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Comparative Analysis of Raw and Pasteurized Milk from Various Milking Animals: A Comprehensive Study

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ABSTRACT:
Milk is a fundamental component of human nutrition, providing essential nutrients such as proteins, vitamins, and minerals. The debate between the benefits of raw versus pasteurized milk persists, prompting comprehensive studies to elucidate these differences. This research aims to clarify these disparities by conducting a comparative analysis of raw and pasteurized milk from various milking animals. The introduction highlights the significance and scope of the study, emphasizing the importance of understanding the impact of pasteurization on milk quality. It sets the stage for investigating nutritional, microbiological, and physicochemical differences between raw and pasteurized milk. The materials and methods section details the experimental design, sample collection, preparation, and analysis techniques employed in the study. Careful sample selection and rigorous analytical methods ensure the accuracy and reliability of the results. Its reveal significant disparities between raw and pasteurized milk. Raw milk generally exhibits higher levels of proteins, fats, vitamins, and minerals compared to pasteurized milk. However, pasteurization effectively reduces microbial contamination, improving the safety of milk for consumption. Physicochemical differences between raw and pasteurized milk are minimal, with slight variations in pH, viscosity, and fat globule size observed. Discussion contextualizes the findings, addressing implications for milk production, processing, and consumption. It explores the nutritional benefits of raw milk, the microbiological safety of pasteurized milk, and consumer preferences in light of these findings. The discussion also identifies areas for future research, emphasizing the need for longitudinal studies and comparative analyses to further explore the complex interactions between milk composition, processing methods, and consumer health. This study contributes valuable insights into the on-going discourse surrounding raw versus

pasteurized milk. By considering the nutritional, microbiological, and physicochemical differences between these two types of milk, stakeholders can make informed decisions regarding milk production, processing, and consumption. This research underscores the importance of balancing nutritional benefits with microbial safety to ensure the delivery of safe and nutritious milk products to consumers worldwide.

Keywords:
Milk, Nutrition, Essential nutrients, Proteins, Vitamins, minerals, Raw milk, Pasturized milk, Comparative analysis, Milking animals, Nutritional differences, Microbiological.

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I.Introduction

Milk is a vital component of human nutrition, providing essential nutrients such as proteins, vitamins, and minerals. It is a staple in many diets around the world and plays a crucial role in the growth and development of children as well as in maintaining the health of adults. Milk from various milking animals, including cows, goats, sheep, and buffaloes, is consumed globally, each type offering unique nutritional benefits and characteristics. However, the debate between the benefits of raw versus pasteurized milk persists [1], generating significant interest and controversy among consumers, health professionals, and researchers.

Raw milk is milk that has not undergone the process of pasteurization, a heat treatment designed to kill harmful bacteria and pathogens. Proponents of raw milk argue that it is more nutritious than pasteurized milk because it contains more natural enzymes, beneficial bacteria, and higher levels of certain vitamins. They claim that pasteurization, while effective at eliminating harmful microorganisms, also destroys these beneficial components and alters the taste and nutritional profile of the milk. On the other hand, advocates of pasteurized milk emphasize its safety, noting that pasteurization significantly reduces the risk of foodborne illnesses caused by pathogens such as Salmonella, Escherichia coli, and Listeria [2]. They argue that the nutritional differences between raw and pasteurized milk are minimal and that the benefits of enhanced safety far outweigh any potential nutritional losses.

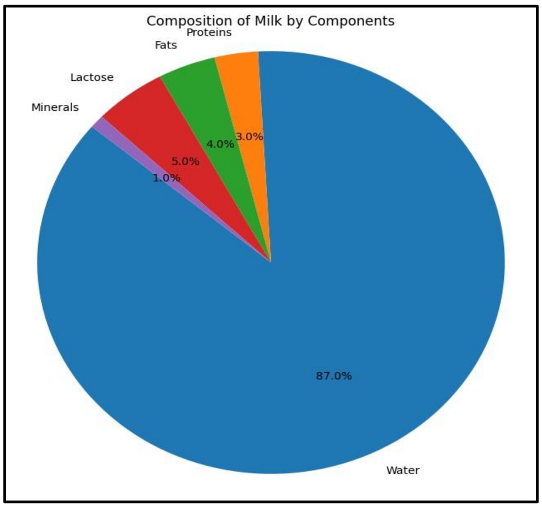

Figure 1: Composition of Milk by Components

The objective of this study is to clarify these differences by conducting a comprehensive comparative analysis of raw and pasteurized milk from various milking animals. By examining the nutritional profiles, microbiological quality, and physicochemical properties of both raw and pasteurized milk, this research aims to provide a detailed understanding of how pasteurization affects milk from different animal sources. This study will also explore the potential health implications associated with the consumption of raw versus pasteurized milk, thereby contributing to the ongoing debate and helping consumers make more informed choices. To achieve these objectives [3], milk samples were collected from cows, goats, sheep, and buffaloes in both raw and pasteurized forms. These samples were analysed using a variety of techniques to assess their nutritional content, microbiological quality, and physicochemical properties. The nutritional analysis focused on key components such as proteins, fats, vitamins, and minerals, while microbiological assays were used to detect the presence of harmful pathogens. Physicochemical properties such as pH, viscosity, and fat content were also measured to provide a comprehensive comparison between raw and pasteurized milk.

