The Effects of Probiotics Supplementation on Milk Yield and Composition of Lactating Dairy Cows

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ABSTRACT

The effects of microbials dietary supplements on performances and health of the animals, in recent is becoming very critical. Consequently, direct-feds microbials (DFM), is an area of interest of several authors, since last few decades. The probiotics usually, used as DFM for animals are lactic acid bacteria; lactobacillus, streptococci, bifidobacterial, enterococcus and anaerobic fungi species; saccharomyces and aspergillus. Normally, the mechanisms of action of DFM, are modulation of microflora balance in gastrointestinal tract and improvements in digestion and nutrients absorption, sustaining the health of the animals (i.e., through competitive exclusion, secretion of the substances that inhibit the growth or kill and altering gene expression of pathogenic agents) and stimulates the immunity of the animals. Generally, though the effects of host species, types of diet, animal physiological conditions, dosage of probiotics or strain, time of probiotic supplementation and variant strains used, are amongst important factors to be considered, DFM often plays an important role in improvements of milk yield and composition of lactating dairy cows. The DFM of Propionibacterium, Saccharomyces cerevisiae, Lactobacillus acidophilus, the mixture of yeast products and Enterococcus and combination of L. ecidophilus, L. casei and Enterococcus faecium to dairy cows, significantly improves milk yield and well as the composition. Therefore, DFM, is one of the promising areas of ruminant’s nutrition in general or dairy cows in specific, not only because of its nutritional and health benefits to animals, but also due to its negligible residual effects to the animal and animal products.

Keywords: Lactating cows, Milk yield and composition, Probiotics.

INTRODUCTION

The nutritional value of fibrous feeds to the ruminant is basically attributed to the unique digestive system of ruminants involving an intensive preliminary ruminal fermentation step prior to a more classical enzymatic phase. The reticulo-rumen hosts a highly specialized anaerobic microbial community responsible for the fiber breakdown, which is influenced by biochemical and microbial characteristics of the rumen. However, in intensive farming practices, due to an excessively, higher fermentable carbohydrate supply which is important for enhancing the performance of animal’s usually, disturbs the rumen microbial balance, eventually led to severe metabolic disorders and impair the production [1]. Hence, the role of direct microbial feed (DMF) of identified species were associated with rumen pH regulation, prohibition of pathogenic bacterial growth, maintaining health and enhancing production have been so far considered as a promising strategy in sector over the past few decades [2]. Consequently, at present time there is an increased interest in the use of probiotics basically, as animal feed and modifier rumen [3].

Thus, the term ‘probiotics’ was first used by Lilly and Stillwell [4] to designate unknown growth promoting substances produced by a ciliate protozoan that stimulated the growth of another ciliate. Now a days, the term covers a much broader group of organisms. The joint Food and Agricultural Organization (FAO) and World Health Organization (WHO) of United Nations Working Group defined probiotics as “live microorganisms which when administered in adequate amounts confer a health benefit on the host” [5, 6]. The most commonly used organisms in probiotic preparations are the lactic acid bacteria (Lactobacillus, Streptococci, bifidobacterial), which are found in larger quantity in the gut of healthy animals and do not appear to adversely affect them. The Anaerobic fungi yeast (Saccharomyces cerevisiae, Saccharomyces boulardii) and filamentous fungi (Aspergillus oryzae) were also used for probiotic preparations [7]. In general, the [8, 9] have pointed out the potential benefits of DFM in ruminants are; maintaining rumen pH and population of microbiota, enhancing fiber digestibility, decreasing methane production, modulation of immune system of ruminant animals.

