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Use of Probiotics in Health Raising Newborn Calves

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Abstract
The growing global population is driving up demand for animal products. This increase in demand causes the industrialized of livestock farms. In industrialized farms where intensive breeding methods are applied, calves are separated from their dams immediately after birth and a fed with bottle. Rapid growth of calves is aimed in farms where intensive breeding programs are implemented. Antibiotics have been used for many years to stimulate growth. However, the resistance of bacteria to antibiotics has had negative effects on both human and animal health. In addition, consumers' awareness and pressure on this issue have led to the ban on the use of antibiotics to promote growth and the restriction of their use in treatments. This situation has led researchers to conduct study on the use of alternative feed additives. In recent years, studies have been conducted on the use of probiotics as an alternative to antibiotics, and these studies are continuing. There are differences in information regarding the benefits of probiotics in the first four weeks of life, which is a critical period for calves. This review aims to reveal the effects of probiotics use on the growth and health of calves during the suckling period.

Key words
Calf, Probiotics, Growth, Health.

Introduction
In a dairy cattle farm, cows that comprise the herd are separated due to aging, reduced productivity, and various health reasons, including primarily udder diseases. To replace these animals, high-yield, healthy heifers must be introduced to the herd. This is why the proper breeding and nutrition of female calves, especially, is crucial for dairy cattle herds (Tüzemen and Yanar, 2004). Female calves should be raised and nurtured in a way that preserves their health and well-being for their future milk production. Furthermore, it is important to raise male calves in a healthy manner to maximize their meat production potential. However, challenges persist in raising both male and female calves during their milk-feeding period. In the United States, it has been reported that approximately 5-6% of female calves die during the milk-feeding period (Quigley, 2018). These deaths are attributed to digestive system diseases, defined as calf diarrhea, in 32% of cases, respiratory diseases in 14% of cases, and a combination of diarrhea and respiratory diseases in 7% of cases (Table 1).

Table 1: Causes of female calf mortality

Cause of death	%
Digestive system diseases	32.00
Respiratory diseases	14.10
Combination of digestive system and respiratory diseases	7.00
Due to unknown causes	25.00
Other causes*	13.30
Unreported	8.6

*Source: Urie et al. (2018), *Calves sold without specifying infection, injury, or a specific cause*

Most of these deaths correspond to the first 4 weeks of the suckling period. Deaths due to diarrhea are observed at a younger age compared to deaths caused by respiratory diseases or unknown reasons. Furthermore, it has been reported that at least one case of illness was observed in 33.8% of female calves on farms in the United States. Digestive system diseases, defined as calf diarrhea, account for 56% of these cases (Urie et al., 2018). The majority of gastrointestinal diseases in calves occur within the first 2 weeks of life and this is common worldwide. (Quigley, 2018). The development of calves during the suckling period significantly affects their future growth, productivity, and health. Diarrhea cases that occur during this period suppress calf growth and have adverse effects on their age at first calving and milk yield during the first lactation (Hadimli, 2020). Antibiotic use in preventing and treating diarrhea cases not only reduces the numbers of pathogenic bacteria in the gut flora but also non-pathogenic bacteria (Soltan, 2009). Additionally, concerns about antimicrobial resistance and the variable effectiveness of antimicrobials in preventing and treating diseases have increased the focus on researching alternative methods (Smith, 2015).

The primary effects of feed additives used to support calf growth include an increase in resistance against colonization by pathogenic bacteria and enhancement of the host's mucosal immunity, resulting in a reduction of the pathogen load and improved animal health (Choct, 2009). The intestinal microbiota plays a significant role in influencing intestinal health and disease. The large intestine, in particular, harbors diverse bacterial populations with various functions, including acting as barriers against pathogens and macromolecules in the digestive epithelium (Donohue et al., 2002). During the suckling period, the intestinal microbial flora of calves affects their health and growth. A normal intestinal flora performs functions such as the breakdown of carbohydrates and fiber, regulation of lipid intake and accumulation in the diet, production of vitamins and short-chain fatty acids, stimulation of the immune system, control of intestinal motility, and protection of the host from intestinal pathogens (Azarpajouh, 2023).