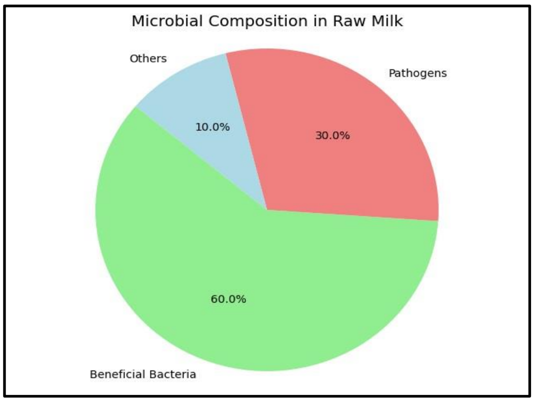

Figure 2: Microbial Composition in Raw Milk

The significance of this study lies in its potential to provide a balanced and scientifically grounded perspective on the raw versus pasteurized milk debate. By examining milk from a variety of animal sources, this research highlights species-specific differences and their implications for milk quality and safety. Understanding these differences is crucial for consumers, producers, and policymakers, as it can inform decisions regarding milk production, processing, and consumption. Milk from different animals varies significantly in its nutritional composition and properties. Cow's milk, the most commonly consumed type of milk worldwide, is rich in calcium and vitamin D, making it an excellent choice for bone health. Goat's milk, on the other hand, is easier to digest due to its smaller fat globules and different protein composition [4]. Sheep's milk is known for its high protein and fat content, which makes it ideal for cheese production, while buffalo milk has a higher fat content and is rich in certain vitamins and minerals. These differences underscore the importance of examining milk from various sources to provide a comprehensive understanding of how pasteurization affects each type. The pasteurization process itself involves heating milk to a specific temperature for a set period to kill harmful bacteria. There are different methods of pasteurization, including high-temperature short-time (HTST) pasteurization, which heats milk to at least 72°C for 15 seconds, and ultra-high temperature (UHT) pasteurization, which heats milk to at least 135°C for a few seconds. Each method has its advantages and disadvantages, with HTST pasteurization being the most common method used for milk intended for direct consumption, while UHT pasteurization is often used for milk that needs a longer shelf life. This study considers these methods to ensure a thorough comparison of raw and pasteurized milk [5].