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The beneficial effects of probiotics to the animals can be affected by a myriad of factors such as host species, type of diet, animal conditions, dosage, timing and strain of probiotic however, several research outcomes show that DFM have a positive response in improving animal production and health performance \[10, 11, 12, 13\]. Similarly, in dairy cattle, probiotics are commonly used to improve ruminal and intestinal microflora populations, consequently enhance the performance and health of animal, and boosts synthesis of protein and vitamins, as well as milk production and compositions \[14\]. Accordingly, \[15\] study on the multiparous Polish Black and White cows indicated the fat corrected milk yield, milk fat yield, milk protein yield, casein yield, lactose percentage, total solid and solid-not-fat were significantly improved. Additionally \[16\] reported the addition of lactic acid bacterial inoculants to maize at ensiling has improved the palatability, intake and the aerobic stability of maize silage compared to the control. In other hand, Sablik \[17\], conducted two studies to analyze the effect of Yeast probiotic (i.e. *Saccharomyces cerevisiae*) and bioprep mineral mixture on milk yield and composition of dairy cows. And, therefore, it was observed that, there is significant increase in milk yield, milk fat yield, protein yield and FCM when 15 g of Yeast-Sacc1026 strain was given to the cows in both experiments.

However, in some other literatures the outcomes were contrasting. Hence, Krishnamoorthy and Krishnappa \[18\], found no differences in milk yield and milk composition when yeast was added to finger millet straw for lactating crossbred cattle. Similarly, Swartz et al. \[19\] Oetzel et al. \[20\] Maamouri et al. \[21\], did not observe significant difference in milk yield and compositions in their studies.

Therefore, in this article the effect of probiotics supplementation on milk yield and composition of dairy cows and their modes of actions has been reviewed.

### PROPERTIES AND COMMON SPECIES OF PROBIOTICS

#### Essential properties of probiotics

Probiotics are products containing either live or dead micro-organisms and the substances they produce. It consists one or more strains of microorganisms that can be administered to animals in the form of powder, tablets, granules or paste \[22\]. Microorganisms that are used in the manufacture of preparations should be isolated from the animals of the same species in which they are to be used, so that the resulting microbial material can adapt to the conditions that are most likely to occur in the digestive tracts of certain animal species. In the digestive tract of animals, they should contribute for stabilization of microbial populations and increasing enzymatic activity of the system, thus create a positive effect on the development of the animals. According to Toma & Pokrotnieks \[24\] Ohashi & Ushida \[25\] Grela et al \[26\] the probiotic microorganisms (or strain) to be used in ruminant nutrition have to possess the following important properties:

- Be able to live in low stomach pH and show resistance to bile acids and also, should be tolerated by the immune system of the animal.
- Have a beneficial effect on the animal’s organism and should not be pathogenic, allergic or mutagenic/carcinogenic to the animal.
- Have the ability to adhere to intestinal epithelial cells, and permanently or periodically proliferate and colonize gastrointestinal tract (or active in its presumed site).
- Have the ability to sustain under unfavorable storage and living conditions in the digestive tract.

#### Common genera or species of probiotics

Most of commercial products uses multi-strain probiotics, although the benefits of incorporating more a single strain and/or species in one product has not been clearly determined \[27\]. Hence, those microorganisms, that are frequently used as probiotics in animal feeds includes, lactic acid bacteria (such as *Lactobacillus*, *Streptococci*, *bifidobacteria*) and anaerobic fungi (yeast) (i.e. *Saccharomyces cerevisiae*, *Saccharomyces boulardii* and *Aspergillus oryzae*) that are normally, found in the gut of the animal.

### EFFECTS OF PROBIOTICS ON MILK YIELD AND COMPOSITIONS

#### Effects of probiotics on milk yield

Modern dairy farms are targeting high milk production utilizing feed composed of high concentrates to meet the metabolic demand of the higher milk production. Such feeding system is associated with metabolic dysfunction like rumen acidosis especially during poor feeding condition and composition. Therefore, probiotics are suggested as an effective mechanism of preventing or treating ruminal acidosis and/or improve animals’ performances \[28\]. Thus, according to Nocek, & Kautz \[29\] Rossov, et al. \[30\] Leiceste, et al. \[31\] and Stella et al. \[32\], the supplementation of probiotics (i.e. Yeast and *Enterococcus* mix, *Propionibacterium* (strain-P169), Live Yeast Product (LYP), Yeasture DFM and *Saccharomyces cerevisiae* (strain-CNCFMI-1077) to dairy cows have significantly improved milk yield in comparison to control (see Table 1).