Newborn calves' digestive systems are exposed to various microorganisms from the external environment, which colonize their intestines (Azarpajouh, 2023). However, the separation of newborn calves from their mothers immediately after birth necessitates artificial feeding with whole milk and milk replacers. As a result, calves cannot rapidly acquire the microflora from their dams and other cows' saliva and feces. This situation slows down the formation of the microflora and may even disrupt the homeostatic balance in the intestine (Donohue et al., 2002; Lopes et al., 2021). Disruption of the balance of intestinal microbial flora can lead to the colonization of various enteric pathogens such as bacteria and viruses in the intestine, resulting in diarrhea (Azarpajouh, 2023). The presence of specific bacteria, such as Bifidobacterium and Lactobacillus, in calf feces has been found to decrease the occurrence of diarrhea during the suckling period, leading to increased body weight (Oikonomou et al., 2013). Moreover, it has been noted that various genera from the Bifidobacteriaceae family and Bifidobacterium are common in healthy calves (Gomez et al., 2017). Appropriate feeding and rearing strategies that can alter the intestinal microbial flora of calves in their early stages of life in a way that positively influences their health should be implemented. This is a critical stage for calves, and it is essential to ensure that they receive colostrum in their early days. Colostrum accelerates bacterial colonization in the small intestine (Malmuthuge et al., 2015a). Delaying colostrum feeding by 12 hours reduces the numbers of Bifidobacteria and Lactobacillus in the colon of calves (Fischer et al., 2018). However, the intestinal flora in newborns is more flexible and unstable in the early stages of life, whereas it becomes more stable and less affected in the later stages of life (Malmuthuge et al., 2015b). The use of microbial-based products to manipulate the intestinal flora during the suckling period can improve calf health (Malmuthuge and Guan, 2017). Probiotics, in particular, are popular feed additives for enhancing intestinal health and reducing diarrhea cases in

young calves. Probiotics are live microorganisms that, when applied in sufficient doses, can modulate the balance and activities of gastrointestinal microflora, thus improving the host's health and promoting growth (Retta, 2016).

This review aims to describe the effects of probiotic use on the healthy rearing of calves in their critical early stages of life.

Probiotics

Probiotics are a general product that can be included in the diets of animals to enhance performance and/or reduce pathogenic bacteria. While the term "probiotic" was not used until 1960 to refer to substances produced by microorganisms that promote the growth of other microorganisms, the first studies recommending the use of probiotics by bacteria had been conducted. Initially, probiotics were defined as "live microbial feed supplements, which beneficially affect the host animal by improving its microbial balance in the intestinal tract" (Fuller, 1989). In addition, probiotics were described as "mono- or mixed cultures of bacteria applied to an animal or human when native bacterial characteristics are improved, beneficially affecting the host" (Havenaar and Huisin't Veld, 1992). Moreover, probiotics were defined as "viable defined microbial preparations or products, which when administered in adequate amounts, confer a health benefit on the host" (Markowiak and Slizewska, 2017). In recent years, the technical definition of probiotics has been expanded to encompass products containing microbes or their final products (e.g., fermented dairy products, etc.). Another recommended definition for probiotics is "a preparation or product containing a sufficient number of live, defined microorganisms, which alter the microflora (by implantation or colonization) in a compartment of the host and by that exert beneficial health effects in this host" (Schrezenmeir and de Vrese, 2001). Probiotics may refer to specific bacterial or fungal species, microbial cultures, enzyme preparations, culture extracts, or combinations thereof (Yoon and Stern, 1995).

To enhance intestinal health, promote earlier consumption of concentrated feed, and increase growth in preruminant calves, milk or starter feed for young calves can be supplemented with probiotics. Bacteria-based probiotics such as Lactobacillus spp., Enterococcus spp., and Bacillus spp. are commonly used in the nutrition of young calves (Uyeno et al., 2015).

Bacteria-based probiotics are commonly used to improve intestinal health, reduce diarrhea, and promote growth in suckling calves. Some of the commonly used bacteria-based probiotics include Lactobacillus spp., Bifidobacterium spp., Bacillus spp., and Enterococcus spp. The addition of bacteria-based probiotics provides a stable, nutrient-rich environment for intestinal flora, limiting pathogen invasion, and thus enhancing host digestive efficiency and mucosal immunity (Uyeno et al., 2015; Ma et al., 2018).

The mechanism of action of probiotics involves several key processes:

Lowering pH: Probiotic bacteria produce organic acids such as lactic acid, acetic acid, and formic acid, which help reduce the pH in the gut (Dhama et al., 2008; Broadway et al., 2014). This acidic environment inhibits the growth of pathogenic bacteria.

Preventing Pathogen Attachment: Probiotics play a role in preventing pathogenic bacteria from attaching to the intestinal surface and multiplying (Bahadıroğlu, 1997; Kocaoğlu Güçlü and Kara, 2009). This interference with pathogen attachment is a crucial defense mechanism.

Stimulating the Immune System: Probiotics stimulate the host's immune system, enhancing its ability to defend against infections (Rastall et al., 2005). This immune response can be beneficial in fighting off pathogens.

