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A Comprehensive Investigation of Sterilized Lactation and Lower Illness in Preweaned Cows

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Abstract
Lactation, a crucial physiological process for calf well-being, is impacted by cleanliness, milk quality and disease transmission. A novel way to overcome these issues is sterilized lactation, which promotes optimum milk production and herd health via the use of controlled circumstances. The main goal is to describe how feeding heat-treated colostrums affects the preweaning period's health and serum immunoglobulin concentration. Completing a path analysis to find intermediary variables that might account for the decreased risk of sickness associated with administering heat-treated colostrums was the secondary goal. This study explores the potential of sterilized lactation in addressing issues like cleanliness, milk quality and disease transmission in cows, focusing on optimal milk production and overall herd health, despite concerns about bacterial contamination along with infectious diseases. Six hypotheses were developed in this research to investigate how HT Colostrums affect serum IgG levels, calf health and immune response gene expression, the makeup of the gut microbiota, long-term growth and economic factors. By comparing predicted and actual prices, statistical analyses T-tests, with a significance level of 5% were used to evaluate the accuracy of anticipated final costs. According to the research, sterilized lactation can improve milk quality, reduce the spread of illness and have an effect on several preweaned cows' health indicators. The research provides a thorough grasp of the complex features of sterilized lactation by using statistical studies, economic assessments and biological evaluations. According to the investigation, calves that were given heat-treated colostrums had a decreased chance of being sick. This is because the heat-treatment method lowered the total coli form count in the colostrums, which in turn enhanced serum IgG concentrations, which further reduced the risk of sickness. Further research is essential to solidify these initial observations and guide the implementation of sterilized lactation practices in dairy farming for enhanced animal welfare and milk quality.

Keywords: lactation, preweaned cows, sterilization, illness, dairy farming, Colostrums, Heat treatment (HT), Test day (TD).

INTRODUCTION

Mammalian lactation, or the process of producing and secreting milk, is an essential physiological mechanism for the well-being of the young. Lactation is the most important process in dairy farming because it results in milk that humans can drink (1). Traditional methods of lactation in cows rely on the animal's inherent processes, which can be problematic when it comes to cleanliness, milk quality and the spread of illness. A rising number of people are interested in finding other ways to make milk production safer and more efficient as a reaction to these concerns (2). The practice of sterilizing the lactation process in preweaned cows under controlled conditions is a novel idea that is attracting interest in the fields of agriculture and veterinary research. Milk quality, bacterial contamination and the transmission of infectious illnesses are the problems that this approach seeks to solve (3). This extensive study explores sterilized lactation in preweaned cows from every angle, with the hope of illuminating the possible advantages, disadvantages and consequences of using this technique in contemporary dairy production (4). This research delves into the molecular mechanics of breastfeeding and looks at the potential effects of sterilization on the nutritional content, safety and composition of milk (5).

Preweaned cow health and welfare have the highest priority in contemporary dairy farming, impacting in addition to the quality of life for the particular cow but also the long-term viability and efficiency of the dairy as a whole. Illnesses that affect growth, development and milk output in the future might disproportionately affect preweaned cows (6). These difficulties highlight an increasing desire for the dairy sector to investigate all-encompassing methods of lowering the disease rate among preweaned cows. Nutrition, housing, management and disease prevention measures as a part of the comprehensive strategy that this study attempts to implement to reduce sickness in preweaned cows (7). A healthy and robust dairy herd depends on preweaned cows and their health is an ethical and practical issue. Dairy producers can preserve animals, boost output and ensure their business longevity by finding and using solutions to reduce disease rates in preweaned cows (8). We are investigating the effects of sterilized lactation on the milk micro biome, to determine if sterilization methods perform to avoid contamination from bacteria and whether sterilizing dairy products can reduce the spread of zoometric illnesses (9). Examining how sterile lactation affects the nutritional profile of milk, looking specifically at how the ratio of vitamins, minerals and vital elements alters. Making sure people's nutritional requirements are satisfied requires a thorough understanding of how sterilization could impact milk quality (10). Evaluate the efficacy of current biosecurity techniques and immunization programs in reducing the prevalence of common diseases in preweaned cows. Overall health management must develop focused tactics to reduce disease transmission in the herd (11). Nutritional strategies demand a more inclusive approach that extends beyond mainstream ruminant species and breeds. It is imperative to amplify basic research efforts in the tropics and subtropics, particularly in elucidating intricate interactions in grasses and legume associations (12). Prospective Ruminant Production Systems (RPS) ought to adopt something out of mixed farming systems' integrated as well as holistic strategy that look for ways dairy and non-ruminant production might work together on farms or in regions, as depicted in Figure (1). To better understand processes like food selection in grazing animals, it is essential to prioritize the complementary nature of different crop associations (13). This allows for the development of new techniques. Notably, progress in this domain, akin to other fields, has occurred in controlled conditions, spanning both Developed Countries (DCs), as well as in monoculture grasslands (14).

