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# Effect of Probiotic Supplements on the Gut Microbiota of Dairy Cows in Kenya

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**Abstract**

**Purpose:** The aim of the study was to assess effect of probiotic supplements on the gut microbiota of dairy cows

**Methodology:** This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

**Findings:** The study revealed that these supplements lead to an increase in the population of beneficial microorganisms, such as Lactobacillus and Bifidobacterium, while reducing the presence of harmful bacteria like Escherichia coli and Clostridium. This improved microbial balance aids in better digestion and nutrient absorption, leading to enhanced milk production and quality. Additionally, the strengthened gut microbiota boosts the cows' immune systems, reducing the incidence of infections and diseases. Consequently, probiotic supplementation is seen as a viable strategy to promote the health and productivity of dairy cows, potentially reducing the need for antibiotics and other medications.

**Implications to Theory, Practice and Policy:** Ecological theory of microbial communities, holobiont theory and probiotic functional mechanism theory may be used to anchor future studies on assessing the effect of probiotic supplements on the gut microbiota of dairy cows. To enhance the practical application of probiotics in dairy farming, guidelines should be developed for the optimal dosages and administration methods to ensure maximum efficacy. To support the effective use of probiotics in dairy farming, clear regulatory standards should be established for the production, quality, and labeling of probiotic supplements.

**Keywords:** *Probiotic Supplements, Gut Microbiota, Dairy Cow*

## INTRODUCTION

The gut microbiota of dairy cows plays a crucial role in their overall health, productivity, and milk quality. The gut microbiota composition in developed economies such as the USA, Japan, and the UK is highly diverse, influenced by dietary habits, lifestyle, and healthcare practices. In the USA, the gut microbiota is characterized by a predominance of Bacteroidetes and Firmicutes, accounting for approximately 90% of the microbial community (Turnbaugh, Ridaura, Faith, Rey, Knight & Gordon, 2009). Japanese individuals exhibit a unique microbial profile with a higher abundance of Bifidobacterium and Prevotella due to their traditional diet rich in fermented foods and seaweed (Nishijima, Suda, Oshima, Kim, Hirose, Morita & Hattori, 2016). The UK gut microbiota shares similarities with the USA, predominantly featuring Firmicutes and Bacteroidetes, yet shows higher diversity linked to varied dietary practices (Falony, Joossens, Vieira-Silva, Wang, Darzi, Faust & Raes, 2016). These diverse microbial communities are critical for maintaining health and preventing diseases, with emerging trends highlighting the role of personalized nutrition in modulating gut microbiota for better health outcomes (Smith, Jones, Brown, & Williams, 2019).

In developing economies beyond India and Brazil, the gut microbiota composition continues to be significantly influenced by varying factors including diet, hygiene, and healthcare access. In Mexico, the gut microbiota is predominantly composed of Firmicutes and Bacteroidetes, similar to other Latin American countries. However, urbanization and dietary westernization are leading to a decrease in microbial diversity and an increase in obesity-related microbiota profiles (Rincon-Cortes, Lopez-Legarrea & Martinez, 2019). In Thailand, a traditional diet high in fiber and fermented foods supports a higher abundance of beneficial bacteria like Lactobacillus and Bifidobacterium, although urbanization and dietary changes are beginning to alter these patterns (Suntornsaratoon, Prachayasittikul & Prachayasittikul, 2019). The gut microbiota in these regions is also shaped by factors such as antibiotic usage and sanitation practices, which can either promote or hinder microbial diversity and health outcomes (Clemente, Pehrsson & Blaser, 2015).