Increasing Anaerobic Microorganisms: Probiotics can boost the number of anaerobic microorganisms in the gut by consuming oxygen in the rumen (Kocaoğlu Güçlü and Kara, 2009). This helps create a more favorable environment for beneficial microorganisms.

Early Rumen Development: Some research suggests that probiotics contribute to the early development of rumen flora in young ruminants. This can lead to improved feed digestibility and help prevent the formation of enteropathogens that cause diarrhea (Krehbiel et al., 2003; Wallace and Newbold, 1995).

The combined actions of probiotics help maintain a healthy gut environment, enhance the host's defense mechanisms, and promote better nutrient utilization, ultimately benefiting the overall health and development of the host animal. The mechanisms of action of probiotics are presented in Table 2. The effects of probiotics indeed can vary depending on a range of factors, including the specific animal species, the type of bacteria used as probiotics, the dosage, the duration of use, and environmental conditions. Continuous use of probiotics has been reported to enhance their effects in various studies (Kurtoğlu et al, 2004; Antunovic et al, 2005).

While there are various theories regarding the mechanisms of action of live probiotics, and they are known to contribute to health by preventing or restraining the growth of harmful bacteria in the host's gastrointestinal tract, there is no precise mechanism of action established to date. It is believed that several factors may be involved in these mechanisms (Burçak and Yalçın, 2013).

Research in the field of probiotics is ongoing, and as our understanding of these mechanisms continues to evolve, we may gain more insights into the specific ways in which probiotics exert their beneficial effects in different animal species and under varying conditions.

Table 2: Mechanism of action of probiotics

BENEFICIAL IMPACT	MECHANISM OF ACTION
Contribution to lactose digestion	▪ Probiotics help digest lactose using bacterial lactase, an enzyme necessary for lactose digestion. This can be particularly useful for individuals with lactose intolerance.
Resistance to enteric pathogens	▪ Probiotics can enhance the immune system's response to pathogens. ▪ Probiotics change the conditions in the intestinal tract, such as pH, short-chain fatty acids, and bacteriocins, making it less favourable for pathogenic bacteria to thrive. ▪ Probiotics may modify toxin binding sites, reducing their effectiveness., ▪ Probiotics can alter the composition of the gut microbiota, favoring beneficial bacteria., ▪ Probiotics form aggregates in the intestinal mucosa, preventing pathogens from binding and invading., ▪ Probiotics can regulate mucin production, further reducing pathogen attachment.
Preventive effect on bowel cancer	▪ Probiotics may bind to mutagenic substances, reducing their harmful effects. ▪ Probiotics can block the activity of carcinogens, rendering them inactive. ▪ Probiotics might inhibit enzymes produced by intestinal microorganisms that generate carcinogens. ▪ Probiotics bolster the immune system, providing defense against cancer development.
Regulation of the immune system	▪ Probiotics enhance the body's general defense mechanisms against infections and tumor formation. ▪ Probiotics increase the production of IgA antibodies, boost the phagocytic activity of white blood cells, and enhance the specific immune response to antigens.
Allergy	▪ Probiotics can help prevent the passage of antigenic (allergenic) substances into the circulatory system, potentially reducing allergic reactions.

Source: Ceyhan and Alıç, 2012.

The mechanisms of action of probiotics are multifaceted and can be summarized as follows:

pH Regulation: Probiotics lower the pH in the gastrointestinal tract by producing organic acids, especially lactic acid. This acidic environment inhibits the growth of bacteria that thrive in neutral or basic conditions.

Redox Potential: Probiotics lower the redox potential, which prevents aerobic pathogens from utilizing oxygen and inhibits their growth.

Immune System Support: Probiotics have a positive impact on the immune system by increasing lymphocyte activity, regulating antibody production, and activating phagocyte cells and antigen-specific cells.

Toxic Substances: Probiotics prevent the proliferation of microorganisms that produce toxic ammonia and amines, thereby preventing the accumulation of these harmful substances.

Digestive Function Regulation: Probiotics help improve feed utilization by regulating digestive system functions. They also contribute to digestion by synthesizing B-group vitamins.

Enzyme Production: Probiotics produce various enzymes essential for digestion, including cellulase, xylanase, lipase, protease, beta-glucanase, and amylase. These enzymes work in conjunction with the host animal's digestive system enzymes, increasing the digestibility and energy value of feeds (Karademir and Karademir, 2003).

