International Journal of Veterinary Sciences and Animal Husbandry 2024; SP-9(1): 586-590

ISSN: 2456-2912
VET 2024; SP-9(1): 586-590

www.veterinarypaper.com
Received: 09-10-2023
Accepted: 16-11-2023

P Das
Ph.D. Scholar, Department of Animal Nutrition, College of Veterinary and Animal Science, Bikaner, Rajasthan, India

MS Meel
Assistant Professor, Department of Animal Nutrition, College of Veterinary and Animal Science, Navania, Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India

Role of direct fed microbials in enhancing bovine productivity: A review

P Das and MS Meel

Abstract

Ruminant nutritionists and microbiologists have been regulating the rumen microbial ecology for over 30 years in order to improve production efficiency and reduce productivity loss due to rumen acidosis. Direct-fed microbials (DFM) are a safe alternative to antibiotics for improving animal performance. Direct-fed microbials (DFM) are a safe alternative to antibiotics for improving animal performance. DFM was largely utilized in young ruminants to promote gut health and establish the intestinal microbiota involved in feed digestion. Host receives protein, vitamins, and short-chain organic acids from beneficial microorganisms. Treatment with DFM increases anti-pathogenic effects and reduces Animal stress. It is common practice in DFM for rumen to use lactic acid producing, utilising bacteria or other microorganism species like Lactobacillus, Bifidobacterium, Enterococcus, Bacillus, Propionibacterium, *Megasphaera elsdenii*, and *Prevotella bryantii*, along with some yeast species like Saccharomyces and Aspergillus. By altering the rumen environment, bacterial DFM has the potential to encourage weight increase and feed efficiency. Fungal DFM aids in the reduction of toxic oxygen in the rumen, the prevention of excessive lactate generation, the improvement of feed digestibility, and the improvement of rumen fermentation patterns. Dry matter intake, milk yield, fat corrected milk yield, and milk fat content may all benefit from DFM. However, the response to DFM differs depending on DFM strains, doses, and feeding times and frequencies. Therefore, the goal of this review study is to overview of the mechanism of action and pros and cons of feeding DFM on many aspects of rumen health and production in cows.

Keywords: Acidosis, antibiotics, bacteria, direct fed microbials, defaunation

Introduction

Increased utilization of feed, health status and productivity are the main objectives of research on rumen microbes. These objectives can be reached by encouraging healthy fermentation and reducing ruminal infections, and getting rid of pathogens. For the past few decades, ruminant nutrition has used antibiotics, ionophores, methane inhibitors, and defaunating agents to alter the microbial ecology and fermentation properties in the rumen and intestinal tract of cattle Seo *et al*. (2010) [50]. Feed additives are not commonly employed due to toxicity issues with the host animals, Salem *et al*. (2014) [47], Salem *et al*. (2014b) [48], Yang *et al*. (2004) [62] defined the DFM as "alive, naturally occurring microbial based feed additives that have been used to improve cattle digestive function." Yeast, fungus, bacteria, cell fragments, and filtrates—both specific and nonspecific-are included in the broad definition of DFM. Frizzo *et al*. (2010) [21], Oetzel *et al*. (2007) [39], Sullivan *et al*. (1999) [55].

Key elements in DFM include animal conditions, DFM strains, dosage, and timing Puniya *et al*. (2015) [41]. DFM research is limited to a few species because DFM that target the rumen must be viable during delivery and active in the rumen. Because of their ability to withstand high temperatures and it has been discovered that the best DFM choices for ruminant animals are Bacilli species. McAllister *et al*. (2011) [34]. Large volumes of concentrates must be fed in intensive production systems, especially when the cows are high-yielding dairy cows, in order to provide adequate nutrition to support high milk output. High-concentrate feeding frequently results in metabolic dysfunction and, finally, rumen acidosis. When implementing high concentrate feeding regimens, the nutritionist's goal is to maximize performance and efficiency through proper nutritional management Henning *et al*. (2004) [26].