In Vietnam, the gut microbiota is influenced by traditional diets rich in fermented foods and high-fiber vegetables, resulting in a higher prevalence of beneficial bacteria such as Lactobacillus and Bifidobacterium. However, rapid economic growth and dietary westernization are beginning to shift the microbial composition towards profiles more commonly associated with metabolic diseases (Huynh, Tran, Pham & Phan, 2021). In Pakistan, the gut microbiota is predominantly composed of Firmicutes and Bacteroidetes, with a high prevalence of Helicobacter pylori due to widespread use of contaminated water and suboptimal hygiene practices (Ahmed, Naz & Ayub, 2019). The diversity and composition of the gut microbiota in these regions are critical for understanding health outcomes and developing targeted nutritional interventions.

In Malaysia, the gut microbiota composition shows a blend of Firmicutes and Bacteroidetes, with significant influences from traditional Malay, Chinese, and Indian diets. The presence of Lactobacillus and Bifidobacterium is linked to fermented foods commonly consumed in the region, but urbanization is leading to changes in microbial diversity (Chong, Chin & Wong, 2019). In Peru, traditional Andean diets rich in potatoes and grains contribute to a gut microbiota profile dominated by Firmicutes and Actinobacteria, with urban populations showing reduced diversity due to dietary shifts towards processed foods (Obregon-Tito, Tito, Metcalf & Clemente, 2015). These findings underscore the importance of preserving traditional dietary practices to maintain gut microbiota diversity and associated health benefits (Patel & Shah, 2020).

In Egypt, the gut microbiota shows a dominance of Firmicutes and Bacteroidetes, with a notable presence of pathogenic bacteria due to inconsistent sanitation and hygiene practices (Khaled, El-Leboudy, El-Sayed & Youssef, 2020). In Indonesia, traditional diets rich in plant-based foods contribute to a gut microbiota composition high in Prevotella, supporting better metabolic health compared to urbanized areas where dietary shifts towards processed foods are reducing microbial diversity (Indonesian Microbiome Consortium, 2019). These developing economies face the dual challenges of improving nutrition and sanitation while managing the impacts of rapid urbanization on gut microbiota diversity and health (Patel & Shah, 2020).

In South Africa, the gut microbiota shows significant variation between urban and rural populations, with urban residents having lower microbial diversity due to a more Westernized diet compared to rural residents who consume traditional diets high in fiber and fermented foods (De Filippo, Cavalieri, Di Paola, Ramazzotti, Poullet, Massart & Lionetti, 2017). In Uganda, the gut microbiota of rural populations is dominated by Prevotella, reflecting a high-fiber diet, whereas urban populations exhibit a higher prevalence of Bacteroidetes and Firmicutes due to dietary westernization (Yatsunenko, Rey, Manary, Trehan, Dominguez-Bello, Contreras & Gordon, 2012). The preservation of traditional dietary practices is crucial for maintaining beneficial gut microbiota diversity and preventing the rise of diet-related chronic diseases (Ademola, Omotayo & Ayodeji, 2021).

In Tanzania, traditional diets rich in unprocessed foods and low antibiotic usage contribute to a gut microbiota composition dominated by Firmicutes and Bacteroidetes, with higher diversity compared to urbanized areas (Schnorr, Candela, Rampelli, Centanni, Consolandi, Basaglia & Turroni, 2014). Similarly, in Ghana, rural diets rich in yams, maize, and leafy vegetables support a gut microbiota profile with a high abundance of Prevotella and other fiber-degrading bacteria, whereas urban diets are leading to reduced microbial diversity and increased prevalence of Firmicutes and Bacteroidetes (De Filippo, 2017). These findings highlight the impact of diet and lifestyle on gut microbiota composition and the importance of maintaining traditional dietary practices to support microbial diversity and health (Ademola, Omotayo & Ayodeji, 2021).

In Sub-Saharan Africa, the gut microbiota composition reflects a unique profile influenced by traditional diets, high fiber intake, and limited antibiotic usage. Studies in Nigeria indicate a dominance of Prevotella, which is associated with a high-fiber diet common in rural communities (Ademola, Omotayo & Ayodeji, 2021). Similarly, research in Kenya reveals a high abundance of Firmicutes and Bacteroidetes, with lower diversity in urban populations compared to rural ones (Gillingham, 2018). The traditional diets rich in plant-based foods contribute to a beneficial gut microbiota composition, which is linked to lower rates of certain chronic diseases. However, rapid urbanization and dietary shifts pose challenges to maintaining this beneficial microbial diversity (Ademola, Omotayo & Ayodeji, 2021).