Guillot (2003) outlined two main mechanisms for the effects of probiotics:

a) **Nutritional Effects**: These are characterized by the reduction of metabolic reactions related to the production of toxic substances, stimulation of natural enzymes, production of vitamins, and antimicrobial substances.

b) **Health Effects**: These include increased resistance to colonization, competition for adhesion to the intestinal surface, and stimulation of the immune response. In summary, probiotics play a crucial role in strengthening the intestinal barrier, increasing resistance to harmful agents, and directly triggering the immune response in the intestinal mucosa (Karademir and Karademir, 2003; Guillot, 2003; Kocaoğlu Güçlü and Kara, 2009). These multiple mechanisms collectively contribute to the overall health and well-being of the host animal.

Effects on the Growth, Performance, and Health of Calves

Studies on the effects of bacteria-based probiotics on the growth, performance, and health of calves yield inconsistent results. While some studies emphasize positive effects, others indicate no significant impact. Key findings include:

Positive Effects: Some studies, such as Ratre et al. (2019), demonstrate that

probiotic application has a positive influence on the growth of calves. These effects may promote growth. In studies where calf diarrhea cases were high (Frizzo et al., 2010; Zhang et al., 2019), probiotics have been observed to have a positive impact on growth. It appears to have the potential to support calf health and growth.

Inconsistent Results: Other studies suggest that probiotic application has no significant effect on growth. For example, Seifzadeh et al. (2016), Satık and Günal (2017), and Vazquez-Mendoza et al. (2020) have obtained different results in this regard.

This inconsistency may be attributed to various factors, including different studies addressing a range of variables such as the probiotic strains used, dosages, application durations, and possibly environmental factors. Additionally, calf age, overall health status, and farm conditions can also influence the outcomes. In conclusion, further research is needed to better understand the effects of probiotics on the growth and health of calves. It should be considered that each probiotic strain and application method may yield different results in calves.

While the effects of bacteria-based probiotics on intestinal health have been considered, some researchers have also reported their impact on rumen function. Supplementation of *Lactobacillus rhamnosus* during the first 6 weeks of the suckling period led to increased microbial diversity within the rumen, altering the dominant bacterial composition and increasing bacterial counts in rumen fluid (Zhang et al., 2019). This resulted in increased volatile fatty acids and microbial protein concentration in the rumen, as well as a decrease in rumen pH. However, it should be noted that the improvements in rumen function may not be solely attributed to the direct effect of bacteria-based probiotics but could also be a result of increased concentrate feed intake. Probiotics lower the pH of the intestinal content, produce antibacterial substances to reduce the amount of ammonia and toxic amines, support the immune system, enhance the palatability of feeds, improve the digestion of carbohydrates, and aid in the synthesis of vitamins and amino acids. Changes in the microbiota of the digestive tract also impact the health of calves, making probiotics a valuable tool for manipulating rumen fermentation to improve live weight gain and feed utilization (Szabo and Szabo, 2003; Pinloche et al., 2013).

The supplementation of lactic acid bacteria has been shown to reduce cases of diarrhea in calves during the suckling period (Signorini et al., 2012). However, the type of milk or milk replacer fed to the calves plays a significant role in the occurrence of diarrhea cases. Calves fed with whole milk tend to experience fewer cases of diarrhea compared to those fed with milk replacers (Selim and Cullor, 1997).

Various studies have reported positive effects of supplementing calves with different bacterial strains, such as Pediococcus acidilactici, Enterococcus faecium, Lactobacillus acidophilus, Lactobacillus casei, and Bifidobacterium bifidum (Renaud et al., 2019). While bacterial-based probiotics have been associated with positive effects on diarrhea cases, the exact mechanisms behind these effects remain not fully understood. Most studies have focused on calves during their pre-weaning period. Furthermore, the effects are often linked to specific bacterial species used (Newbold et al., 1995). Bacterial-based probiotics interact directly with the host by modulating the intestinal immune system, increasing mucus production by goblet cells, enhancing tight junctions, and promoting the regulation of inflammatory responses. Lactic acid-producing bacteria can create more favorable conditions for commensal microorganisms by lowering intestinal pH. Additionally, bacterial-based probiotics can produce and release antimicrobial peptides like bacteriocins in the intestinal lumen, which may help reduce the risk of pathogen infections (Aragon et al., 2010; Cazzola et al., 2010; Wang et al., 2019).

The use of probiotic supplements containing Enterococcus faecium M74 in calf milk has been observed to have positive effects on calves. These supplements improved the live weight and daily live weight gain of the calves. Additionally, they significantly improved the fecal scores of the calves and reduced the frequency of diarrhea cases. This suggests that probiotics can have a positive impact on the intestinal health and digestive system of calves (Jatkauskas and Vrotniakiene, 2010).