Corresponding Author:
MS Meel
Assistant Professor, Department of Animal Nutrition, College of Veterinary and Animal Science, Navania, Rajasthan University of Veterinary and Animal Sciences, Bikaner, Rajasthan, India

Rumen acidosis can lead to a number of problems if left untreated, such as inconsistent feed intake, decreased milk production, anomalies in the digestive system, and probable reproductive and health problems such endometritis, lung illness, and laminitis Hall *et al*. (1999) [24]. One example given by Callaway *et al*. (1997) [11] is the inhibition of the growth of lactic acid-generating bacteria such as Streptococcus bovis and Lactobacillus species with feed additives like ionophores. Utilising direct-fed microbials (DFM) such as the lactic acid utilizer *Megasphaera elsdenii* to increase the population of lactic acid-using bacteria is another tactic for regulating lactic acid levels in the rumen. Recent research has demonstrated the possibility to alter the rumen microbiota by dietary change s made during infancy in order to achieve long-term effects (such as the reduction of enteric methane production) Meale *et al*. (2021) [35]. Therefore, early-life DFM supplementation in young ruminants may offer us a chance to get a lasting benefit. However, more study in this field is required.

Microorganisms Used in DFM Products

Among the microbes used in DFM for ruminants are Lactobacillus, Bifidobacterium, Enterococcus, Streptococcus, Bacillus, and Propionibacterium. *Prevotella bryantii* and *Megasphaera elsdenii* have also been used as DFM to enhance or stabilize rumen ecosystem. Many commercially available yeast products contain species of Saccharomyces and Aspergillus. Gaggía *et al*. (2010) [16] (Table 1).

Table 1: Common DFM microorganisms used in ruminant feed

Microorganisms	Genus and species
Lactic acid-producing bacteria *Lactobacillus* species	*Lactobacillus brevis*
	L. lactis
	L. johnsonii
	L. fermentum
	L. plantarum
	L. acidophilus
	Lactobacillus casei ssp. *casei*
Bifidobacterium species	*Bifidobacterium longum*
	B. lactis
	B. bifidum
	B. infantis
	B. pseudolongum
Enterococcus species	*E. faecalis*
	E. faecium
Lactic acid-utilizing bacteria *Megasphaera* *Propionibacterium*	*Megasphaera elsdenii*
	Propionibacterium freudenreichii
	P. shermanii
Other species	*Bacillus cereus*
	Saccharomyces cerevisiae
	Bacillus licheniformis
	Prevotella bryantii
	Lactococcus lactis subsp. *lactis*
	Pediococcus acidilactici
	Aspergillus oryzae
	Candida utilis

In the intestine, lactic acid producing bacteria (LAB) have anti-inflammatory qualities. For example, lactobacilli and enterococci shield dairy cows from ruminal acidosis. In addition, Yoon and Stern (1995) [64] stimulate bacteria that use lactic acid (LUB). Using LUB as DFM, lactate concentrations have been successfully lowered and ruminal pH has been maintained. *M. elsdenii* supplementation has been suggested for protecting transition animals from acute acidosis Kung *et al*. (1995) [31]. Propionibacteria ferment lactate to create propionate. Dairy cows in their early lactation, propionate formation in the rumen increases the amount of glucose produced by the liver, increasing the number of lactose synthesis substrates and increasing energy efficiency, and reducing ketosis. Weiss *et al*. (2008) [59], Reynolds *et al*. (2003) [42]. Elevated propionate concentrations have the potential to modify rumen fermentation, raise the molar proportion of ruminal propionate, and reduce the amount of hydrogen available in the rumen for the production of methane.

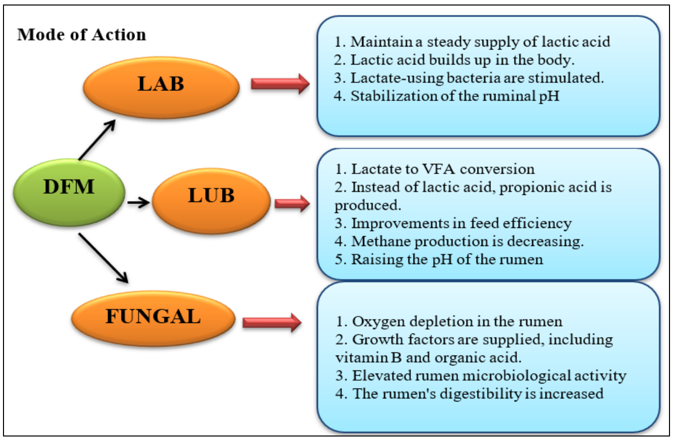

Fig 1: Different mode of action of DFM

In ruminants, fungal DFM has been utilized extensively to improve performance and normalize rumen fermentation. Yeast cells in the rumen use the readily available oxygen on the surfaces of freshly consumed food to sustain metabolic activity. Moreover, *S. cerevisiae* prevented lactate accumulation in the rumen by competing with other starch-using bacteria Lynch and Martin (2002) [32] for starch fermentation.