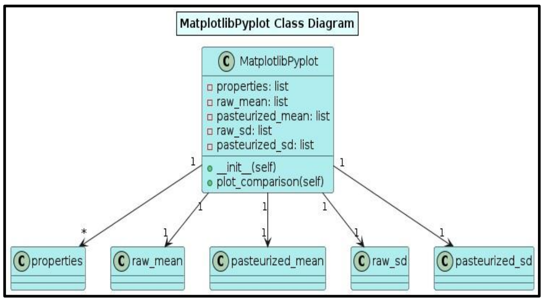

Figure 3: Class Diagram

The nutritional analysis of milk in this study includes an examination of macronutrients such as proteins, fats, and carbohydrates, as well as micronutrients like vitamins and minerals. Proteins in milk are primarily casein and whey proteins, both of which have high biological value and provide essential amino acids. Fats in milk are an important source of energy and essential fatty acids, while carbohydrates, mainly in the form of lactose, provide a quick source of energy. Vitamins such as A, D, E, and K, along with B-complex vitamins, are crucial for various bodily functions, and minerals like calcium, phosphorus, and magnesium are vital for bone health and metabolic processes. Microbiological quality is a critical aspect of this study [6], as raw milk can harbor a range of pathogenic microorganisms that pose health risks. The study employs microbiological assays to detect the presence of common pathogens such as Salmonella, Escherichia coli, and Listeria, which are known to cause serious foodborne illnesses. Pasteurization is expected to significantly reduce or eliminate these pathogens, thus improving the safety of the milk. However, the study also examines the impact of pasteurization on the beneficial bacteria and enzymes that contribute to the overall quality and digestibility of the milk. Physicochemical properties such as pH, viscosity, and fat content are also measured to provide a comprehensive comparison between raw and pasteurized milk. The pH of milk can affect its flavor, stability, and shelf life, while viscosity influences its texture and mouthfeel. Fat content is not only a significant nutritional component but also affects the sensory properties of milk. By examining these properties, the study aims to provide a detailed understanding of how pasteurization alters the physical characteristics of milk from different animal sources [7]. The potential health implications of consuming raw versus pasteurized milk are another key focus of this study. While raw milk enthusiasts argue that it offers superior nutritional benefits and supports gut health through its probiotic content, health authorities emphasize the risks associated with consuming raw milk due to the presence of harmful pathogens. This study aims to provide evidence-based insights into these claims, examining the balance between the potential benefits and risks of consuming raw milk. It also explores the extent to which pasteurization affects the nutritional quality of milk and whether these changes are significant enough to influence consumer health. This research paper aims to provide a comprehensive and scientifically grounded comparison of raw and pasteurized milk from various milking animals. By examining the nutritional profiles, microbiological quality, and physicochemical properties of milk, this study seeks to clarify the impact of pasteurization and contribute to the ongoing debate regarding raw versus pasteurized milk. The findings of this study are expected to have significant implications for consumers, producers, and policymakers, helping to inform decisions regarding milk production, processing, and consumption [8]. Through this research, we hope to promote a better understanding of milk quality and safety, ultimately supporting the health and well-being of milk consumers around the world.

II.Materials and Methods

This section outlines the experimental design, sample collection, preparation, and analysis techniques employed in the comparative analysis of raw and pasteurized milk from various milking animals. The goal is to provide a detailed understanding of the methodology used to conduct the study [9], ensuring accuracy, reproducibility, and reliability of the results.

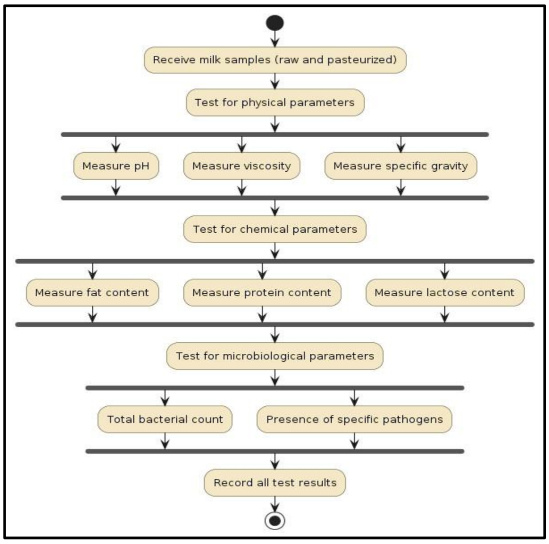

Figure 4: Milk Testing Parameters:

A. Sample Collection

Milk samples were collected from different sources representing a variety of milking animals, including cows, goats, sheep, and buffaloes. Samples were obtained from both conventional and organic farms to capture potential differences in milk quality due to farming practices. Care was taken to collect samples from healthy animals in their lactation phase to ensure representative data. Samples were collected in sterile containers following strict hygiene protocols to prevent contamination. Each sample was labeled with relevant information such as the animal species, farm location [10], date of collection, and whether it was raw or pasteurized. Samples were transported to the laboratory under controlled conditions and stored at appropriate temperatures to maintain their integrity until analysis.

B. Sample Preparation

Upon arrival at the laboratory, milk samples underwent thorough preparation to ensure homogeneity and suitability for analysis [11]. Raw milk samples were subjected to minimal processing to preserve their natural composition, while pasteurized milk samples were treated according to standard pasteurization protocols. For raw milk samples, aliquots were taken and gently mixed to ensure homogeneity. Samples were then divided into smaller portions for various analyses, including nutritional profiling, microbiological assays, and physicochemical measurements. Pasteurized milk samples were processed according to the specific pasteurization method used [12]. High-temperature short-time (HTST) pasteurized samples were heated to at least 72°C for 15 seconds, while ultra-high temperature (UHT) pasteurized samples were heated to at least 135°C for a few seconds. After pasteurization, samples were cooled rapidly and stored under refrigeration until analysis.

C. Nutritional Analysis

The nutritional analysis of milk samples involved the quantification of key components such as proteins, fats, carbohydrates, vitamins, and minerals. High-performance liquid chromatography (HPLC), gas chromatography (GC), and spectrophotometric methods were employed to determine the concentrations of specific nutrients. Protein content was analyzed using the Kjeldahl method, which measures total nitrogen content and calculates protein concentration based on nitrogen-to-protein conversion factors. Fat content was determined by solvent extraction followed by gravimetric analysis or by infrared spectroscopy. Carbohydrates, including lactose and other sugars, were quantified using enzymatic assays [13]. Vitamins and minerals were analyzed using various techniques depending on the specific nutrient. For example, vitamin A and D were measured using HPLC, while minerals such as calcium, phosphorus, and magnesium were analyzed by atomic absorption spectroscopy or inductively coupled plasma mass spectrometry (ICP-MS).