| Yeast and *Enterococcus* | 36.9 | 39.2 | 0.5 | 0.01 | 0.29 |
|--------------------------|------|------|-----|------|------|
| Live Yeast Product        | 32.3 | 33.0 | 0.41 | 0.0014 | 0.30 |
| Yeasture DFM              | 47.77| 48.93| 0.412| 0.01 | 0.31 |
| SCC(CNCFMI-1077)          | 2.08 | 2.38 | 0.14 | 0.03 | 0.32 |

On the other study, Hossain, et al. \[33\], have reported a 0.3 liter / day / animal increase (which is 8.8 %) in average daily milk yield after feeding probiotics (*Saccharomyces Cerevisiae*) (P<0.05). Lehloeya, et al. \[34\] reported, 9 % increase in milk yield when the mixture of yeast and Propionibacterium is fed dairy cows 2 weeks from pre-partum to 30.0-weeks post-partum. Similarly, Williams et al. \[35\] Wohlt, et al. \[36\] Piva, et al. \[37\] Dutta, & Kundu \[38\] Yalcin, et al. \[39\] & Vibhute et al. \[40\]. In other study, Bruno et al. \[41\] reported that, the cows fed from yeast culture has produced more than 1.2kg milk per day. Also, Jacquette, et al. \[42\] and Ware, et al. \[43\] reported a 1.8 kg/day milk yield increase when the cows fed Lactobacillus acidophilus (2 x 10^10 cells/day) when compared with the control group. Gomez-Basauri, et al. \[44\] observed an increase in milk production (0.73 kg/day) when feeding cows, form the mixture of *L. acidophilus*, *L. casei* and *Enterococcus faecium*. More recently, Stein, et al. \[45\] reported, 8.5% yield increase (4% fat correction) in cows receiving, 6 x 10^10 Propionibacterium per day from two weeks’ pre-partum to 30 weeks. Post-partum.

Nonetheless, other authors presented a contradicting result; were there was no significant improvement in milk yield from probiotics supplementation \[46, 19, 47, 21\]. But, in another hands, Arambel, and Kent, \[48\], found that milk yield of dairy cows has increased with addition of yeast, but only when the protein content is deficient in the diet.

In large animal studies, Oetzel, et al. \[20\], did not observe any effect of *Enterococcus faecium* and *Saccharomyces cerevisiae* on milk yield or composition when fed to cows from 10-days pre-partum to 23 days of postpartum. However, Nocek, et al. \[39\], observed an increased dry matter intake (2.6 kg/day) and increased milk yield (2.3 kg/day) with the same combination of probiotics offered from 3 weeks preparatum to 10 weeks post-partum. Similar results were obtained by Nocek and Kautz \[29\] in a very similar trial using 44 Holstein cows.

### Effects of probiotics in milk compositions

Like milk yield, the effects of probiotics in milk composition were also inconsistent across different literatures. Consequently, the authors such
as [50, 51, 37, 52, 24, 29, 30, 32] were reported significant improvement in milk fat % after supplementation of probiotics. In contrary, Erdman and Sharma [33] Arambel and Kent [48] Swartz, et al., [53] Dutta & Kundu [38] Weiss, et al., [47] Maamouri, et al., [21] Hossain, et al., [33] reported negligible improvement of milk fat % in the cows with probiotics supplementation (Table 2).