Effects of DFM on young calves

Young calves may be more susceptible to the spread of pathogens since they must absorb a substantial portion of the nutrients in their ration in their intestines. New settings, such as transportation, weaning, immunization, and dehorning, stress newborn calves Krehbiel *et al*. (2003) [28]. Before their gut flora has fully colonized, calves are quickly separated from cows. Diarrhea and weight loss may be more likely as a result of this condition. Therefore, giving scouring calves beneficial microorganisms may hasten the colonization of stressed intestinal habitats and the return of GIT function to normal Kung (2001) [30]. When compared to calves who did not receive LAB, oral delivery enhanced BW gain and decreased incidence of diarrhea Frizzo *et al*. (2010) [21]. Although there are normally less helpful microbes in neonatal calves, such as *Lactobacillus* and *Bifidobacteria*, it has been demonstrated by numerous researches that probiotic supplements containing these microbes accelerate growth. When calves were fed LAB, Frizzo *et al*. (2010) [21] observed increased daily growth. Sadrsaniya *et al*. (2015) [45] observed Probiotics supplementation significantly ($p \leq 0.01$) increased average daily weight gain (ADG) in Mehsana Buffalo Calves. Srinivas *et al*. (2011) [53] also find similar results in which probiotics supplementation significantly increased ADG (g/d) in Murrah buffalo bull calves.

Effects of DFM on adult ruminants

Researchers Wadhwa *et al*. (2013) [58] suggest that adding live yeast to the rumen ecology may assist maintain ecosystem balance and raise the quantity of microorganisms that break down cell walls in cattle. As a valuable and extremely nutrient-dense feed supplement for ruminants, yeast generates a variety of significant fermentation metabolites, including protein, carbohydrates, high-potency vitamins, essential minerals, and enzymes Szucs *et al.* (2013) [56] and Yalcin *et al.* (2011) [61]. Transition periods are stressful for dairy cows. Grummer (1995) [23] as a result of breastfeeding, calving, and switching to diets high in quickly fermented carbohydrates. During this period, abrupt changes may cause metabolic issues in dairy cows, including sub-acute acidosis. Oetzel *et al.* (2007) [39], Chiquette *et al.* (2008) [14]. In numerous trials, DFM demonstrated increased feed efficiency, milk production, and growth performance. Stein *et al.* (2006) [54], Nocek *et al.* (2002) [37], Krehbiel *et al.* (2003) [28], Ghorbani *et al.* (2002) [22]. Dairy cow performance has been improved with the use of LAB with yeast or LUB as DFM. In a supplement, Enterococcus faecium containing yeast performed best in the pre- and postpartum phases. DFM supplementation in ruminant diets significantly improves dairy cow and buffalo reproductive performance. Alnaimy *et al.* (2017) [7], El-Bordeny *et al.* (2021) [18], El-Nagar *et al.* (2021) [19], Mostafa *et al.* (2014) [33]. According to Soltan *et al.* (2019) [52], Holstein dairy cows given isolates of *Streptococci* and *Lactobacilli* had better uterine involution, a higher conception rate at third insemination, and a lower incidence of repeat breeders. Additionally, Ahmad *et al.* (2020) [4] discovered that adding fermented yeast culture (*Saccharomyces cerevisiae*) to Murrah buffalo boosted conception rates by 12.5%.