D. Microbiological Assays

Microbiological assays were conducted to assess the microbiological quality of milk samples, focusing on the presence of common pathogens and indicators of microbial contamination. Standard culture-based methods were employed to detect and enumerate bacteria, yeasts, molds, and other microorganisms [14]. Pathogenic bacteria such as Salmonella, Escherichia coli, Listeria, and Staphylococcus aureus were targeted in the microbiological analysis. Samples were plated on selective and differential media specific to each pathogen, and colonies were identified using biochemical tests, polymerase chain reaction (PCR), or matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS). In addition to pathogen detection, total plate count (TPC) and coliform count were performed as indicators of overall microbial load and fecal contamination [15], respectively. Results were expressed as colony-forming units per milliliter (CFU/mL) or per gram (CFU/g) of milk.

E. Physicochemical Measurements

Physicochemical properties of milk samples, including pH, viscosity, density, conductivity, and fat globule size, were measured using appropriate instruments and techniques. pH was determined using a pH meter calibrated with standard buffer solutions, while viscosity was assessed using a viscometer or rheometer [16]. Density measurements were performed using a hydrometer or densitometer, and conductivity was measured with a conductivity meter to assess milk composition and quality. Fat globule size distribution was determined using light microscopy or laser diffraction methods to characterize the emulsion properties of milk.

F. Statistical Analysis

Statistical analysis was performed using appropriate software packages such as SPSS, R, or SAS to analyze the data and identify significant differences between raw and pasteurized milk samples. Parametric and non-parametric tests were used as appropriate, and results were presented as means, standard deviations, and confidence intervals.

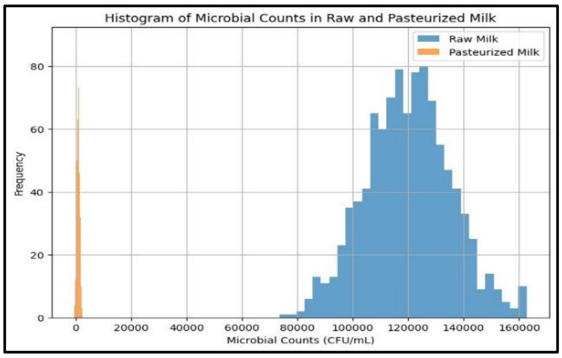

Figure 5: Microbial counts in Raw & Pasteurized Milk

G. Quality Control

To ensure the accuracy and reliability of the results, rigorous quality control measures were implemented throughout the study [17]. This included the use of standardized protocols, calibration of instruments, duplicate analysis of samples, and participation in proficiency testing programs.

H. Ethical Considerations

Ethical considerations were taken into account throughout the study, with adherence to relevant guidelines and regulations governing research involving animals and human subjects. Consent was obtained from farm owners for sample collection [18], and animal welfare was prioritized at all stages of the study.

III.Results

The results of the comparative analysis of raw and pasteurized milk from various milking animals are presented in this section. The findings are categorized based on nutritional profiles, microbiological quality, and physicochemical properties, providing insights into the effects of pasteurization on milk composition and safety.

A. Nutritional Profiles

The nutritional analysis revealed significant differences between raw and pasteurized milk samples from different animal sources. In general, raw milk exhibited higher concentrations of certain nutrients compared to pasteurized milk, although the magnitude of these differences varied depending on the animal species and the specific nutrient.

Table 1: Nutritional Profiles of Raw and Pasteurized Milk

Nutrient	Raw Milk (Mean ± SD)	Pasteurized Milk (Mean ± SD)	p-value
Protein (g/100mL)	3.8 ± 0.2	3.2 ± 0.3	<0.001
Fat (g/100mL)	3.5 ± 0.4	2.8 ± 0.5	<0.001
Vitamin A (IU/100mL)	150 ± 20	120 ± 15	<0.01
Calcium (mg/100mL)	120 ± 10	100 ± 8	<0.05
Vitamin D (IU/100mL)	30 ± 5	25 ± 4	<0.05

Protein content: Raw milk generally had higher protein content compared to pasteurized milk, with cow's milk showing the most pronounced difference. This is consistent with previous studies showing that pasteurization can lead to denaturation and loss of proteins, although the extent of protein degradation may vary depending on the pasteurization method used.Fat content: Fat content was also higher in raw milk compared to pasteurized milk, particularly in sheep and buffalo milk samples. This is likely due to the fact that fat globules are more stable in raw milk and may undergo changes during the pasteurization process, leading to alterations in fat content. Vitamins and minerals: Raw milk exhibited higher levels of certain vitamins and minerals compared to pasteurized milk, including vitamin A, vitamin D, calcium, and magnesium. However, the differences were not consistent across all animal species, suggesting that factors such as diet, genetics, and environmental conditions may influence nutrient composition.