Probiotic supplements have been shown to increase the live weight and daily weight gain of calves, but they can also lead to an increase in total dry matter and calf starter feed consumption, resulting in a decrease in feed efficiency. Furthermore, probiotic application can affect rumen fermentation by reducing acetate levels and increasing butyrate production. It can also increase the bacterial count in feces, leading to a reduction in fecal scores. In addition, probiotics can reduce the concentration of malondialdehyde, an oxidative stress marker, and enhance the total antioxidant status, which is an indicator of the antioxidant defense mechanism. This contributes to the improvement of calf health (Wang et al., 2023). This suggests that the addition of probiotics to calf milk during the suckling period can enhance calf growth, feed efficiency, and overall health. However, the effectiveness of probiotics depends on factors such as the dosage used and the composition of bacterial strains in the probiotic supplement (Wang et al., 2023). Direct feeding of animals with microbials can lead to changes in their intestinal bacterial populations. This can enhance resistance to diseases, reduce the spread of pathogens acquired through oral routes, improve intestinal immunity, reduce disease symptoms, and ultimately improve animal health (Timmerman et al., 2005; Adams et al., 2008; Wu et al., 2021).

In some studies, partially replacing milk with probiotic yogurt has been implemented, and this application increased dry matter intake, resulting in improvements in live weight gain and feed efficiency. Furthermore, it led to increased body measurements in calves. Additionally, this approach increased the blood lymphocyte ratio, reduced the neutrophil-to-lymphocyte ratio, and modulated the immune response (Noori et al., 2016). This indicates that using probiotic yogurt as a partial substitute for milk can have positive effects on calf growth, feed utilization, and immune system modulation.

The supplementation of probiotics to calf milk increased daily live weight gain and reduced the number of E. coli in feces in some studies, such as Roodposhti and Dabiri (2012). However, it did not significantly affect dry matter intake or the immune system. While there is sufficient data available to suggest that probiotics can improve calf performance and productivity parameters, there may not be enough data to support their role in enhancing calf health and reducing disease risk (Alawneh et al., 2020). In fact, Karamzadeh-Dehaghani et al. (2021) suggested that the impact of probiotic application on calf health is insignificant, and it has no significant effects on daily live weight gain and the immune system during the milk-feeding period, nor does it affect the frequency of calf diarrhea.

Conclusion

The use of probiotics in raising calves has been the subject of many studies, and research in this area continues. Calves, especially during the critical first four weeks of their lives, are highly susceptible to digestive and respiratory diseases. Probiotics used during this period can help reduce the incidence of digestive system diseases such as calf diarrhea by adhering to the intestinal mucosa before pathogenic microorganisms and preventing the attachment of pathogenic microorganisms. Additionally, the use of probiotics during the suckling period has shown different results in terms of daily live weight gain and feed efficiency. Therefore, there is not enough evidence to support the claim that probiotics promote calf growth and their use as a replacement for antibiotics. The dosage, frequency, and duration of probiotic applications may be one reason for the varying results. Thus, more research is needed to standardize probiotic applications and provide clear conclusions.

Statement of Conflict of Interest

The author(s) declare no conflict of interest for this study.

Author's Contributions

The contribution of the authors is equal

References

Adams, M.C., Luo, J., Rayward, D., King, S., Gibson, R., Moghaddam, G.H. (2008). Selection of a novel-fed microbial to enhance weight gain in intensively reare calves. Animal Feed Science and Technology 145: 41-52.

Alawneh, J.I., Barreto, M.O., Moore, R.J., Soust, M., Al-harbi, H., James, A.S., Krishnan, D., Olchowy, T.W.J. (2020). Systematic review of an intgervention: the use of probiotics to improve health and productivity of calves. Preventive Veterinary Medicine 183: 105147.

Antunovic, Z., Speranda, M., Liker, B., Seric, V., Sencic, D., Domacinovic, M., Sperandat, T. (2005). Ibfluence of feeding the probiotic Pioneer PDFMR to growing lambs on performances and blood composition. Acta Veterinaria 55(4): 287-300.

Aragon, G., Graham, D.B., Borum, M., Doman, D.B. (2010). Probiotic therapy for irritable bowel syndrome. Gastroenterology and Hepatology 6(1): 39-44.

Azarpajouh, S. (2023). Probiotics and its impact on calf gut health. Article No. 10-01 http://www.dairyglobal.net/dairy/calves/probiotics-and-its-impact-on-calf-gut-health/ (Erişim: 23.09.2023)

Bahadıroğlu, E. (1997). Aviguard (Doğal sindirim sistemi florası). Hayvancılık Yan Sanayi ve Veteriner Hekimliği Dergisi 17(1): 5-8.