During the postpartum phase, DFM raised milk output, dry matter intake, and milk protein content. Nocek *et al.* (2002) [37]. For cows receiving DFM throughout the postpartum period, there were decreased levels of betahydroxybutyrate on day 1 postpartum and greater levels of blood glucose and insulin. Nocek *et al.* (2002) [37]. According to Yasuda *et al.* (2007) [63], dextran supplementation resulted in a considerable (p<0.05) increase in milk output (3-16%) as well as concentrations and total amounts of fat, protein, and SNF. Despite lowering the dry matter intake, Kundrna *et al.* (2007) [29] found that yeast supplementation greatly increased the milk output. Yeast supplementation tended to lower their dry matter consumption and enhance their milk supply, according to Alshaikh *et al.* (2007) [6]. According to Chandrasekharaiah *et al.* (2007) [12], prebiotic characteristics, sources, and production, together with their impact on animal production, have the potential to improve milk yield and composition in Indian conditions. According to Yalcin *et al.* (2011) [61], nursing dairy Holstein calves fed yeast culture produced 6.3% more milk and had significantly greater milk fat content (p<0.05) in their milk composition. According to research by Vibhute *et al.* (2011) [57], the multi-strain probiotic was successful in raising the milk production (4.65-5.41 L), milk fat, milk protein, and SNF content of nursing cows. According to Shreedhar *et al.* (2016) [51], probiotic-supplemented cows had considerably (p<0.05) increased milk output, fat, protein, SNF, and total solids. The buffaloes in the yeast-supplemented group showed increases (p>0.05) in total solids, solids not fat (SNF) percentage, average milk yield, and 6% fat corrected milk (FCM) yield El-Bordeny *et al.* (2019) [18]. Probiotics added to the diet of crossbred cows resulted in a significant (p≤0.05) increase in milk output, fat, and SNF, as reported by Satendra *et al.* (2007) [49]. According to research by Korake *et al.* (2021) [27], feeding 20 gm probiotics increased milk production, milk fat, and SNF content considerably (p<0.05).

Table 2: Effects of DFM on calf performance and productivity

Strains	Effects
Saccharomyces cerevisiae	Holstein dairy cows 120 g/cow/day or 240 g/cow/day Increased milk yield by 3.6% in Holstein dairy cows Zhu *et al.* (2016) [65]
Saccharomyces cerevisiae	Weight gain improved in calf by 6.6% Bayatkouhsar *et al.* (2013) [9]
Lactobacillus casei ssp. casei	Increased milk yield and quality, increased feed efficiency, reduced ruminal acidosis in cattle Poppy *et al.* (2012) [40]
L. acidophilus	Increased ADG by 8.33% in calf Hasunuma *et al.* (2011) [25]
Propionibacterium bryantii	Lactate concentration was reduced, indicating that it had the potential to prevent acidosis Chiquette *et al.* (2008) [14]
Enterococcus faecium & *Saccharomyces cerevisiae*	Increased milk fat, milk protein percentages Oetzel *et al.* (2007) [39]
Lactobacillus acidophilus	Reduced diarrhea incidence in calves Abu-Tarboush *et al.* (1996) [2] Control loss of BW in calves Cruywagen *et al.* (1996) [15]
Bifidobacterium pseudolongum	Reduced diarrhea incidence in calves Abe *et al.* (1995) [1]
Aspergillus oryzae	In the rumen, there are higher levels of total VFA, propionate, and acetate. Counts of cellulolytic bacteria tended to be greater Beharka *et al.* (1991) [10]

Conclusion

By increasing effectiveness, protecting against gastrointestinal tract infections, reducing the frequency of both acute and subacute acidosis, output of ruminant animals by balancing the ruminal environment. DFM also boosts milk output, improves milk composition, and eliminates the need for antibiotics. DFM also helps postpartum dairy cows and buffaloes reproduce more successfully. When compared to single-strain probiotics, a mixture of several DFM strains with diverse modes of action may enable better enhancement as a result of their complementary effects. To identify effective DFM and DFM combinations, it is necessary to consider factors such as viability and stability during storage, interactions with the host's endogenous microbiota, and the anticipated long-term impact. Therefore, it is advised that strains that have the potential to be employed as DFMs host-microbe and microbe-microbe interactions as part of their mode of action. understood using contemporary system biology technology. Meanwhile, further research into the potential detrimental consequences of microbes on antibiotic resistance may expedite the development of DFMs. DFM feeding regimens should take host, diet, and environmental factors into account.