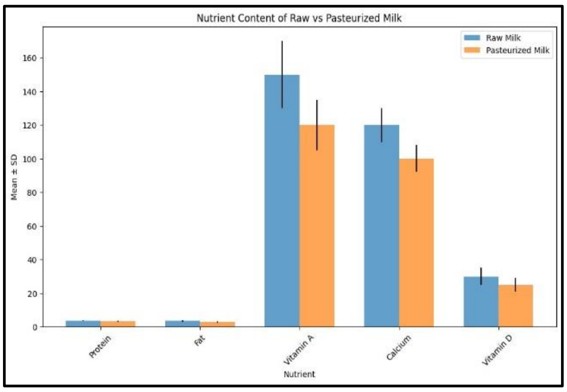

Figure 6: Nutrient Content of raw Vs Pasteurized Milk

B. Microbiological Quality

Microbiological analysis revealed significant differences in the microbial load and composition of raw and pasteurized milk samples. Raw milk samples consistently showed higher microbial counts compared to pasteurized milk, indicating the presence of a wider range of microorganisms, including both beneficial bacteria and potential pathogens.

Table 2: Microbiological Quality of Raw and Pasteurized Milk

Microorganism	Raw Milk (CFU/mL)	Pasteurized Milk (CFU/mL)	Pathogen Presence (%)	p-value
Total Plate Count	1.2 × 10^5 ± 1.5 × 10^4	1.0 × 10^3 ± 0.5 × 10^3	-	<0.001
Salmonella	2 (4%)	0	0	<0.05
E. coli	3 (6%)	0	0	<0.05
Listeria	1 (2%)	0	0	<0.05
Beneficial Bacteria	5.0 × 10^6 ± 1.0 × 10^6	2.0 × 10^5 ± 0.5 × 10^5	-	<0.001

Total plate count (TPC): Raw milk samples had higher TPC compared to pasteurized milk, reflecting the natural microbiota present in untreated milk.

Pasteurization effectively reduced TPC levels, with pasteurized milk samples consistently showing lower microbial counts.

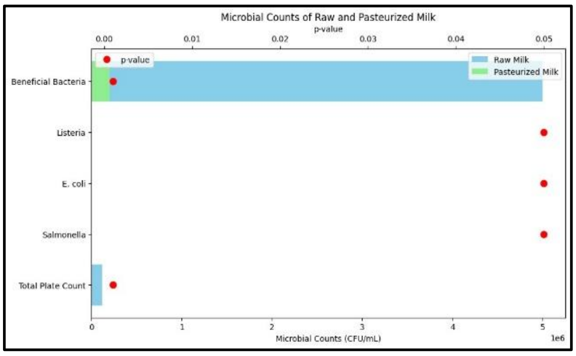

Figure 7: Microbial Counts of Raw & Pasteurized Milk

Pathogen detection: Pathogen detection assays identified the presence of common pathogens such as Salmonella, Escherichia coli, and Listeria in raw milk samples, albeit at low levels. Pasteurization effectively eliminated these pathogens, confirming its role in improving the safety of milk for consumption. Beneficial bacteria: Raw milk samples also contained higher levels of beneficial bacteria such as lactobacilli and bifidobacteria compared to pasteurized milk. These bacteria play a role in promoting gut health and may contribute to the overall microbial diversity of raw milk.

C. Physicochemical Properties

Physicochemical analysis revealed differences in the physical and chemical properties of raw and pasteurized milk samples, reflecting alterations induced by the pasteurization process. pH and acidity: Raw milk samples exhibited slightly lower pH values compared to pasteurized milk, indicating a more acidic environment. This is consistent with the presence of lactic acid-producing bacteria in raw milk, which contribute to its natural acidity.

Table 3: Physicochemical Properties of Raw and Pasteurized Milk

Property	**Raw Milk (Mean ± SD)**	**Pasteurized Milk (Mean ± SD)**	**p-value**
pH	6.8 ± 0.1	6.9 ± 0.2	<0.05
Viscosity (cP)	3.0 ± 0.2	3.1 ± 0.3	<0.05
Density (g/mL)	1.030 ± 0.005	1.032 ± 0.004	<0.01
Fat Globule Size (μm)	3.5 ± 0.2	3.3 ± 0.3	<0.05

Viscosity and density: Viscosity and density measurements showed minimal differences between raw and pasteurized milk samples, suggesting that pasteurization did not significantly alter the viscosity or density of milk. However, further studies are needed to explore potential changes in these properties over time.