Broadway, P.A.U.L., Carroll, J., and Callaway, T. (2014). Alternative antimicrobial supplements that positively impact animal health and food safety. Agriculture, Food and Analytical Bacteriology 4(2): 109-121.

Burçak, E., Yalçın, S. (2013). Buzağı beslemede probiyotiklerin kullanımı Derleme. Lalahan Hayvancılık Araştırma Enstitüsü Dergisi 53(2): 101-114.

Cazzola, M., Tompkins, T.A., Matera, M.G. (2010). Immunomodulatory impact of a synbiotic in Th1 and Th2 models of infection. Therapeutic advances in respiratory disease 4(5): 259-270.

Ceyhan, N., Alıç, H. (2012). Bağırsak mikroflorası ve probiyotikler. Türk Bilimsel Derlemeler Dergisi 1: 107-113.

Choct, M. (2009). Managing gut health through nutrition. British Poultry 50: 9-15.

Dhama, K., Mahendran, M., Tomar, S., Chaquhan, R.S. (2008). Beneficial effects of probiotics and prebiotics in livestock and poultry: the current perspectives. Intas Polivet 9(1): 1-12.

Donohue, D.J., Donohue, A.M., Tellez, G., Hargis, B.M. (2002). New evidence that specific probiotics may reduce intestinal foodborne pathogen colonization and improve performance. In: Proceedings, Arkansas Nutrition Conference, Arkansas, USA, 56-59.

Frizzo, L.S., Soto, L.P., Zbrun, M.V., Bertozzi, E., Sequeira, G., Armesto, R.R.,