References

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

2. Abu-Tarboush HM, Al-Saiady MY, Keir El-Din AH. Evaluation of diet containing lactobacilli on performance, fecal coliform, and lactobacilli of young dairy calves. Anim Feed Sci Technol. 1996;57:39-49.
3. Ahmad Para I, Ahmad Shah I, Punetha M, Hussain Dar M, Rautela A, Gupta D, *et al*. Feed fortification of periparturient Murrah buffaloes with dietary yeast (*Saccharomyces cerevisiae*) elevates metabolic and fertility indices under field conditions. Biol Rhythm Res. 2020;51(6):858-868.
4. Alshaikh MA, Alsiad MY, Zahran SN, Mogawar HH, Aulshowime TA. Effect of feeding yeast culture from different sources on the performance of lactating Holstein cows in Saudi Arabia. Asian-Australas J Anim Sci. 2007;15(3):352-356.
5. Alnaimy A, Habeeb M. Importance of Yeast in Ruminants Feeding on Production and Reproduction. Ecol Evol Biol. 2017;2(4):49-58.
6. Tarek AM, Hossam ME, Abd EL-Kader MK, Hossen AM. Influence of propionibacteria supplementation to rations on intake, milk yield, composition and plasma metabolites of lactating buffaloes during early lactation. Sci Int; c2014. p. 13-19.
7. Bayatkouhsar J, Tahmasebi AM, Naserian AA, Mokarram RR, Valizadeh R. Effects of supplementation of lactic acid bacteria on growth performance, blood metabolites and fecal coliform and lactobacilli of young dairy calves. Anim Feed Sci Technol. 2013;186(1-2):1-11.
8. Beharka AA, Nagaraja TG, Morrill JL. Performance and ruminal function development of young calves fed diets with Aspergillus oryzae fermentation extract. J Dairy Sci. 1991;74:4326-4336.
9. Callaway TR, Martin SA. Effects of cellobiose and monensin on *in vitro* fermentation of organic acids by mixed ruminal bacteria. J Dairy Sci. 1997;80:1126-1135.
10. Chandrasekharaiah M, Sampath KT, Prasad CS, Samanta AK, Kolte AP. Prebiotics: the rumen modulator for enhancing the productivity of dairy animals. Indian Dairyman. 2007;59(8):58-61.
11. Chiquette J, Allison MJ, Rasmussen MA. *Prevotella bryantii* used as a probiotic in early-lactation dairy cows: Effect on ruminal fermentation characteristics, milk production, and milk composition. J Dairy Sci. 2008;91:3536-3543.
12. Cruywagen CW, Jordaan I, Venter L. Effect of Lactobacillus acidophilus supplementation of milk replacer on pre-weaning performance of calves. J Dairy Sci. 1996;79:483-486.
13. Gaggìa F, Mattarelli P, Biavati B. Probiotics and prebiotics in animal feeding for safe food production. Int J Food Microbiol. 2010;54:110.
14. El-Bordeny N, Abdou A, Abo-Eid H, Abdo M, Abdel-Gawad R. Effect of Yeast-Based Probiotics Supplementation on the Productive and Reproductive Performance of Lactating Buffaloes. Egypt J Nutr Feeds. 2019;22(1):33-44.
15. El-Nagar HA, El-Hais AM, Mandouh MS. Influence of yeast and Lactobacillus products as feed supplements on blood parameters and reproductive performance of lactating Egyptian Buffaloes. Egypt J Anim Prod. 2021;58(1):1-8.