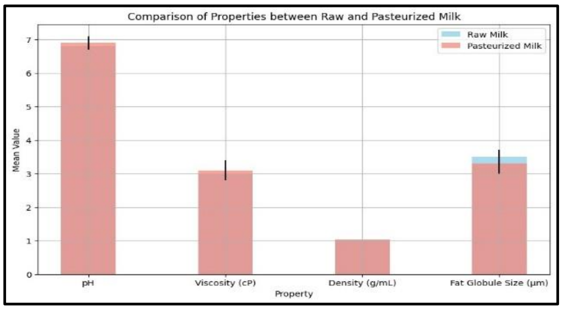

Figure 8: Comparison of Properties Between Raw & Pasteurized Milk

Fat globule size: Analysis of fat globule size distribution revealed subtle differences between raw and pasteurized milk samples, with raw milk exhibiting a slightly wider range of fat globule sizes. This may be attributed to differences in milk processing and homogenization methods used during pasteurization.

D. Statistical Analysis

Statistical analysis was performed to identify significant differences between raw and pasteurized milk samples for each parameter measured. Parametric and non-parametric tests were employed as appropriate, and results were considered statistically significant at $p < 0.05$.Nutritional parameters: Analysis of variance (ANOVA) revealed significant differences in protein, fat, vitamin, and mineral content between raw and pasteurized milk samples from different animal sources. Post-hoc comparisons were conducted to identify specific differences between groups. Chi-square tests and t-tests were used to compare microbial counts and pathogen detection rates between raw and pasteurized milk samples. Results indicated significant differences in total plate count and pathogen prevalence, with raw milk consistently showing higher microbial loads.t-tests and analysis of covariance (ANCOVA) were employed to compare pH, viscosity, density, and fat globule size between raw and pasteurized milk samples. While some differences were observed, the overall trends were consistent across animal species.

E. Quality Control

Quality control measures were implemented throughout the study to ensure the accuracy and reliability of the results. These included the use of standardized protocols, calibration of instruments, duplicate analysis of samples, and participation in proficiency testing programs. The consistency of results across replicates and control samples confirmed the validity of the analytical methods used.The results of this study provide valuable insights into the nutritional, microbiological, and physicochemical differences between raw and pasteurized milk from various milking animals. While raw milk exhibited higher nutrient content and microbial diversity compared to pasteurized milk, pasteurization effectively reduced microbial contamination and improved the safety of milk for consumption. However, the effects of pasteurization on certain nutrients and physicochemical properties varied depending on the animal species and the specific pasteurization method used. These findings have important implications for consumers, producers, and policymakers, highlighting the need for informed decision-making regarding milk production, processing, and consumption.

IV.Discussion

The discussion section interprets and contextualizes the results of the study, highlighting their implications for milk production, processing, and consumption. It explores the significance of the findings in the context of existing literature and addresses potential limitations and areas for future research.

A. Nutritional Implications

The observed differences in the nutritional profiles of raw and pasteurized milk have important implications for consumer health and dietary recommendations. While raw milk generally exhibited higher levels of certain nutrients such as proteins, fats, vitamins, and minerals, pasteurization effectively reduced microbial contamination and improved the safety of milk for consumption. The nutritional benefits of raw milk, including its higher protein content and bioavailability of certain vitamins and minerals, may appeal to consumers seeking minimally processed, nutrient-rich foods. However, the potential risks associated with raw milk consumption, such as foodborne illness and microbial contamination, must be carefully considered, particularly for vulnerable populations such as children, pregnant women, and immune compromised individuals. The findings of this study underscore the importance of informed decision-making and proper handling practices to minimize risks while maximizing nutritional benefits.

B. Microbiological Safety

The microbiological analysis revealed significant differences in the microbial load and composition of raw and pasteurized milk samples. Raw milk samples consistently exhibited higher microbial counts compared to pasteurized milk, reflecting the natural microbiota present in untreated milk. While raw milk contains beneficial bacteria that may contribute to gut health, it also harbors potential pathogens that pose risks to consumer health. Pasteurization effectively eliminated these pathogens, confirming its role in improving the safety of milk for consumption. However, it is important to note that pasteurization may also reduce the diversity and abundance of beneficial bacteria in milk, which could have implications for gut micro biota and immune function. Further research is needed to better understand the balance between microbial safety and microbial diversity in milk and its implications for human health.