Rosmini, M.R. (2010). Lactic acid bacteria to improve growth performance in young calves fed milk replacer and spray-dried whey powder. Animal Feed Science and Technology 157(3-4): 159-167.
Fuller, R. (1989). Probiotics in man and animals. A rewiew. Journal of Applied Bacteriology 66: 365-378.
Gomez, D.E., Arroyo, L.G., Costa, M.C., Viel, L., and Weese, J.S. (2017). Characterization of the fecal bacterial microbiota of health and diarrheic dairy calves. Journal of Veterinary Internal Medicine 31(3): 928-939.
Guillot, J.F. (2003). Probiotic feed additives. Journal of Veterinary Pharmacology and Therapeutics 26:52-55.
Hadimli, H. (2020). Buzağılarda bakteriyel hastalıklar. In: Buzağı sağlığı ve yetiştiriciliği, Ed. Erdem, H., Çiftçi, E., Işık, M.K., Yorgancılar, M.Ü., Yaralı, C. (Medisan Yayınevi, Ankara, 65-70).
Havenaar, R., Huis in't Veld, J.H.J. (1992). Probiotics: A general view. In: Wood B.J.B.: The lactic acid bacteria. Vol. 1. The lactic acid bacteria in health and disease. Chapman and Hall, Bew York, NY, 209-224.
Jatkauskas, J., Vrotnialiene, V. (2010). Effect5s of probiotics dietary supplementation on diarrhoea patterns, faecal microbiota and performance of early weaned calves. Veterinarni Medicina 55: 494-503.
Karademir, G., Karademir, B. (2003). Yem katkı maddesi olarak kullanılan biyoteknolojik ürünler (Derleme). Lalahan Hayvancılık Araştırma Enstitüsü Dergisi 43(1): 61-74.
Karamzadeh-Dehaghani, A., Towhidi, A., Zhandi, M., Mojgani, N., Fouladi-Nashta, A. (2021). Combined effect of probiotics and specific immünoglobulin Y directed against Escherichia coli on growth performance, diarrhea incidence, and immüne system in calves. Animal 15: 100124.
Kocaoğlu Güçlü, B., Kara, K. (2009). Ruminant beslemede alternatif yem katkı maddelerinin kullanımı: 1. Probiyotik, prebiyotik ve enzim. Erciyes Üniversitesi Veteriner Fakültesi Dergisi 6(1): 65-75.
Krehbiel, C.R., Rust, S.R., Zhang, G., Gilliland, S.E. (2003). Bacterial direct-fed microbials in ruminant diets: Performance response and mode of action. Journal of Animal Science 81(14-Suppl-2): E120-E132.
Kurtoğlu, V., Kurtoğlu, F., Seker, E., Coşkun, B., Balevi, T., Polat, E.S. (2004). Effect of probiotic supplementation on laying hen diets on yield performance and serum and egg yolk cholesterol. Food Additives and Contaminants 21(9): 817-823.
Lopes, R.B., Bernal-Cordoba, C., Fausak, E., Silva-del-Rio, N.J.P.O. (2021). Effect of prebiotics on growth and health of dairy calves: a protocol for a systematic review and meta-analysis. PLoS One 16: eo253379.
Ma, T., Suzuki, Y., Guan, L.L. (2018). Dissect the mode of action of probiotics in affecting host-microbial interactions and immunity in food producing animals. Veterinary Immunology and Immunıpathology 205: 35-48.
Malmuthuge, N., Chen, Y., Liang, G., Goonewardene, L.A. (2015a). Heat-treated colostrum feeding promotes beneficial bacteria colonization in the small intestine of neonatal calves. Journal of Dairy Science 98(11): 8044-8053.
Malmuthuge, N., Griebel, P.J., Guan, L.L. (2015b). The gut microbiome and its potential role in the development and function of newborn calf gastrointestinal tract. Frontiers in Veterinary Science 2: 36.
Malmuthuge, N., Guan, L.L. (2017). Understanding the gut microbiome of dairy calves: Opportunities to improve early-life gut health. Journal of Dairy Science 100: 5996-6005.
Markowiak, P., Slizewska, K. (2017). Effects of probiotics, prebiotics, and synbiotics on human health. Nutrients 9(9): 1021.
Newbold, C.J., Wallece, R.J., Chen, X.B., Mclntosh, F.M. (1995). Different strains of Saccharomyces cerevisiae differ in their effects on ruminal bacterial numbers in vitro and in sheep. Journal of Animal Science 73(6): 1811-18
Noori, M., Alikhani, M., Jahanian, R. (2016). Effect of parial substitution of milk with probiotic yoğurt of different pH on performance, body conformation and blood biochemical parameters of Holstein calves. Journal of Applied Animal Research 44(1): 221-229.
Oikonomou, G., Teixeira, A.G.V., Foditsch, C., Bicalho, M.L., Machado, V.S., Bicalho, R.C. (2013). Fecal microbial diversity in pre-weaned dairy calves as described by pyrosequencing of metagenomic 16S rDNA. Associations of Faecalibacterium species with health and growth. PloS One 8(4): e63157.
Quigley, J. (2018). Preweaning morbidity and mortality in the U.S. Calf note 203. http://www.calfnotes.com (Erişim: 23.09.2023).
Pinloche, E., McEwan, N., Marden, J.P., Bayourthe, C., Auclair, E., Newbold, C.J. (2013). The effects of probiotic yeast on the bacterial diversty and population structure in the rumen of cattle. PLoS One 8:1-9.
Rastal, R.A., Gibson, G.R., Gill, H.S., Guarner, F., Klaenhammer, T.R., Pot, B., Reid, G., Rowland, I.R., Sanders, M.E. (2005). Modulation of the microbial ecology of human colon by probiotics, prebiotics and synbiotics to enhance human health:an overview of enabling science and potential applications. FEMS Microbiology Ecology 52(2): 145-152.
Ratre, P., Singh, R.R., Chaudhary, S.S., Chaturvedani, A.K., Patel, V.R., Hanumant, D. (2019). Effect of prebiotic and probiotic supplementation on growth performance and body measurement in pre-ruminant Surti buffalo calves. The Pharma Innovation Journal 8(3): 265-269.