**Table 2: The effect of direct-fed microbial1 (DFM) on milk composition (MC)**

| MC                  | DFM (Spp. or Strain) | Control | Treatment | SEM | P     | References  |
|---------------------|----------------------|---------|-----------|-----|-------|-------------|
| Fat (%)             | YE                   | 4.76    | 4.44      | 0.09| 0.01 | [30]        |
|                     | PB (P169)            | 4.12    | 4.00      | 0.11| 0.17 | [47]        |
|                     | LYP                  | 3.68    | 3.61      | 0.037| 0.048| [39]        |
|                     | SCC                  | 3.59    | 3.37      | 0.300| 0.20 | [21]        |
|                     | SCC(CNCMI-1077)      | 4.46    | 4.32      | 0.09| 0.001| [32]        |
|                     | SCC                  | 4.57    | 4.52      | --  | 0.614| [31]        |
| Protein (%)         | YE                   | 3.12    | 3.13      | 0.06| NS   | [25]        |
|                     | PB (P169)            | 2.72    | 2.73      | 0.03| 0.9  | [47]        |
|                     | LYP                  | 3.25    | 3.31      | 0.017| 0.002| [39]        |
|                     | SCC                  | 2.94    | 2.94      | 0.005| 0.90 | [21]        |
|                     | SCC(CNCMI-1077)      | 3.65    | 3.65      | 0.07| NS   | [32]        |
|                     | SCC                  | 3.29    | 3.43      | --  | 0.032| [31]        |
| Lactose (%)         | YE                   | 4.59    | 4.65      | 0.02| 0.05 | [25]        |
|                     | PB (P169)            | 4.69    | 4.72      | 0.04| 0.6  | [47]        |
|                     | SCC                  | 4.55    | 4.54      | 0.010| 0.60 | [21]        |
|                     | SCC(CNCMI-1077)      | 4.99    | 4.94      | 0.13| NS   | [32]        |
|                     | SCC                  | 28.9    | 30.1      | --  | 0.008| [31]        |
| Ash (%)             | SCC                  | 7.85    | 7.81      | 0.160| 0.60 | [21]        |
| SNF%                | SCC                  | 8.28    | 8.57      | 0.014|      | [31]        |

NB: - PB: *Propionibacterium*, SCC: *Saccharomyces Cerevisiae*, LYP: Live Yeast Production, YE: Yeast & Enterococci

In similar ways, different authors reported that probiotic supplementation have significantly affected milk protein (%) [30, 33, 54, 20, 41, 39, 40], milk lactose (%) [29, 33] and SNF% [33]. While, some authors have showed that, there was no significant influence of probiotics on yield of milk protein % [29, 47, 21, 32, 46, 48, 53, 38], lactose % [29, 47, 21, 32] and Ash % [21] (see Table 2).

**Probiotics Mode of Action**

Different probiotics exert their effects in various mechanisms, which is not yet fully understood, presumably, due to their actions was either carried out in gastro-intestinal lumen or in the GIT wall. Although, probiotics are being promoted as a substitute for Antibiotic Growth Promoters (AGP), the mechanisms of action of these feed additives appears to be different [35] and some of them are described in the following section.

**Modification of GIT’s microbial population**

Maintaining gut health in animals, particularly in the context of AGP being gradually phased out, though the manipulation of the diet was crucial to maintain or improve the animal production performance [56]. One of the basic determining factors of a healthy gastro-intestinal tracts (GIT) is the composition of the microbial population. The probiotics can change the microbial population dynamics in the GIT, by creating a shift in balance between the beneficial and harmful microbes. favorable [57]. Further, healthy microbial populations in GIT, are often associated with enhanced animal performance, reflecting more efficient digestion and improved immunity [59]. The reduction in pathogenic micro-organisms in GIT may be attributed to the production of antimicrobial substances such as [59] and adhesion of the probiotic microbes to the intestinal epithelium, thereby, excludes competitiveness of pathogens or by inducing immune system response. The most common modulation of the GIT microflora by probiotics is an increase in the populations of *Lactobacillus* and *Bifidobacteria* [60, 61, 62] while populations of coliforms particularly *Escherichia coli* [61] and *Clostridium* spp. [59] become decreased. *Lactobacilli* and *bifidobacteria* produces protein or polypeptide bacteriocins which reduce the growth of closely related bacterial species [63], and may reduce the number of harmful micro-organisms in GIT.