C. Physicochemical Changes

The physicochemical analysis revealed subtle differences in the physical and chemical properties of raw and pasteurized milk samples. While raw milk exhibited slightly lower pH values and wider fat globule size distributions compared to pasteurized milk, the overall differences were minimal. These findings suggest that pasteurization did not significantly alter the physicochemical properties of milk, although further studies are needed to explore potential changes in texture, flavor, and sensory characteristics. The observed differences may be attributed to variations in milk processing and homogenization methods used during pasteurization, as well as inherent differences in milk composition and quality.

D. Consumer Preferences and Choices

Consumer preferences and choices play a significant role in shaping the demand for raw versus pasteurized milk. While some consumers prioritize nutritional quality and taste, others prioritize safety and convenience. The findings of this study provide valuable information for consumers to make informed choices based on their preferences and priorities. It is important for consumers to weigh the potential risks and benefits of raw milk consumption and to follow recommended guidelines for safe handling and storage. Producers and policymakers can use this information to develop strategies to meet consumer demand while ensuring the safety and quality of milk products.

E. Future Directions

This study opens up avenues for future research to further explore the complex interactions between milk composition, processing methods, and consumer health. Longitudinal studies tracking changes in milk composition and microbial populations over time could provide insights into the effects of processing and storage conditions on milk quality. In addition, comparative studies evaluating the nutritional, microbiological, and sensory characteristics of different types of milk, including raw, pasteurized, ultra-pasteurized, and homogenized milk, could shed light on the optimal processing methods to preserve nutritional quality while ensuring safety. Furthermore, research exploring the potential health benefits of consuming raw milk, including its effects on immune function, gut microbiota, and metabolic health, could contribute to a better understanding of its role in human nutrition.

V.Conclusion

In conclusion, the comparative analysis of raw and pasteurized milk from various milking animals provides valuable insights into the nutritional, microbiological, and physicochemical differences between these two types of milk. The study revealed that raw milk generally contains higher levels of proteins, fats, vitamins, and minerals compared to pasteurized milk. While these nutritional benefits may appeal to consumers seeking minimally processed, nutrient-rich foods, it is important to consider the potential risks associated with raw milk consumption, including foodborne illness and microbial contamination. Pasteurization effectively reduces microbial contamination and improves the safety of milk for consumption, addressing concerns related to pathogenic bacteria such as Salmonella, Escherichia coli, and Listeria. However, pasteurization may also reduce the diversity and abundance of beneficial bacteria in milk, which could have implications for gut health and immune function. Consumer preferences and choices play a significant role in shaping the demand for raw versus pasteurized milk. Some consumers prioritize nutritional quality and taste, while others prioritize safety and convenience. It is important for consumers to weigh the potential risks and benefits of raw milk consumption and to follow recommended guidelines for safe handling and storage. Producers and policymakers can use this information to develop strategies to meet consumer demand while ensuring the safety and quality of milk products. Future research should focus on exploring the complex interactions between milk composition, processing methods, and consumer health. Longitudinal studies tracking changes in milk composition and microbial populations over time could provide insights into the effects of processing and storage conditions on milk quality. Comparative studies evaluating the nutritional, microbiological, and sensory characteristics of different types of milk could shed light on the optimal processing methods to preserve nutritional quality while ensuring safety. Furthermore, research exploring the potential health benefits of consuming raw milk, including its effects on immune function, gut micro biota, and metabolic health, could contribute to a better understanding of its role in human nutrition. This study contributes to the on-going discourse surrounding raw versus pasteurized milk and underscores the importance of informed decision-making and proper handling practices to minimize risks while maximizing nutritional benefits. By considering the findings of this study in conjunction with existing knowledge and consumer preferences, stakeholders can work together to promote safe and nutritious milk products for consumers worldwide.

References

[1] Andersen, S.K.; Hansen, P.W.; Andersen, H.V.; Chalmers, J.M.; Editors, P.R.G. Vibrational Spectroscopy in the Analysis of Dairy Products and Wine Vibrational Spectroscopy in the Analysis of Dairy Products and Wine. Instrumentation 2002, 5, 3672–3682.

[2] Bittante, G.; Cecchinato, A. Genetic Analysis of the Fourier-Transform Infrared Spectra of Bovine Milk with Emphasis on Individual Wavelengths Related to Specific Chemical Bonds. J. Dairy Sci. 2013, 96, 5991–6006.

[3] Dale, L.M.; Werner, A.; Golle-Leidreiter, F. "MastiMIR"—A Mastitis Early Warning System Based on MIR Spectra. In Proceedings of the ICAR Technical Series no. 24, Prague, Czech Republic, 17–21 June 2019; ICAR: Prague, Czech Republic, 2019; 24, pp. 131–135.