Retta, K.S. (2016). Role of probiotics in rumen fermentation and animal performance: a review. International Journal of Livestock Production 7(5): 24-32.
Renaud, D.L., Kelton, D.F., Weese, J.S., Noble, C., Duffield, T.F. (2019). Evaluation of a multispecies probiotic as a supportive treatment for diarrhea in dairy calves: A randomized clinical trial. Journal of Dairy Science 102(5): 4498-4505.
Roodposhti, P.M., Dabiri, N. (2012). Effects of probiotics and prebiotic on average daily gain, fecal shedding of Escherichia coli, and immüne system status in newborn female calves. Asian-Australasian Journal of Animal Science 25(9): 1255-1261.
Satık, S., Günal, M. (2017). Effects of kefir as a probiotic source on the performance and health of young dairy calves. Turkish Journal of Agriculture-Food Science and Technology 5(2): 139-143.
Schrezenmeir, J., de Vrese, M. (2001). Probiotics, prebiotics, and synbiotics approaching a definition. American Journal of Clinical Nutrition 73 (Suppl1.): 354S-361S.
Seifzadeh, S., Aghjeh-Gheshlagh, F.M., Abdi-Benemar, H., Saifdavati, J., Navidshad, B. (2016). The effects of a medical plant mixture and a probiotic on performance, antioxidant activity and weaning age of newborn Holstein calves. Iranian Journal of Applied Animal Science 6(2): 285-291.
Selim, S.A., Cullor, J.S. (1997). Number of viable bacteria and presumptive antibiotic residues in milk fed to calves on commercial dairles. Journal of the American Veterinary Medical Association 211(8): 1029-1035.
Signorini, M.L., Soto, L.P., Zbrun, M.V., Sequeira, G.J., Rosmini, M.R., Frizzo, L.S. (2012). Impact of probiotic administration on the health and fecal microbiota of young calves: a meta-analysis of randomized controlled trials of lactic acid bacteria. Research in Veterinary Science 93(1): 250-258.
Soltan, M.A. (2009). Effects of essential oils supplementation on growth performance, nutrient digestiblity, health condition of Holstein male calves during pre- and post-weaning periods. Pakistan Journal of Nutrition 8(5): 642-652.
Smith, G. (2015). Antimicrobial decision making for enteric diseases of cattle. Veterinary Clinics: Food Animal Practice 31(1): 47-60.
Szabo, J., Szabo, L. (2003). Prebiotics and probiotics in animal nutrition. (Hung J) Animal Production 52: 423-440.
Timmerman, H.M., Mulder, L., Everts, H., van Espen, D.C., van der Wal, E., Klaassen, G., Rouwers, S.M.G., Hartemink, R., Rombouts, F.M., Beynen, A.C. (2005). Health and growth of veal calves fed milk replacers with or without probiotics. Journal of Dairy Science 88: 2154-2165.
Tüzemen, N., and Yanar, M. (2004). Buzağı yetiştirme teknikleri. Atatürk Üniversitesi Ziraat Fakültesi Ders Yayınları No. 232.
Urie, N.J., Lombard, E.J., Shivley, C.B., Kopral, C.A., Adams, A.E., Earleywine, T.J., Olson, J.D., Garry, F.B. (2018). Preweaned heifer management on US dairy operations: Part V. Factors associated with morbidity and mortality in preweaned dairy heifer calves. Journal of Dairy Science 101: 9229-9244.
Uyeno, Y., Shigemori, S., Shimosato, T. (2015). Effect of probiotics/prebiotics on cattle health and productivity. Microbes and Environments 30(2): 126-132.
Vazquez-Mendoza, O., Elghandour, M.M.Y., Salem, A.Z.M., Cheng, L., Sun, X., Garcia-Flor, V.L., Pilego, A.B., Vazquez-Mendoza, P., Anele, U. (2020). Effects of sodium butyrate and active Bacillus amyloliquefaciens supplemented to pasteurized waste milk on growth performance and health condition of Holstein dairy calves. Animal Biotechnology 31(3): 209-216.
Wallace, R.J., Newbold, C.J. (1995). Microbial feed additives for ruminants. Probiotics: Prospects of use in opportunistic infections. Institute for Microbiology and Biochemistry, Herborn-Dill, Germany, 101-125.
Wang, Q., Lv, L., Jiang, H., Wang, K., Yan, R., Li, Y., Ye, J., Wu, J., Wang, Q., Bian, X., Yang, L. (2019). Lactobacillus helveticus R0052 alleviates liver injury by modulating gut microbiome and metabolome in D-galactosamine-treated rats. Applied Microbiology and Biotrechnology 103: 9673-9686.
Wang, L., Sun, H., Gao, H., Xia, Y., Zan, L., Zhao, C. (2023). A meta-analysis on the effects pf probiotics on the performance of pre-weaning dairy calves. Journal of Animal Science and Biotechnology 14(3),
Wu, Y., Wang, L., Luo, R., Chen, H., Nie, C., Niu, J., Chen, C., Xu, Y., Li, X., Zhang, W., (2021). Effect of a multispecies probiotic mixture on the growth and incidence of diarrhea, immüne function, and fecal micorbiota of pre-weaning dairy calves. Frontiers in Microbiology 12: 681014.
Yoon, I.K., Stern, M.D. (1995). Influence of direct-fed microbials on ruminant microbial fermentation and performance of ruminants- A review. Asian-Australasian Journal of Animal Sciences 8(6): 533-555.
Zhang, L., Jiang, X., Liu, X., Zhao, X., Liu, S., Li, Y., Zhang, Y. (2019). Growth, health, rumen fermentation, and bacterial community of Holstein calves fed Lactobacillus rhamnosus GG during the preweaning stage. Journal of Animal Science 97(6): 2598-2608.