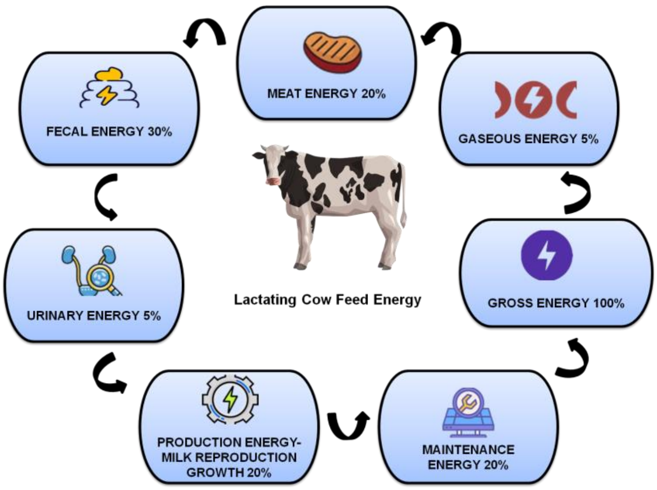

Figure (1). Partitioning Feed Energy in Lactating Cows

https://www.researchgate.net/figure/Energy-utilization-by-a-lactating-cow-showing-average-partition-of-feed-energy-by-the_fig2_221973402

The study randomized controlled experiment was to determine if preweaned dairy calves with a spontaneous respiratory disease were far better after receiving antibiotic therapy. Using portable breathing radiology and metabolic grading, the calves were identified. The secondary objective was to determine whether the patient's symptoms at diagnosis influenced their reaction to therapy (15). Estimating the prevalence of (Bovine Respiratory Disease) BRD in California's preweaned dairy calves and identifying management approaches related to BRD were the objectives of this cross-sectional research (16). The study included 100 dairies from three different locations in California. The purpose of the research (17) was to find out how it is for Escherichia

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coli bacteria to be resistant to ciprofloxacin and ceftriaxone in dairy calves that are protected against bovine respiratory illness by using enrofloxacin or tulathromycin. Three groups of calves were randomly allocated to high-risk calves for BRD that were 2–3 weeks old and did not have clinical pneumonia. The research (18) was to determine how common constipation-causing enteric pathogens were in a cross-section of Australian dairy farms. The secondary goal was to examine whether current calf management practices on these farms correlated with herd-level morbidity and mortality. Study was carried out as part of a cross-sectional research that used questionnaires to collect pertinent data on health outcomes and practices particular to farms. The research (19) was to examine the effects on development, sickness duration and severity of preweaning dairy calves with spray-dried maternal-derived bovine colostrums replacers when diarrhea first appears. The primary objective is to examine how sterilized lactation influences milk quality, bacterial contamination and disease transmission in preweaned cows.

MATERIALS AND METHODS

Understanding the lactation cycle is crucial for optimizing dairy cow productivity. Farmers can implement effective feeding strategies to support their health, milk production and overall well-being. Early lactation is essential for high milk yield and coping with limited cow appetite. Ensuring cows return to estrus is vital for reproductive success. Early lactation prevents live weight and body condition loss, especially for high-performing cows yet it is pivotal in overall herd productivity and health. Therefore, understanding and addressing cows' nutritional needs during each phase of the lactation cycle is crucial. Figure (2) illustrates the dynamic stages in the lactation journey of dairy cows, providing a visual depiction of the key phases involved in milk production.

Mid-lactation: Continue with good milk yield.

Late lactation: Good milk yield, regain lost condition, grow calf.

Dry period: Preparing for calving requires stopping milking two months before calving to let the calf develop.