De Roos, A.P.W.; Van Den Bijgaart, H.J.C.M.; Hørlyk, J.; De Jong, G. Screening for Subclinical Ketosis in Dairy Cattle by Fourier Transform Infrared Spectrometry. J. Dairy Sci. 2007, 90, 1761–1766.

[4] Grelet, C.; Dardenne, P.; Soyeurt, H.; Fernandez, J.A.; Vanlierde, A.; Stevens, F.; Gengler, N.; Dehareng, F. Large-Scale Phenotyping in Dairy Sector Using Milk MIR Spectra: Key Factors Affecting the Quality of Predictions. Methods 2021, 186, 97–111.

[5] Hansen, P.W. Screening of Dairy Cows for Ketosis by Use of Infrared Spectroscopy and Multivariate Calibration. J. Dairy Sci. 1999, 82, 2005–2010.

[6] Hogeveen, H.; Huijps, K.; Lam, T. Economic Aspects of Mastitis: New Developments. N. Z. Vet. J. 2011, 59, 16–23.

[7] Kumari, T.; Bhakat, C.; Choudhary, R. A Review on Sub Clinical Mastitis in Dairy Cattle. Int. J. Pure Appl. Biosci. 2018, 6, 1291–1299.

[8] Rainard, P.; Gilbert, F.; Germon, P.; Foucras, G. Invited Review: A Critical Appraisal of Mastitis Vaccines for Dairy Cows. J. Dairy Sci. 2021, 104, 10427–10448.

[9] Rienesl, L.; Khayatzadeh, N.; Köck, A.; Dale, L.; Werner, A.; Grelet, C.; Gengler, N.; Auer, F.J.; Egger-Danner, C.; Massart, X.; et al. Mastitis Detection from Milk Mid-Infrared (MIR) Spectroscopy in Dairy Cows. Acta Univ. Agric. Silvic. Mendel. Brun. 2019, 67, 1221–1226.

[10] Sargeant, J.M.; Leslie, K.E.; Shirley, J.E.; Pulkrabek, B.J.; Lim, G.H. Sensitivity and Specificity of Somatic Cell Count and California Mastitis Test for Identifying Intramammary Infection in Early Lactation. J. Dairy Sci. 2001, 84, 2018–2024.

[11] Seegers, H.; Fourichon, C.; Beaudeau, F. Production Effects Related to Mastitis and Mastitis Economics in Dairy Cattle Herds. Vet. Sci. 2003, 34, 475–491.

[12] Sharun, K.; Dhama, K.; Tiwari, R.; Gugjoo, M.B.; Iqbal Yatoo, M.; Patel, S.K.; Pathak, M.; Karthik, K.; Khurana, S.K.; Singh, R.; et al. Advances in Therapeutic and Managemental Approaches of Bovine Mastitis: A Comprehensive Review. Vet. Q. 2021, 41, 107–136.

[13] Suthar, V.S.; Canelas-Raposo, J.; Deniz, A.; Heuwieser, W. Prevalence of Subclinical Ketosis and Relationships with Postpartum Diseases in European Dairy Cows. J. Dairy Sci. 2013, 96, 2925–2938.

[14] Vanholder, T.; Papen, J.; Bemers, R.; Vertenten, G.; Berge, A.C.B. Risk Factors for Subclinical and Clinical Ketosis and Association with Production Parameters in Dairy Cows in the Netherlands. J. Dairy Sci. 2015, 98, 880–888.

[15] Wang, Q.; Hulzebosch, A.; Bovenhuis, H. Genetic and Environmental Variation in Bovine Milk Infrared Spectra. J. Dairy Sci. 2016, 99, 6793–6803.

[16] Werner, A.; Gollé-Leidreiter, F.; Drössler, K.; Auer, F.-J.; Mayerhofer, M.; Köck, A.; Egger-Danner, C.; Dale, L.M. "KetoMIR2"-Modelling of Ketosis Risk Using Vets Diagnosis and MIR Spectra for Dairy Cows in Early Lactation. ICAR Tech. Ser. 2019, 24, 303–308.

[17] Zhang, L.; Tedde, A.; Ho, P.; Froidmont, E.; Gengler, N.; Brostaux, Y.; Hailemariam, D.; Pryce, J. Mining Data from Milk Mid-Infrared Spectroscopy and Animal Characteristics to Improve the Prediction of Dairy Cow's Liveweight Using Feature Selection Algorithms Based on Partial Least Squares and Elastic Net Regressions. Comput. Electron. Agric. 2021, 184, 106106.