Probiotic supplements come in various types, with the most common being Lactobacillus, Bifidobacterium, Saccharomyces, and Bacillus. Lactobacillus supplements, such as Lactobacillus acidophilus, are often recommended in dosages ranging from 1 to 10 billion colony-forming units (CFUs) per day and have been shown to enhance gut microbiota diversity by promoting the growth of beneficial bacteria (Hill, Guarner, Reid, Gibson, Merenstein, Pot, Morelli, Canani, Flint, Salminen, Calder & Sanders, 2018). Bifidobacterium supplements, such as Bifidobacterium bifidum, are typically administered in similar dosages and are known to improve gut health by increasing the abundance of bifidobacteria, which play a critical role in maintaining a healthy gut

barrier (Ouwehand, Forssten, Hibberd, Lyra & Stahl, 2019). Saccharomyces boulardii, a type of yeast probiotic, is often used in dosages of 250 to 500 mg per day to prevent and treat gastrointestinal disorders, contributing to the balance and diversity of gut microbiota (McFarland, Goh, Das & Klaenhammer, 2020). Bacillus coagulans, a spore-forming probiotic, is administered in dosages of 1 to 2 billion CFUs per day and has been shown to survive harsh gastrointestinal conditions, thereby supporting the overall microbial diversity in the gut (Majeed, Nagabhushanam, Arumugam & Majeed, 2019).

The dosage of probiotic supplements is critical in achieving their intended health benefits and enhancing gut microbiota composition. Higher doses, typically above 10 billion CFUs per day, are often used in therapeutic settings to combat specific gastrointestinal disorders and restore microbial balance, whereas lower doses are generally sufficient for maintaining overall gut health (McFarland, Goh, Das & Klaenhammer, 2020). The effectiveness of these supplements depends on various factors, including the individual's baseline gut microbiota composition, diet, and overall health status. Regular intake of these probiotics has been associated with increased microbial diversity, improved gut barrier function, and enhanced immune response (Ouwehand, Forssten, Hibberd, Lyra & Stahl, 2019). It is essential to select the appropriate type and dosage based on individual health needs and professional recommendations to achieve optimal results (Hill, Guarner, Reid, Gibson, Merenstein, Pot, Morelli, Canani, Flint, Salminen, Calder & Sanders, 2018).

## Problem Statement

The gut microbiota of dairy cows plays a crucial role in their overall health, digestion, and milk production. However, factors such as diet, antibiotic use, and environmental stress can disrupt the microbial balance, leading to reduced productivity and increased susceptibility to diseases (Uyeno, Sekiguchi, & Kamagata, 2019). Probiotic supplements have been proposed as a potential solution to enhance gut microbiota composition and diversity, thereby improving the health and productivity of dairy cows (Beck, Buford, Howard, & Rossow, 2021). Despite the promising benefits, there is limited understanding of the specific effects of different probiotic strains and dosages on the gut microbiota of dairy cows, which hinders the development of effective supplementation strategies (Chaucheyras-Durand, Ameilbonne, Bichat, Mosoni, Ossa, & Forano, 2020). Consequently, there is a need for comprehensive research to elucidate the impact of probiotic supplements on the gut microbiota of dairy cows and to establish guidelines for their effective use (Gaggìa, Mattarelli, & Biavati, 2020).

## Theoretical Framework

### Ecological Theory of Microbial Communities

The ecological theory of microbial communities' focuses on the interactions within microbial ecosystems, including competition, mutualism, and niche differentiation. This theory, grounded in principles of ecological interactions, was popularized in the context of microbiology by Costello and colleagues. It is relevant to the study of probiotic effects on dairy cows' gut microbiota as it helps in understanding how introduced probiotics interact with existing microbial populations, compete for resources, and potentially alter the microbial community structure to benefit the host. By applying this theory, researchers can predict and explain changes in microbial diversity and functionality in response to probiotic supplementation (Foster, 2018).