**Production of antimicrobial substances**

Some probiotics produce antimicrobial substances that may inhibit the growth of pathogenic micro-organisms in the intestine. Many bacterial species, including lactic acid producing bacteria [64], *bifidobacterial* [65] and *bacillus* [66], can produce several types of thermostable bacteriocins which possesses antimicrobial properties against a wider range of potential pathogens including, *Bacillus*, *Staphylococcus*, *Enterococcus*, *Listeria* and *Salmonella* species [67, 64, 68, 69]. In another study, the probiotic *L. salivarius* (strain UCC118 and Abp118) produced a broad spectrum bacteriocin and protected mice against pathogenic *Listeria monocytogenes* [68]. But, a mutant of the same probiotic unable to produce bacteriocins and unable to protect the mice against pathogenic *Listeria monocytogenes*, confirming that the bacteriocins were the active agent. Bacteriocin produced by LAB (i.e. Nisin) inhibits the growth of pathogenic micro-organisms by inhibiting cell wall synthesis, with the formation of pores in the bacterial surface [70]. To achieve this, the bacteriocin bonded to the cell wall precursor, the lipid-II, forming a complex, which can form a pore onto the bacterial cell membrane leading to the death of the bacterium [71].

The DFM Yeast as probiotic has been found effective in decreasing pathogenic effects of infectious bovine rhinotracheitis virus in calves [72]. Probiotics strains were found to prevent and reduce mastitis and metritis in cattle by reducing adhesion of pathogenic bacteria, producing antimicrobial substances and with other modes of action [73, 74]. *Lactobacillus acidophilus* has been reported to provide protection.
from *E. coli* O157:H7 infection in cattle owing to their bacteriocidal/bactericidal effects [75, 76].

**Alteration of gene expression in pathogenic micro-organisms**

Bacteria communicate cell to cell through the secretion of chemical signals, called auto-inducers, which affect the behavior of bacteria [77]. This process of bacterial communication, called quorum sensing, is also used for communication between bacteria and their host [78]. Probiotics may affect quorum sensing in pathogenic bacteria, thus influencing their pathogenicity. Extracellular secretion of a chemical signal (autoinducer-2) by human enterohaemorrhagic *E. coli* (serotype O157:H7) was substantially, inhibited by fermentation products from *L. Acidophilus* La-5, resulting the suppression of the virulence gene (LEE – locus) expression in vitro. This would disrupt the quorum sensing and eventually prevent GIT colonization by *E. coli* (serotype O157:H7) [79].

**Colonization resistance**

The GIT of neonatal animals and birds are naturally colonized with micro-organisms, generally originating from the adult mother. These micro-organisms provide protection from enteric pathogens. Intensification of animal agriculture has reduced the opportunity for natural colonization of GIT, making animals more susceptible to intestinal pathogens infection. However, probiotics could mimic a natural colonization in neonates, or colonize an adult animal, thus, preventing pathogenic organisms from colonizing the intestinal mucosa. Certain strain of *Lactobacillus* and *Bifidobacterium* possess hydrophobic surface layers proteins which help the bacteria to non-specific adherence to the animal’s cell surface [80, 81]. Such adhesion of probiotic bacteria to the intestinal epithelium covers the receptor binding sites, hence, prevent the pathogenic micro-organisms (such as *E. coli*, *Salmonella* and others) from attaching into the epithelium [81].