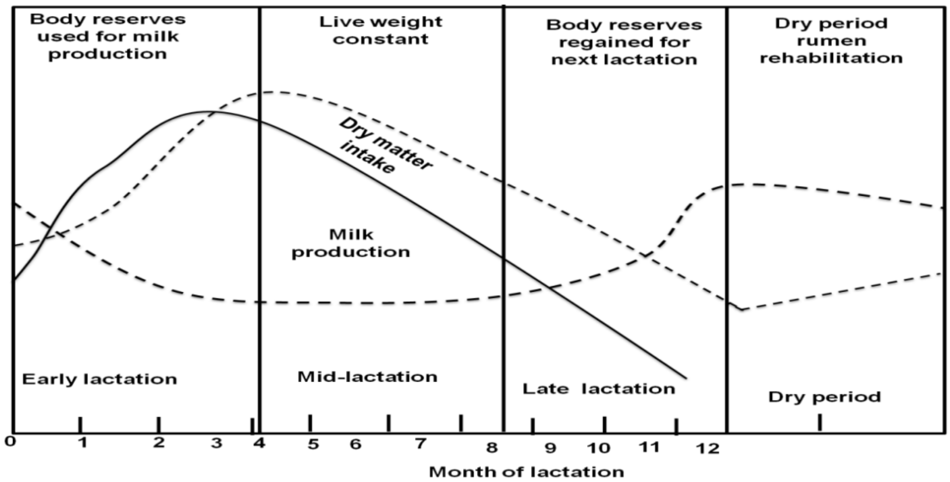

Figure (2). Stages in the Lactation Journey of Dairy Cows: Understanding the Dynamic Phases of Milk Production

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2F1-Phases-of-lactation-cycle-in-dairy-cow_fig2_326156581&psig=AOvVaw3Yf4M8zIobIADxzXMeurhM&ust=1702105901164000&source=images&cd=vfe&opi=89978449&ved=2ahUKEwjzg5LepP-CAxVLTmwGHadwC1MQr4kDegQIARBK

Colostrums Preparation

The process of Colostrums preparation began with the collection of first-milking Colostrums within 2 hours post-calving by farm personnel. This freshly collected Colostrum was refrigerated at 4°C for a period ranging from 24 to 48 hours before that is pooled. Once pooled, the refrigerated Colostrums underwent a meticulous mixing process and they were divided into equal aliquots. Two treatment conditions were established: one aliquot remained untreated, while the other underwent heat treatment using a commercial batch pasteurizer set at 60°C for 60 minutes. The pasteurization process was monitored, with the equipment programmed to reach and maintain the target temperature, followed by automatic cooling to 15.6°C. Although times and temperatures were displayed digitally during heat treatment (HT), we were not recorded due to the absence of electronic recording equipment for the batch pasteurizers at the time, Figure (3) shows the overall conceptual framework of the study. It is noteworthy that agitation of the Colostrums occurred throughout the entire heat treatment process. Duplicate 50-mL aliquots of both fresh (untreated) and heat-treated Colostrums were collected from each batch and frozen at −20°C for analysis. The effects of heat treatment on Colostrum's characteristics are detailed in a related manuscript. Finally, the freshly prepared and heat-treated Colostrums were transferred to sanitized 3.8-L bottles and refrigerated for later feeding to the enrolled calves, typically taking place within 24 to 48 hours of preparation.

Hypothesis 1: Investigating the Impact of HT Colostrums on Serum IgG Levels and Calf Health in Dairy Farming

This study examines the hypothesis that the administration of HT Colostrums to calves has a measurable impact on both serum IgG (immunoglobulin G) concentration and the overall health of the calves. The study investigates the potential benefits of heat treatment on Colostrums, a primary source of maternal antibodies, in transferring immunity to newborns. The hypothesis suggests that heat treatment can modify the composition of Colostrums, potentially enhancing their effectiveness in promoting immunoglobulin absorption, leading to increased serum IgG levels in recipient calves. The research aims to determine if these modified Colostrums result in higher IgG concentrations in treated calves compared to untreated ones. The study suggests that calves receiving HT Colostrums can experience improved health outcomes, potentially reducing infectious diseases and overall morbidity. The findings could influence on-farm colostrum management strategies and improve the health and resilience of young calves in agricultural settings.