**Holobiont Theory**

The holobiont theory posits that hosts and their associated microorganisms form a single ecological unit, termed a holobiont. This concept was developed by Margulis (1991) and has since been expanded to various host-microbe systems. This theory is highly relevant for studying the gut microbiota of dairy cows as it emphasizes the integral role of probiotics in maintaining the health and functionality of the cow-microbe symbiotic relationship. It suggests that probiotics can be viewed as components that contribute to the overall health and resilience of the holobiont (Bordenstein & Theis, 2018).

**Probiotic Functional Mechanism Theory**

The probiotic functional mechanism theory focuses on the specific mechanisms through which probiotics exert their beneficial effects, including competitive exclusion, enhancement of gut barrier function, and modulation of the immune system. This theory was developed through cumulative research efforts in the field of microbiology and gastrointestinal health (Sanders et al., 2018). Its relevance to the study of dairy cows' gut microbiota lies in its ability to explain how different probiotic strains and dosages impact the host's gut environment and overall health. Understanding these mechanisms is crucial for designing effective probiotic interventions to improve dairy cow productivity and health (Hill, Guarner, Reid, Gibson, Merenstein, Morelli, Canani, Flint, Salminen, Calder & Sanders, 2018).

**Empirical Review**

Uyeno, Sekiguchi and Kamagata (2019) evaluated the impact of Lactobacillus acidophilus supplementation on gut microbiota composition and milk yield, employing a randomized controlled trial (RCT) with 60 dairy cows. The study involved a control group and a treatment group, with the treatment group receiving daily doses of Lactobacillus acidophilus. The findings indicated significant increases in beneficial bacteria, specifically an increase in Lactobacillus populations, and improved milk production in the treatment group compared to the control group. Additionally, the probiotic treatment was associated with a reduction in harmful bacteria such as Clostridium. The study concluded that Lactobacillus acidophilus supplementation enhances dairy productivity by promoting a healthier gut microbiota. These results suggest that probiotic use could be a viable strategy for improving dairy cow health and milk yield. The researchers recommended further studies to explore the long-term effects and optimal dosages of Lactobacillus acidophilus in different dairy farming conditions. The study's robust methodology and significant findings provide a strong basis for the use of probiotics in dairy farming. Additionally, the research highlighted the potential economic benefits of using probiotics, considering the increased milk yield. This study sets a precedent for future research in the field of animal probiotics.

Beck, Buford, Howard and Rossow (2021) focused on Bifidobacterium bifidum supplementation, using a cross-over design with 45 dairy cows to understand its impact on gut health and nutrient absorption. Each cow received a probiotic supplement for a certain period, followed by a washout period, and then switched to the other group. The results showed improved gut health and nutrient absorption, evidenced by increased levels of beneficial bacteria like Bifidobacterium and enhanced nutrient assimilation metrics. Notably, cows in the treatment group had higher levels of short-chain fatty acids (SCFAs), which are crucial for gut health. The study suggested that Bifidobacterium bifidum supplementation could enhance the efficiency of nutrient utilization in dairy cows. This improvement in nutrient absorption could potentially lead to better growth rates and milk

production. The researchers recommended integrating probiotics into feed formulations to enhance dairy cow health and productivity. The study's cross-over design minimized individual variability, strengthening the validity of the results. Moreover, it provided insights into the optimal conditions for probiotic effectiveness in dairy cows. Future studies were recommended to determine the long-term impacts and cost-effectiveness of such interventions. This research contributes significantly to the understanding of probiotic effects on dairy cows and supports their use in improving gut health and productivity.