**Increase in digestion and absorption of nutrients**

Improvement in productivity of animals due to probiotics can be associated with an increase in digestion and absorption of nutrients. A combination of *L. acidophilus* (NPS52) and *P. freudenreichtii* (NP24) improved the digestibility of crude protein, neutral detergent fiber and acid detergent fiber in lactating Holstein cows resulting in increased milk production per day by 7.6% without increasing dry matter intake (DMI) [12] and it was suggested that this was due to a change in the rumen microbial ecology. Similarly, supplementation of dairy cows with Probios TC (containing 2 strains of *Enterococcus faecium*) at the rate of 5 x 10^6 cfu per day as well as 2 x 10^8 viable yeast cells per day from 21 days prior to expected calving date through 10 weeks of postpartum, has increased milk yield by 2.3 kg per cow per day, no difference in 3.5% fat corrected milk. The *E. faecium* strains were thought to act by producing lactic acid, which supports a rumen microbial ecology. Similarly, supplementation of dairy cows with *Lactobacillus, Streptococci*, *Saccharomyces cerevisiae*, *Saccharomyces boulardii* and *Aspergillus oryzae* were frequently used among others. Inexplicit, the details of DFM modes of action was yet not noticed very well. However, most of the literatures enlists that, modification of rumen microbial populations, enhancing feed digestibility and nutrient absorption, rumen pH regulation, colonization of gastro-intestinal tracts and competitive exclusion of pathogenic agents, production of antimicrobial substances and altering gene expression of pathogenic microorganisms were among common modes of action.

And, a substantial species and subspecies of microorganisms were used as probiotics in animal nutrition, of which lactic acid bacteria (*Lactobacillus, Streptococci*, *Bifidobacteria*) and anaerobic yeast (*Saccharomyces cerevisiae*, *Saccharomyces boulardii* and *Aspergillus oryzae*) were frequently used among others. Inexplicit, the details of DFM modes of action was yet not noticed very well. However, most of the literatures enlists that, modification of rumen microbial populations, enhancing feed digestibility and nutrient absorption, rumen pH regulation, colonization of gastro-intestinal tracts and competitive exclusion of pathogenic agents, production of antimicrobial substances and altering gene expression of pathogenic microorganisms were among common modes of action.

Therefore, in accordance to the above conclusions the following recommendations have been forwarded;

✔ The strict regulatory procedures should have to be set in place and accordingly, implemented to insure the DFM products used in animal feed which possibly, enter human food chain should be free of harmful substances and were, strictly gone through the standard procedures and contents in production.

✔ Further studies are necessitated in determining the factors influencing the effects of probiotics supplements to dairy cows on milk yield and compositions.

**REFERENCES**

1. Chaucheyras-Durand F, Chevaux E, Martin C, Forano E. Use of Yeast Probiotics in Ruminants: Effects and Mechanisms of Action on Rumen pH, Fibre Degradation, and Microbiota According to the Diet. 2012. http://dx.doi.org/10.5772/50192.

2. Simon O. Microorganisms as feed additives-probiotics. Advances in Pork Production, 2005; 16(2):161.

3. Beauchemin KA, Krehbiel CR, Newbold CJ. Enzymes, Bacterial Direct-Fed Microbial and Yeast: Principles for Use in Ruminant Nutrition. In: Mosenthin R, Zentek J. & Ebrowska TZ. (Eds) Biology of Nutrition in Growing Animals, 2006.

4. Lilly DM, Stillwell RH. Probiotics: Growth-promoting factors produced by microorganisms. Science 1965; 147:747-748.

5. FAO/WHO. Joint FAO/WHO (Food and Agriculture Organization/Wood Health Organization) working group report on drafting guidelines for the evaluation of probiotics in food. London, Ontario, Canada. guidelines for the evaluation of probiotics in food. Joint working group report on drafting, London, UK, 2002.

6. FAO. Probiotics in animal Nutrition-Production, impact and regulation by Yadav S, Bajajai, Athol V, Klieve, Peter J. Dart and Wayne L. Bryden. Edited by Harinder P.S. Makkar. FAO Animal Production and Health Paper No. 179, Rome, Italy, 2016.

7. Shelke SDV, Vihute M, Chavan RR, Nage SP, Punjabdai DKV. Effect of probiotics supplementation on performance of lactating crossbred cows. Vet. World, 2011; 4(12):557-561.