16. Elghandour MMY, Vázquez Chagoyán JC, Salem AZM, Kholif AE, Martínez Castañeda JS, *et al*. Effects of *Saccharomyces cerevisiae* at direct addition or pre-incubation on *in vitro* gas production kinetics and degradability of four fibrous feeds. Ital J Anim Sci. 2014;13:295-301.
17. Frizzo LS, Sotto LP, Zbrun MV, Bertozzi E, Sequeira G, Armesto RR, *et al*. Lactic acid bacteria to improve growth performance in young calves fed milk replacer and spray-dried whey powder. Anim Feed Sci Technol. 2010;157:159-167.
18. Ghorbani GR, Morgavi DP, Beauchemin KA, Leede JAZ. Effect of bacterial direct-fed microbials on ruminal fermentation, blood variables, and the microbial populations of feedlot cattle. J Anim Sci. 2002;80:1977-1986.
19. Grummer RR. Impact of changes in organic nutrient metabolism on feeding the transition dairy cow. J Anim Sci. 1995;73:2820-2833.
20. Hall TA. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. Nucleic Acids Symp Ser; c1999. p. 95-98.
21. Hasunuma T, Kawashima K, Nakayama H, Murakami T, Kanagawa H, Ishii T, *et al*. Effect of cellooligosaccharide or symbiotic feeding on growth performance, fecal condition and hormone concentrations in Holstein calves. Anim Sci J. 2011;82(4):543-548.
22. Henning PH. Acidosis in high-producing ruminants - myth or menace? AFMA Matrix. 2004;13 nr. 1. pp. 38-41.
23. Korake R, Sharma S. Effect of Probiotics on milk yield and its Production Economics in Crossbred cows. Int J Curr Microbiol Appl Sci. 2021;10(4):773-777.
24. Krehbiel CR, Rust SR, Zhang G, Gilliland SE. Bacterial direct-fed microbials in ruminant diets: Performance response and mode of action. J Anim Sci. 2003;81:E120-E132.
25. Kung L. Direct-fed microbials for dairy cows and enzymes for lactating dairy cows: New theories and applications. In: 2001 Pennsylvania State Dairy Cattle Nutrition Workshop. Grantville, PA; c2001. p. 86-102.
26. Kung L, Hession JR, Hessio AO. Preventing *in vitro* lactate accumulation in ruminal fermentations by inoculation with *Megasphaera elsdenii*. J Anim Sci. 1995;73:250-256.
27. Lynch HA, Martin A. Effects of *Saccharomyces cerevisiae* culture and *Saccharomyces cerevisiae* live cells on *in vitro* mixed ruminal microorganism fermentation. J Dairy Sci. 2002;85:2603-2608.
28. Mostafa TH, Elsayed FA, Ahmed MA, Elkholany MA. Effect of using some feed additives (TW-Probiotics) in dairy cow rations on production and reproductive performance. Egypt J Anim Prod. 2014;51(1):1-11.
29. McAllister TA, Beauchemin KA, Alazzeh AY, Baah J, Teather RM, Stanford K. Review: The Use of direct fed microbials to mitigate pathogens and enhance production in cattle. Can J Anim Sci. 2011;91:193-211.
30. Meale SJ, Popova M, Saro C, Martin C, Bernard A, Lagree M. Early life dietary intervention in dairy calves results in a long-term reduction in methane emissions. Sci Rep. 2021;11(1):3003. https://doi.org/10.1038/s41598-021-82084-9
31. Nocek JE, Kautz WP, Leedle JAZ, Allman JG. Ruminal supplementation of direct-fed microbials on diurnal pH variation and in situ digestion in dairy cattle. J Dairy Sci. 2002;85:429-433.
32. Nocek JE, Kautz WP, Leedle JAZ, Block E. Direct-fed microbial supplementation on the performance of dairy