Hypothesis 2: A Comprehensive Analysis of How HT Colostrums Mitigates Illness Risk in Calves

The study proposes a path analysis to understand the causal relationships between the administration of HT Colostrums and the health outcomes of calves. It suggests that HT Colostrums, due to their enhanced immunoglobulin content and modified composition, can indirectly affect other critical health-related variables, such as immune response, disease resistance and overall well-being in preweaned calves. The study aims to provide a comprehensive understanding of the mechanisms contributing to a reduced risk of illness in calves, which could guide targeted interventions in colostrums management practices, optimize disease prevention strategies for young calves and advance holistic approaches for overall dairy herd health improvement. This approach could guide targeted interventions in colostrum management practices and optimize disease prevention strategies for young calves.

Hypothesis 3: Effect of HT Colostrums on Immune Response Gene Expression

The study investigates the impact of HT Colostrums on the expression of genes related to immune response pathways in preweaned calves. It aims to determine if the altered Colostrum composition induces specific changes in gene expression profiles related to critical immune factors, contributing to an improved immune response in HT Colostrum-treated calves compared to untreated ones. The investigation aims to understand the molecular mechanisms underlying this potential enhancement, providing valuable insights into the immunogenetic effects of HT Colostrums.

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Hypothesis 4: Comparative Analysis of Gut Microbiota Composition in Calves Receiving HT and Untreated Colostrums

The study aims to differentiate the gut microbiota of preweaned calves given HT Colostrums from those given untreated colostrums by examining the changes in colostrum composition that drive these modifications. The research aims to understand how variations in colostrums components can shape the microbial communities in the gastrointestinal tract of preweaned calves. The ultimate goal is to enhance our understanding of these dynamic interactions, providing a basis for practices that promote the early development of a resilient and balanced gut micro-biome. This knowledge could influence long-term health outcomes and immune responses in preweaned calves, promoting targeted strategies to optimize the microbial ecology of the gastrointestinal tract.

Hypothesis 5: Long-Term Impact of HT Colostrums on Growth and Productivity in Calves

The study investigates the potential long-term benefits of administering HT Colostrums to calves, focusing on their growth rates, weight gain and overall productivity. It aims to determine if early interventions contribute to sustained improvements in these aspects throughout the animals' lives. The research aims to understand the potential implications of this intervention on the long-term well-being and performance of the animals by studying its effects on calves' development.

Hypothesis 6: Economic Analysis of HT Colostrums Implementation in Dairy Farming

The study explores the economic feasibility of integrating HT Colostrums into dairy farming practices. It evaluates the cost-effectiveness and potential return on investment of adopting HT Colostrums protocols, considering factors like reduced veterinary expenses and improved herd health. The aim is to provide valuable insights for dairy farmers' decision-making and provide a comprehensive understanding of the financial implications of this innovative approach in colostrums management.

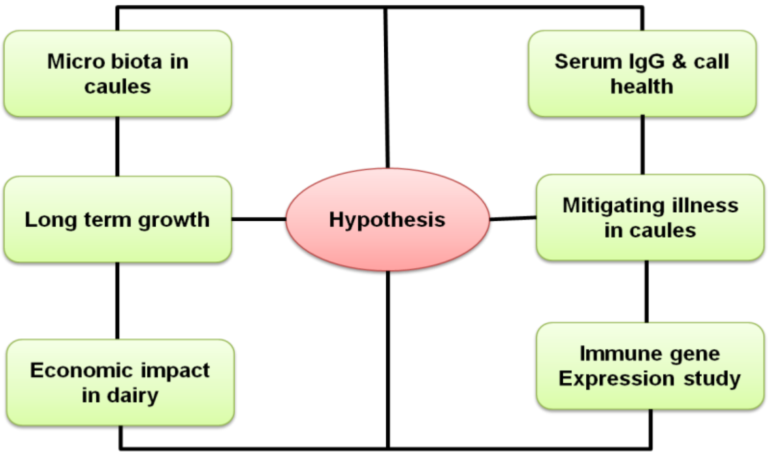

Figure (3). Conceptual framework

(Source Author)

STATISTICAL ANALYSIS

T-test

The accuracy of the predicted ultimate cost is evaluated by the use of a paired t-test. The two sets of data required for the paired t-test are the expected price t_j and the actual price $\hat{t}_j$ with n samples for each in Equation (1-4).