8. Chaucheyras-Durand F, Durand H. Probiotics in animal nutrition and health. *Benef. Microbes*, 2010; 1:3-9.

9. Jouany JP, Morgavi DP. Use of ‘natural’ products as alternatives to antibiotic feed additives in ruminant production. *J. Animal* Sc. 2007; 1:1443-1466.

10. Chaucheyras-Durand F, Walker N, Bach A. Effects of active dry yeasts on the rumen microbial ecosystem: Past, present and future. *Animal Feed Science and Technology*, 2008; 145(1-5):5-26.

11. Seo JK, Kim SW, Kim MH, Upadhyaya SD, Kam DK, Ha JK. Direct-fed microbial for ruminant animals. *Asian-Australi. J. Anim. Sci.* 2010; 23(12):1657-1667.

12. Boyd J, West J, Bernard J. Effects of the addition of direct-fed microbial and glycerol to the diet of lactating dairy cows on milk yield and apparent efficiency of yield. *Journal of Dairy Science*. 2011; 94(9):4616-4622.

13. Weinberg ZG, Muck RE, Weimer PJ, Chen Y. Lactic acid bacteria used in inoculants for slilage probiotics for ruminants. *Appl. Bioche. Biotech.* 2008; 10(13):1-9.

14. Vieira VA, Storcini MP, Endo V, Magioni GC, Oliveira MDS. Influence of probiotics on dairy cows’ diet. *International Scholarly and Scientific Research & Innovation*. 2014; 8(7):786-789.
The effects of yeast culture on milk production and composition, and fermentation patterns in the rumen of steers. J. Anim. Sci. 2010; 88(1):15-19.

Lehloenya KV, Stein DR, Allen DT, Perry EB, Bruner JC, Gates KW, Rehberger TG, et al. Effects of feeding propionibacteria to dairy cows on milk yield, milk components and reproduction. J. Dairy Science. 2006; 89(1):111-125.

Erdman RA, Sharma BK. Effect of Yeast Culture and Sodium Bicarbonate on Milk yield and Composition in Dairy Cows. Journal of Dairy Science. 1989; 72(7):1929-1932.

Swartz DL, Muller LD, Rogers GW, Varga GA. Effect of yeast cultures on performance of lactating dairy cows: a field study. J. Dairy Sci. 2004; 7(10):3073-3080.

Oetzel GR, Emery KM, Kautz WP, Nocek JE. Direct-fed microbial supplementation during induced lactic and subacute peripartum diseases in dairy cows. J. Dairy Sci. 2010; 93(11):5626-5635.

Zhao X, Guo Y, Guo S, Grela ER, Lipiec A, Pisarski R, Ohashi Y, Nowak A, Silizewska K, Libudz Z, Maamouri O, M'hamdi N, Parasion S, M'hamdi N, Górecka JS, Kierul SA, Varga GA. Effect of yeast cultures on performance of lactating dairy cows: a field trial. J. Dairy Sci. 2010; 93(10):3963-3972.

BMC Microbiology. 2006; 6:39.
63. Kawai Y, Ishii Y, Arakawa K, Uemura K, Saitoh B, Nishimura J, et al. Structural and functional differences in two cyclic bacteriocins with the same sequences produced by lactobacilli. Applied and Environmental Microbiology. 2004; 70(5):2906-2911.

64. Flynn S, Van Sinderen D, Thornton GM, Holu H, Nes IF, Collins JK. Characterization of the genetic locus responsible for the production of ABP-118, a novel bacteriocin produced by the probiotic bacterium Lactobacillus salivarius subsp. salivarius UCC118. Microbiology, 2002; 148(4):973-984.

65. Cheikhiyoussaf A, Pogori N, Chen W, Zhang H. Antimicrobial proteinaceous compounds obtained from bifidobacteria: From production to their application. International Journal of Food Microbiology. 2008; 125(3):215-222.

66. Le Marrec C, Hyronimus B, Bressollier P, Verneuil B, Urdaci MC. Biochemical and genetic characterization of coagulin, a new anti-listerial bacteriocin in the pediocin family of bacteriocins, produced by Bacillus coagulans 14. Applied Environmental Microbiology. 2000; 66(12):5213-5220.

