclaved or irradiated *Aspergillus oryzae* fermentation extract on fermentation in the rumen simulation technique (Rusitec). J. Agric. Sci., 116: 159-162.

Newbold, C.J., R.J. Wallace and F.M. McIntosh, 1996. Mode of action of the yeast *Saccharomyces cerevisiae* as a feed additive for ruminants. Br. J. Nutr., 76: 249-261.

Newman, K.E. and K.A. Jacques, 1995. Microbial Feed Additives for Pre-Ruminants. In: Biotechnology in Animal Feeds and Animal Feeding, Wallace, R.I. and A. Chesson (Eds.). 1st Edn., Wiley-Blackwell, USA., ISBN-13: 978-3527300655, pp: 247-258.

Nisbet, D.J. and S.A. Martin, 1990. Effect of dicarboxylic acids and *Aspergillus oryzae* fermentation extract on lactate uptake by the ruminal bacterium *Selenomonas ruminantium*. Applied Environ. Microbiol., 56: 3515-3518.

Nisbet, D.J. and S.A. Martin, 1994. Factors affecting L-lactate utilization by *Selenomonas ruminantium*. J. Anim. Sci., 72: 1355-1361.

Nissle, A., 1959. [Explanations of the significance of colonic dysbacteria and the mechanism of action of *E. coli* therapy (mutaflor)]. Medizinische, 4: 1017-1022, (In German).

Nocek, J.E., W.P. Kautz, J.A.Z. Leedle and J.G. Allman, 2002. Ruminal supplementation of direct-fed microbials on diurnal pH variation and *in situ* digestion in dairy cattle. J. Dairy Sci., 85: 429-433.

Offer, N.W. and A. Cruive, 1991. Maximizing Fiber Digestion in the Rumen: The role of Yeast Culture. In: Biotechnology in the Feed Industry, Lyons, T.P. (Ed.). Alltech Technical Publication, Kentucky, USA., pp: 79.

Pagan, J., 1990. Improving phosphorus digestion in the horse: A role for yeast culture. Proceedings of the Alltech's European Lecture Tour, (AELT'90), Alltech Technical Publications.

Panchal, C.J., I. Russell, A.M. Sills and C.G. Stewart, 1984. Genetic manipulation of brewing and related yeast strains. Food Technol., 38: 99-106.

Parvez, S., K.A. Malik, S.A. Kang and H.Y. Kim, 2006. Probiotics and their fermented food products are beneficial for health. J. Applied Microbiol., 100: 1171-1185.

Raeth-Knight, M.L., J.G. Linn and H.G. Jung, 2007. Effect of direct-fed microbials on performance, diet digestibility and rumen characteristics of holstein dairy cows. J. Dairy Sci., 90: 1802-1809.

Reiter, B. and B.G. Harnulv, 1984. Lactoperoxidase antibacterial system: Natural occurrence, biological functions and practical applications. J. Food Protect., 47: 724-732.

Salem, F.A., A.S. Soliman, S.M. Abdelmawla and M.R.M. El-Mahdy, 2000. Effect of some feed additives to rations of growing sheep on growing performance, rumen fermentation, blood constituents and carcass characteristics. Ann. Agric. Sci., 38: 1885-1904.

Smith, H.W., 1971. The bacteriology of the alimentary tract of domestic animals suffering from *Escherichia coli* infection. Ann. N. Y. Acad. Sci., 176: 110-125.

Stein, D.R., D.T. Allen, E.B. Perry, J.C. Bruner and K.W. Gates *et al*., 2006. Effects of feeding propionibacteria to dairy cows on milk yield, milk components and reproduction. J. Dairy Sci., 89: 111-125.

Swinney-Floyd, D., B.A. Gardner, F.N. Owens, T. Rehberger and T. Parrot, 1999. Effects of inoculation with either *Propionibacterium* strain P-63 alone or combined with *Lactobacillus acidophilus* strain LA53545 on performance of feedlot cattle. J. Anim. Sci., 77: 77-77.

Vandenbergh, P.A., 1993. Lactic acid bacteria, their metabolic products and interference with microbial growth. FEMS Microbiol. Rev., 12: 221-238.

Varel, V.H., K.K. Kreikemeier, H.J.G. Jung and R.D. Hatfield, 1993. *In vitro* stimulation of forage fiber degradation by ruminal microorganisms with *Aspergillus oryzae* fermentation extract. Applied Environ. Microbiol., 59: 3171-3176.

Waldrip, H.M. and S.A. Martin, 1993. Effects of an *Aspergillus oryzae* fermentation extract and other factors on lactate utilization by the ruminal bacterium *Megasphaera elsdenii*. J. Anim. Sci., 71: 2770-2776.

Wallace, R.J., D. Colombatto and P.H. Robinson, 2008. Enzymes, direct-fed microbials and plant extracts in ruminant nutrition. Anim. Feed Sci. Technol., 145: 1-4.

Walter, P.H., N. Weiss and W. Holzapfel, 1992. The Genera Lactobacillus and Carnobacterium. In: The Prokaryotes, A Handbookon the Biology of Bacteria: Ecophysiology, Isolation, Identification, Applications, Balows, A., H.G. Turper, M. Dworkin, W. Harder and K.H. Scheifer (Eds.). Springer-Verlag, New York pp: 1535-1573.

Weidmir, R.D. and M.J. Arambel, 1985. Effect of supplemental *Saccharomyces cerevisiae* and/or *Aspergillus oryzae* on rumen function. Proceedings of the 18th Conference on Rumen Function, (RF'85), Chicago, IL.

Wilks, D., 1997. Feed additives, a look at how feed additives can be beneficial, dairy feed facts. University of Minnesota, June 1997.

Williams, P.E.V., 1989. Understanding the Biochemical Mode of Action of Yeast Culture. In: Animal Feeds: Biological Additives, University of Sydney (Ed.). University of Sydney, Post Graduate Committee in Veterinary Science, Sydney South, NSW, Australia, ISBN: 9780909973674, pp: 79-101.

Williams, P.E.V., A. Walker and J.C. MacRae, 1990. Rumen probiosis: The effects of addition of yeast culture (viable yeast (*Saccharomyces cerevisiae*) plus growth medium) on duodenal protein flow in wether sheep. Proc. Nutr. Soc., 49: 128A-128A.

Yang, W.Z., K.A. Beauchemin, D.D. Vedres, G.R. Ghorbani, D. Colombatto and D.P. Morgavi, 2004. Effects of direct-fed microbial supplementation on ruminal acidosis, digestibility and bacterial protein synthesis in continuous culture. Anim. Feed Sci. Technol., 114: 179-193.

Yoon, I.K. and M.D. Stern, 1995. Influence of direct-fed microbials on ruminal microbial fermentation and performance of ruminants-A review. Asian-Austr. J. Anim. Sci., 8: 533-555.