$$\mathrm{dif} = t_j - \hat{t}_j \quad (1)$$

$$\overline{\mathrm{dif}} = \frac{\sum \mathrm{dif}}{m} \quad (2)$$

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$$\mathrm{TC} = \sqrt{\frac{\sum\left(\mathrm{dif}-\overline{\mathrm{dif}}\right)^2}{\mathrm{m}-1}} \tag{3}$$

$$\mathrm{s-value} = \sqrt{\mathrm{m}_{\mathrm{TC}}^{\mathrm{dif}}} \tag{4}$$

Where $\overline{\mathrm{dif}}$ and TC denote the mean of difference and the standard deviation of the sample, in that order. The acceptance or rejection of the null hypothesis is determined by permitting a significant threshold of 5% (0.05).

RESULT

Data collection

Eight hundred thirty-four hybrid cows were held for further study if four or more monthly milk records were obtained between eight days after calving and three hundred forty-four days thereafter. Once all quality control steps were implemented, a total of 4,277,000 herds collected 149,508 records about test days (TDs) and 8563 cows that were crossbred. With the help of 87 Cattle Development Centre (CDC) and 30 districts, these cows were dispersed to 728 communities. From one herd to forty-three, was the range for the number of cows. Nearly 40% of the cows belonged to herds consisting of two or more cows, while 75% belonged to herds consisting of three cows. From ten to three hundred and forty-nine cows were maintained by each CDC (20).

Test day model (TDM)

A linear model was employed to analyze the influence of calving year, season, management techniques and environmental factors on lactation performance. The study aims to understand biological relationships and interactions in dairy production data, providing insights into underlying mechanisms. It considers specific management circumstances and adjusts residuals from the Total Milk Daily (TDM) model to account for herd TDM, age, Days in Milk (DIM), calendar month of freshening, pregnancy status and management influences. The model is designed to accommodate inherent variability in conditions across herds and environments, allowing for a more nuanced assessment of multifaceted factors influencing dairy production. This approach ensures a comprehensive understanding of dairy production. The model employed to characterize variables such as milk, fat, or protein on a given TDM is expressed as in Equation (5),

$$Z_{jiklmno} = s_j + b_{il} + c_{ik} + e_{in} + d_{im} + f_{jiklmno}, \tag{5}$$

$Z_{jiklmno}$ Represents the dependent continuous variable under consideration, where $s_j$signifies the jth observed TDM for a particular herd. The components of the model includek^{th} denoting the k^{th} age in months for the o^{th} observation, with i serving to divide the herd data into two halves, distinguishing between older and newer data. The l^{th}days in milk (DIM) on the TDM of the o^{th} observation are represented byc_{ik}. DIM, assessed every 10 days, spans 1 to 45 for first and subsequent lactations, capturing various stages of lactation. The variable e_{in} denotes the m^{th} month post-freshening for the o^{th} examination, while d_{im} represents the n^{th} day of pregnancy. The parameter n distinguishes between the initial five months along with the sixth month, yet extends to the ninth month and beyond, applying to both first as well as second lactations. The residual term $jiklmno$ accounts for variability in the o^{th} observation, incorporating factors such as the cow's period of pregnancy, month post-freshening, DIM, age in months and the specific herd TMD. The given context outlines a linear model for analyzing milk, fat, or protein observations in dairy cows, where the elements of the observation vector 'Z' are unspecified to be associated in Equation (6).

$$w'Y^{-1}w\beta = w'Y^{-1}z \tag{6}$$

The text describes a model for calculating the residual variance-covariance structure of a cow, assuming an autocorrelation structure. It uses a frequency environment with information about TDM, age and DIM, a vector of interest coupled with a partial residual estimate. The model is based on an 'W' is a $n \times n$ matrix, where$\frac{Y}{\sigma^2} = \rho$ as shown in Equation (7)

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$$\rho^r and\ r = |(s_j - s_i)/30| \quad (7)$$

The model uses autocorrelation parameters for milk yield, fat yield and protein yield, generating standardized residuals to ensure uniform variance across Total Daily Milk measurements. Table (1) provides detailed data on birth weight, growth rate, Age at First Calving, milk yield and other performance parameters.