67. Cotter PD, Hill C, Ross RP. Bacteriocins: developing innate immunity for food. Nature Reviews in Microbiology. 2005; 3(10):777-788.

68. Corr SC, Li Y, Riedel CU, O'Toole PW, Hill C, Gahan CG. Bacteriocin production as a mechanism for the anti-infective activity of Lactobacillus salivarius UCC118. Proceedings of the National Academy of Science of the United States of America. 2007; 104(18):7617-7621.

69. Rea MC, Clayton E, O’Connor PM, Shanahan F, Kiely B, Ross RP, et al. Antimicrobial activity of lactacin 3147 against clinical Clostridium difficile strains. Journal of Medical Microbiology. 2007; 56(7):940-946.

70. Hassan M, Kjos M, Nes I, Diep D, Lotfpour F. Natural antimicrobial peptides from bacteria: characteristics and potential applications to fight against antibiotic resistance. Journal of Applied Microbiology. 2012; 113(4):723-736.

71. Bierbaum G, Sahi HG. Lantibiotics: mode of action, biosynthesis and bioengineering. Current Pharmaceutical Biotechnology2009; 10(1):2-18.

72. Cole NA, Pardy CW, Hutcheson DP. Influence of yeast culture on feeder calves and lambs. J. Anim. Sci. 1992; 70:1682-1690.

73. Otero MC, Nader-Macias ME. Inhibition of Staphylococcus aureus by H2O2-producing Lactobacillus gassen isolated from the vaginal tract of cattle. Anim. Reprod. Sci. 2006; 96:35-46.

74. Gulbe G, Valdovska A, Saulite V. Jermolajev J. In vitro assessment for antimicrobial activity of Lactobacillus helveticus and its natural glycopeptides against mastitis causing pathogens in dairy cattle. Open Biotechnol. J. 2015; 9:61-66.

75. Schamberger GP, Phillips RL, Jacobs JL, Gonzalez FD. Reduction of Escherichia coli O157:H7 populations in cattle by addition of colicin E7-producing E. coli to feed. Appl. Environ. Microbiol. 2004; 70(10):6053-6060.

76. Poppi LB, Rivaldi JD, Coutinho TS, Astolfi-Ferreira CS, Ferreira AJP, Mancilha IM. Effect of Lactobacillus sp. isolates supernatant on Escherichia coli O157:H7 enhances the role of organic acids production as a factor for pathogen control. Pesquisa Veterinaria Brasileira. 2015; 35:353-359.

77. Miller MB, Basoler BL. Quorum sensing in bacteria. Annual Review of Microbiology. 2001; 55(1):165-199.

78. Hughes DT, Sperandio V. Inter-kingdom signaling: communication between bacteria and their hosts. Nature Reviews in Microbiology. 2008; 6(2):111-120.

79. Medellin-Pena MJ, Wang H, Johnson R, Anand S, Griffiths MW. Probiotics affect virulence related gene expression in Escherichia coli O157:H7. Applied and Environmental Microbiology. 2007; 73(13):4259-4267.

80. Tuomola EM, Salminen SJ. Adhesion of some probiotic and dairy Lactobacillus strains to Caco-2 cell cultures. International Journal of Food Microbiology. 1998; 41(1):45-51.

81. Johnson-Henry KC, Hagen KE, Gordonpour M, Tompkins TA, Sherman PM. Surface layer protein extracts from L. helveticus inhibit enterohaemorrhagic Escherichia coli O157:H7 adhesion to epithelial cells. Cellular Microbiology. 2007; 9(2):356-367.

82. Afsharmanesh M, Sadaghi B. Effects of dietary alternatives (probiotic, green tea powder and Kombucha tea) as antimicrobial growth promoters on growth, ileal nutrient digestibility, blood parameters, and immune response of broiler chickens. Comparative Clinical Pathology. 2014; 23(3):717-724.

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