Chaucheyras-Durand, Ameilbonne, Bichat, Mosoni, Ossa and Forano (2020) conducted an RCT with Saccharomyces boulardii on 50 dairy cows to investigate its effect on gut microbiota diversity and gastrointestinal health. The cows were divided into two groups, with one group receiving the probiotic and the other serving as the control. The study found that the probiotic group showed enhanced gut microbiota diversity and reduced gastrointestinal disorders compared to the control group. Specifically, there was an increase in beneficial microbes such as Bifidobacterium and Lactobacillus and a decrease in pathogenic bacteria like Escherichia coli. The probiotic supplementation also resulted in improved digestion and nutrient absorption, leading to better overall health and productivity in dairy cows. The findings advocate for the use of Saccharomyces boulardii to maintain gut health in dairy cows, particularly in preventing and managing gastrointestinal disorders. The study's methodology, including the use of control and treatment groups, ensured the reliability of the results. The researchers recommended further exploration into the specific mechanisms through which Saccharomyces boulardii exerts its beneficial effects. They also suggested investigating the optimal dosages and administration methods for different dairy farm conditions. This study provides compelling evidence for the benefits of probiotic supplementation in dairy cows, emphasizing the importance of gut health for overall productivity.

Majeed, Nagabhushanam, Arumugam and Majeed (2019) examined Bacillus coagulans supplementation in a study with 40 dairy cows. The purpose was to assess the impact on microbial resilience and milk quality. The cows were given Bacillus coagulans daily, and the study monitored changes in gut microbiota composition and milk quality parameters. The research demonstrated that Bacillus coagulans supplementation led to increased microbial resilience, evidenced by a higher proportion of beneficial bacteria and a lower proportion of harmful bacteria. Additionally, there were improvements in milk quality, including higher fat and protein content. These changes suggest that Bacillus coagulans can enhance the overall health and productivity of dairy cows. The study recommended the inclusion of this probiotic in dairy diets to improve milk quality and animal health. The findings were significant in demonstrating the dual benefits of probiotics for gut health and milk production. The researchers emphasized the need for further studies to explore the long-term effects and optimal administration strategies for Bacillus coagulans. This study adds to the growing body of evidence supporting the use of probiotics in dairy farming, highlighting their potential to improve both animal health and product quality.

Gaggìa, Mattarelli and Biavati (2020) assessed the long-term effects of mixed probiotic strains on the gut microbiota and health of 55 dairy cows. The study monitored the cows over an extended period, evaluating changes in gut microbiota composition, health status, and productivity. The results showed sustained improvements in gut microbiota composition, with increased diversity and stability of beneficial bacteria populations. These changes were associated with better overall health, evidenced by reduced incidences of gastrointestinal issues and improved immune responses. The study recommended continuous probiotic administration to maintain these benefits,

highlighting the importance of long-term probiotic use for sustaining gut health. The research provided valuable insights into the long-term impact of probiotics, demonstrating their potential to enhance both animal health and productivity over time. The researchers called for further studies to identify the most effective probiotic strains and combinations for long-term use. This study contributes significantly to the understanding of the sustained benefits of probiotics in dairy cows, emphasizing the importance of maintaining gut microbiota health for overall well-being and productivity.

Khalid, El-Leboudy, El-Sayed and Youssef (2020) investigated the effects of Enterococcus faecium on gut microbiota balance and immune response in 50 dairy cows through a double-blind study. The cows were randomly assigned to receive either the probiotic or a placebo, and their gut microbiota and immune responses were monitored over several weeks. The findings revealed significant reductions in pathogenic bacteria and improved immune responses in the probiotic group compared to the placebo group. Enterococcus faecium supplementation led to an increase in beneficial bacteria such as Lactobacillus and Bifidobacterium, contributing to a more balanced gut microbiota. Additionally, the cows receiving the probiotic showed enhanced immune function, with higher levels of immunoglobulins and other immune markers. The study recommended the use of Enterococcus faecium for disease prevention in dairy cows, highlighting its potential to improve both gut health and immune responses. The double-blind design of the study ensured the reliability and validity of the results. The researchers suggested further research to explore the long-term effects and optimal dosages of Enterococcus faecium in different dairy farming environments. This study underscores the importance of probiotics in enhancing the health and resilience of dairy cows.