Table (1). Comparative Analysis: Dairy Herd Performance Metrics (Source: Author)

Parameter	Commercial herd	SD	Cornell herd2	SD
Average monthly temperature (°C)	9.45	9.32	8.53	9.20
First-lactation records (n)	613	-	1,264	-
Weaning weight (kg)	84.16	10.89	82.07	10.23
Average age at first calving (d)	682	65	693	57
Birth weight (kg)	42.57	5.12	41.67	5.05
Post weaning ADG (kg/d)	0.95	0.19	NA	NA
Birth height (cm)	NA3	NA	80.82	5.73
Weaning height (cm)	NA	NA	93.76	9.92
Average mega calories above maintenance from milk replacer (Mcal/d)	NA	NA	2.84	0.68

Using TDM residual lactation records, which were created by aggregating TD residuals, the researchers examined the impact of preweaning and prepubertal nutrition on the subsequent lactation production of heifers and calves. It is the difference between these residual values positive and negative that is of interest, as they are the product of a grand mean. The assumption underlying this analysis is that the majority of test-day residuals can be attributed to unexplained variation post-adjustments or genetic relationships among the variables of interest. Furthermore, the assessment extends to the evaluation of these genetic relationships in the context of the variable of interest. The study investigates the impact of preweaning and prepubertal nutrition on later lactation production in dairy herds. Figure (4) and Table (2) display the cows typically produce an average of 439 kg of Total Milk Protein (TDM) and an additional 850 kg of milk or ADG in the first lactation. In the second lactation, both Mean TDM and Extra Milk Yield increased, reaching 622 kg and 891 kg, respectively. However, in the third lactation, the Mean TDM increased to 775 kg, while the Extra Milk Yield decreased to 523 kg. Further analysis is needed to understand the factors influencing these variations and their implications for dairy herd management.

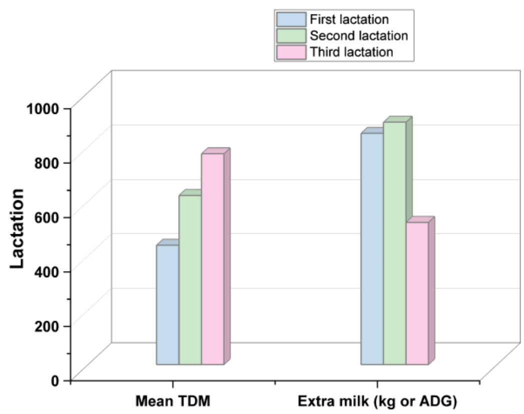

Figure (4). Lactation Metrics: Parity-Driven Insights for Dairy Productivity

(Source Author)

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Table (2). Numerical outcomes of Lactation metrics (Source: Author)

Lactation	Mean TDM	Extra milk (kg or ADG)
First lactation	439	850
Second lactation	622	891
Third lactation	775	523

DISCUSSION

The study explores the potential benefits and impacts of HT Colostrums in dairy farming, but acknowledges limitations such as potential variability in individual cow responses due to genetics, health status and environmental conditions. Standardizing the heat treatment process across farms can pose challenges, potentially causing variations in the composition and effectiveness of HT Colostrums. Addressing these limitations is crucial for accurate interpretation and generalization of the findings. The discussion should consider practical implementation in real-world dairy farming scenarios, considering diverse management practices and operational constraints faced by farmers. Openly discussing these drawbacks can provide a more nuanced understanding of incorporating HT Colostrums into routine colostrums management practices.

CONCLUSION

Sterilized lactation has the ability to be a novel approach for enhancing the health and safety of preweaned cows and their milk. This research highlights this possibility. Sterilized lactation can limit the transmission of diseases, mitigate bacterial contamination and favorably affect numerous health indicators in preweaned cows, according to statistical analysis, economic evaluations and biological evaluations. These encouraging results highlight the compatibility of sterile lactation with ecological and ethical farming norms, adding important ideas to the discussion of sustainable agriculture. Nevertheless, further study is necessary to confirm these preliminary findings, improve methods and provide guidance for the broad use of sterile lactation techniques in agriculture. When it comes to improving animal welfare and preserving good milk quality in the dairy business, sterile lactation is a potential progression.

Limitation: Another study is required to investigate the generalizability of sterilized lactation across different dairy farming contexts, since the study recognizes that its efficacy can differ depending on farm-specific characteristics.

Future Scope: To make this novel method even more effective in enhancing dairy herd health, future research should look at ways to optimize sterilized lactation practices, taking into account things like geographical variances, herd characteristics and technology improvements.

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