cattle during the transition period. J Dairy Sci. 2003;86:331-335.

33. Poppy GD, Rabiee AR, Lean IJ, Sanchez WK, Dorton KL, Morley PS. A meta-analysis of the effects of feeding yeast culture produced by anaerobic fermentation of *Saccharomyces cerevisiae* on milk production of lactating dairy cows. J Dairy Sci. 2012;95(10):6027-6041.
34. Puniya AK, Salem AZM, Kumar S, Dagar SS, Griffith GW, Puniya M, *et al*. Role of live microbial feed supplements with reference to anaerobic fungi in ruminant productivity: A review. J Integr Agric. 2015;14:550-560.
35. Reynolds CK, Aikman PC, Lupoli B, Humphries DJ, Beever DE. Splanchnic metabolism of dairy cows during the transition from late gestation through early lactation. J Dairy Sci. 2003;86:1201-1217.
36. Robinson JA, Smolenski WJ, Greening RC, Ogilvie RL, Bell RL, Barsuhn K, *et al*. Prevention of acute acidosis and enhancement of feed intake in the bovine by *Megasphaera elsdenii*. J Anim Sci. 1992;70(Suppl. 1):310.
37. Sadrsaniya DA, Raval AP, Bhagwat SR, Nageshwar A. Effects of probiotics supplementation on growth and nutrient utilization in female Mehsana buffalo calves. Indian Vet J. 2015;92(9):20-22.
38. Sahu J, Yadav A, Kumari T, Pal P. Probiotic supplementation to produce healthier calves: A short note. Pharma Innov J. 2019;8(3):494-495.
39. Salem AZM, Kholif AE, Elghandour MMY, Buendía G, Mariezcurrena MD, Hernandez SR, Camacho LM. Influence of oral administration of Salix babylonica extract on milk production and composition in dairy cows. Ital J Anim Sci. 2014;13:10-14.
40. Salem AZM, Kholif AE, Olivares M, Elghandour MMY, Mellado M, Arece J. Influence of S. *babylonica* extract on feed intake, growth performance and diet *in vitro* gas production profile in young lambs. Trop Anim Health Prod. 2014;46:213-219.
41. Satendra K, Brajendu K. Yield and economics of dairy cattle. J Anim Feed Sci Technol. 2007;5:55-60.
42. Seo JK, Kim JS, Kim MH, Upadhaya SD, Kam DK, Ha JK. Direct-fed microbials for ruminant animals. Asian-Australas J Anim Sci. 2010;23:1657-1667.
43. Soltan MA, Ahmed HA, Latif MAA, Galal M. Assessment Impact of Using Locally Produced Probiotic Bacteria on the Productive and Reproductive Performance of Holstein Dairy Cows. Assiut Vet Med J. 2019;65(162):39-50.
44. Srinivas D, Rama J, Raghava E. Effect of dietary inclusion of yeast culture (*Saccharomyces cerevisiae*) on growth performance of graded Murrah buffalo bull calves. Buffalo Bull. 2011;30(1):63-66.
45. Stein DR, Allen DT, Perry EB, Bruner JC, Gates KW, Rehberger TG, Mertz K, Jones D, Spicer LJ. Effects of feeding propionibacteria to dairy cows on milk yield, milk components, and reproduction. J Dairy Sci. 2006;89:111-125.
46. Sullivan HM, Martin SA. Effects of a *Saccharomyces cerevisiae* culture on *in vitro* mixed ruminal microorganism fermentation. J Dairy Sci. 1999;82:2011-2016.
47. Szucs JP, Suli A, Halasz TA, Z Bodor. Effect of live yeast culture *Saccharomyces cerevisiae* on milk production and some blood parameters. Sci Papers Anim Sci Biotec. 2013;46(1):40-44.
48. Weiss WP, Wyatt DJ, McKelvey TR. Effect of feeding propionibacteria on milk production by early lactation dairy cows. J Dairy Sci. 2008;91:646-652.
49. Yalcin S, Yalcin S, Can P, Gurdal AO, Bagci C, Eltan O. The nutritive value of live yeast culture (*Saccharomyces cerevisiae*) and its effect on milk yield, milk composition and some blood parameters of dairy cows. Asian-Australas J Anim Sci. 2011;24:1377-1385.
50. Yang WZ, Beauchemin KA, Vedres DD, Ghorbani GR, Colombatto D, Morgavi DP. Effects of direct-fed microbial supplementation on ruminal acidosis, digestibility, and bacterial protein synthesis in continuous culture. Anim Feed Sci Technol. 2004;114:179-193.
51. Yasuda K, Hashikawa SS, Tomita Y, Shibala S, Tsuneo. A new symbiotic consisting of Lactobacillus casei subsp. Casei and Dextran improves milk production of Holstein Dairy cows. J Vet Med Sci. 2007;69(2):205.
52. Yoon IK, Stern MD. Influence of direct-fed microbials on ruminal microbial fermentation and performance of ruminants: A review. Asian-Australas J Anim Sci. 1995;8:533-555.
53. Zhu W, Zhang BX, Yao KY, Yoon I, Chung YH, Wang JK, Liu JX. Effects of Supplemental Levels of *Saccharomyces cerevisiae* fermentation Product on Lactation Performance in Dairy Cows under Heat Stress. Asian-Australas J Anim Sci. 2016;29(6):801-806.