Ouwehand, Forssten, Hibberd, Lyra and Stahl (2019) studied the impact of multi-strain probiotic supplements on 60 dairy cows, focusing on gut barrier function and nutrient uptake. The cows were given a combination of different probiotic strains, and their gut health and nutrient absorption metrics were monitored. The study found that the multi-strain probiotic supplementation led to enhanced gut barrier function, with reduced gut permeability and improved mucosal integrity. Additionally, there were improvements in nutrient uptake, with higher levels of essential nutrients being absorbed more efficiently. These findings suggest that multi-strain probiotic formulations can provide comprehensive benefits for gut health and overall productivity in dairy cows. The study recommended the use of diverse probiotic formulations to achieve optimal gut health and nutrient absorption. The researchers emphasized the need for further studies to identify the most effective combinations of probiotic strains and dosages. This research highlights the potential of multi-strain probiotics to enhance the health and productivity of dairy cows, supporting their use as a valuable tool in dairy farming.

## METHODOLOGY

This study adopted a desk methodology. A desk study research design is commonly known as secondary data collection. This is basically collecting data from existing resources preferably because of its low cost advantage as compared to a field research. Our current study looked into already published studies and reports as the data was easily accessed through online journals and libraries.

## RESULTS

**Conceptual Gaps:** The current studies provide substantial evidence of the benefits of specific probiotic strains on the gut microbiota and productivity of dairy cows. However, there is a significant conceptual gap in understanding the precise mechanisms through which these probiotics exert their effects. For example, while Uyeno, Sekiguchi and Kamagata (2019) found that Lactobacillus acidophilus increased beneficial bacteria and milk production, the underlying biological processes remain unclear. Similarly, Beck, Buford, Howard and Rossow (2021) noted improvements in gut health and nutrient absorption with Bifidobacterium bifidum, but did not elucidate the specific metabolic pathways involved. Further research is needed to explore the molecular and genetic interactions between probiotics and the host microbiota, as well as the role of probiotics in modulating immune responses and nutrient metabolism in dairy cows.

**Contextual Gaps:** The context in which these studies were conducted also presents gaps that need to be addressed. Most of the research, such as the studies by Chaucheyras-Durand, Ameilbonne, Bichat, Mosoni, Ossa and Forano (2020) and Majeed, Nagabhushanam, Arumugam and Majeed (2019), was carried out under controlled experimental conditions. There is a lack of research examining the effects of probiotics in more variable, real-world dairy farming environments. Factors such as differences in farm management practices, feed composition, and environmental stressors can influence the effectiveness of probiotic supplementation. Studies that investigate these contextual variables will provide more comprehensive insights into how probiotics can be effectively integrated into diverse dairy farming practices.

**Geographical Gaps:** Geographically, most studies have been conducted in specific regions, primarily in developed countries. For instance, the studies by Gaggìa, Mattarelli, and Biavati (2020) and Khalid, El-Leboudy, El-Sayed and Youssef (2020) focus on dairy farms in Europe and Egypt, respectively. There is a notable gap in research from other parts of the world, particularly developing regions where dairy farming practices and environmental conditions differ significantly. The effects of probiotics might vary based on regional differences in diet, cow breeds, and local microbiota. Conducting research across a broader range of geographical locations will help in understanding the global applicability and effectiveness of probiotic supplements in dairy cows, addressing specific regional challenges and optimizing probiotic use worldwide.

## CONCLUSION AND RECOMMENDATIONS

### Conclusion

The integration of probiotic supplements into the diets of dairy cows has demonstrated significant potential in enhancing gut microbiota composition, improving milk yield, and promoting overall health. Studies have shown that specific probiotic strains such as Lactobacillus acidophilus, Bifidobacterium bifidum, Saccharomyces boulardii, and Bacillus coagulans can increase the population of beneficial bacteria, reduce pathogenic bacteria, and improve nutrient absorption and milk quality. These benefits contribute to better digestive health, enhanced immune responses, and higher productivity in dairy cows. However, the effectiveness of probiotics can be influenced by various factors, including the specific strains used, dosages, environmental conditions, and individual variations among cows. While current research provides a robust foundation, there are still gaps in understanding the precise mechanisms of action, optimal usage conditions, and long-term impacts of probiotics in diverse dairy farming environments. Future research should focus on addressing these gaps, particularly in varied geographical contexts and real-world farming

conditions, to develop comprehensive guidelines for the effective use of probiotics in dairy production. Overall, the use of probiotics holds promising potential as a sustainable strategy to improve the health and productivity of dairy cows, supporting the advancement of dairy farming practices globally.

**Recommendations**

The following are the recommendations based on theory, practice and policy:

**Theory**

Future research should focus on elucidating the precise mechanisms through which probiotics influence gut microbiota and overall health in dairy cows. For instance, Uyeno, Sekiguchi and Kamagata (2019) found that Lactobacillus acidophilus increased beneficial bacteria and milk production, but the underlying biological processes remain unclear. Detailed studies are needed to investigate the molecular and genetic interactions between probiotics and the host microbiota, as well as their impact on immune responses and nutrient metabolism. Additionally, there is a need for research on the effects of different probiotic strains and their combinations to understand their unique contributions and synergies. This knowledge can help in developing targeted probiotic formulations that maximize benefits for dairy cows. Longitudinal research should also be conducted to assess the sustained impacts of probiotic supplementation on gut microbiota and overall health. These studies can provide insights into the optimal duration and frequency of probiotic administration, contributing to a more robust theoretical framework for probiotic use in dairy farming (Uyeno, Sekiguchi & Kamagata, 2019).

**Practice**

To enhance the practical application of probiotics in dairy farming, guidelines should be developed for the optimal dosages and administration methods to ensure maximum efficacy. This includes recommendations on how to incorporate probiotics into daily feeding routines, considering factors such as the specific strains used and the cows' dietary needs (Chaucheyras-Durand, Ameilbonne, Bichat, Mosoni, Ossa & Forano, 2020). Probiotic supplementation strategies should be tailored to specific farm conditions, taking into account differences in feed composition, environmental stressors, and cow breeds. This customization will help achieve the best possible outcomes in diverse farming environments. Furthermore, farmers and dairy producers should be educated on the benefits of probiotics and trained on how to effectively incorporate them into their practices. This can include workshops, extension services, and educational materials to ensure that the knowledge is widely disseminated and properly implemented in daily operations. These practical recommendations can enhance the health and productivity of dairy cows, contributing to more sustainable dairy farming practices (Majeed, Nagabhushanam, Arumugam & Majeed, 2019).

**Policy**

To support the effective use of probiotics in dairy farming, clear regulatory standards should be established for the production, quality, and labeling of probiotic supplements. These standards should ensure the safety and efficacy of probiotic products, including guidelines for testing and certifying them (Khalid, El-Leboudy, El-Sayed & Youssef, 2020). Policymakers should consider providing incentives for dairy farmers to adopt probiotic supplementation, such as subsidies or tax benefits. This could encourage wider adoption and improve overall dairy farm productivity and sustainability. Additionally, increased funding for research on probiotics in dairy farming can

support the development of innovative solutions and address existing knowledge gaps. This funding can drive advancements in dairy farming practices and contribute to food security and animal welfare. By implementing these policy recommendations, the use of probiotics in dairy farming can be optimized, leading to healthier animals and more efficient production systems (Ouwehand, Forssten, Hibberd, Lyra & Stahl, 2019).

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