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Effects of Different Seasons on Milk Quality: A Study on Two Cattle Breeds in Rainy and Drought Contexts

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ABSTRACT

The primary focus of dairy farming in the central region of Peru centers on producers. However, there is limited information on how different altitudinal zones, particularly during rainy and dry seasons, affect milk production. The present study aimed to investigate the effects of the rainy and dry seasons on the physicochemical properties of milk from Brown Swiss and Holstein cattle. A total of sixty cows were selected for the study, comprising 30 Brown Swiss and 30 Holstein. The study was conducted across two distinct seasons, including rainy and dry seasons. All animals received the same semi-intensive management and were fed ryegrass and balanced feed. Each animal provided 500 ml of milk for analysis in the morning. The milk was transported at a temperature of 2 °C, where they were analyzed with the Lactoscan equipment to evaluate protein, lactose, fat, total solids, milk density, freezing point, salts, and pH. Significant differences were observed in the interaction between Brown Swiss and Holstein breeds across different seasons, including rainy and dry periods. Significant differences were observed in protein content, showing a positive effect in the interaction "rain: Brown" a value of 3.50 ± 0.36, while "rain: Holstein" showed 3.14 ± 0.05. Statistical differences were observed in the interactions for lactose content, with rain: Brown at 4.82% and dry: Holstein at 4.37%. Similarly, there were significant differences in fat content and total solids for rain interaction of rain: Holsten, and dry: Brown. Nevertheless, no differences were observed in terms of milk density, freezing point, salts, and pH. It is concluded that there was an influence of the interaction between breed physiology and seasonal conditions on milk composition. The results also highlight the impact of season-specific environmental factors on the quality of milk.

Keywords: Breed comparison, Milk composition, Milk quality, Physiological stability

INTRODUCTION

Climate affects the growth and quality of forage and feed crops. Droughts, floods, and extreme weather events can reduce the availability of high-quality feed, leading to lower milk production and altered milk composition. Dairy production holds a prominent position in global agribusiness, as it plays a crucial role in supplying essential nutrients for human nutrition (Britt et al., 2018; Godfrey et al., 2019), while also contributing to employment and income generation in numerous countries (Loos and Zeller, 2014; Garcia-Olarte et al., 2024a). Milk, as a cornerstone of the economic sector, is highly valued for its nutritional richness, providing essential nutrients crucial for growth, particularly during infancy, and supporting overall health (Barłowska et al., 2011).

Ensuring food quality is paramount to guaranteeing food safety and safeguarding human health, while also maintaining the nutritional integrity of the food supply (Sachs, 2012; Hernandez et al., 2019; Kamboj et al., 2020). However, many producers lack the means to access or evaluate the nutritional or chemical composition of milk, especially in rural areas where production methods may be rudimentary and resources limited (Anstalt, 2013).

The physicochemical composition of milk represents critical variables in assessing its quality (Rodriguez et al., 2015; Guajardo et al., 2020; Garcia-Olarte et al., 2024b). Milk is a complex mixture of proteins, carbohydrates, fats, minerals, vitamins, and other constituents (Fox, 2008; Guetouache et al., 2014). Among various types of milk, cow's milk remains predominant (Vanga and Raghavan, 2018), with all milk varieties generally sharing identical constituents, albeit in different concentrations, basic nutritional elements, such as protein, fats, and minerals in all types of milk, the specific amounts of these components can differ significantly depending on the source and processing methods and especially the season (Ceballos et al., 2009). The chemical composition of specific elements and minerals commonly found in milk is of significant importance due to their absorption in the gut and subsequent biological utilization, these

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components play essential roles in maintaining health, growth, and energy supply for consumers, including transport, assimilation into cells, and conversion into biologically systemic forms (Zamberlin et al., 2012).

In Peru, while there are existing reports on the physicochemical properties of milk (Vilca and Oyarce, 2022), misinformation persists due to the diverse altitudinal zones, varied feeding practices, and differing temperature and humidity conditions across regions. It is noteworthy that the majority of producers in the central region of Peru primarily focus on cattle milk production (Wuletaw et al., 2011). However, there is lack of information on how altitudinal zones, particularly during rainy and dry seasons, impact milk production. This knowledge gap is significant given Peru's mega-diverse environment characterized by highly variable climates. Recent studies emphasize the significant impact of climate, particularly the rainy and dry seasons, on milk production and composition in dairy cows (Narmilan et al., 2021). Seasonal heat stress leads to reduced milk production, primarily due to decreased feed intake and altered metabolic processes (Wankar et al., 2021). Typically, milk production is higher during the cooler months. Additionally, genetic selection for heat-tolerant traits can enhance resistance to seasonal stress (Moore et al., 2023). Understanding the influence of seasons and breeds is crucial for optimizing milk production and improving the quality of dairy products. Therefore, the present study aimed to investigate the effects of the rainy and dry seasons on the physicochemical properties of milk from Brown Swiss and Holstein cattle in the central highlands of Peru.

MATERIALS AND METHODS

Ethical approval

Explicit approval for the research procedures was granted under the official sanction of letter Nº 006-GRJ-DRA-AAC-PERÚ-2023, dated September 25, 2023. Furthermore, the execution of all research protocols was conducted with due diligence and in full compliance with the explicit permission and authorization obtained from the pertinent overseeing authorities. The research was conducted in strict accordance with both international and national guidelines governing the ethical care and utilization of research animals.

Study area

The studies were conducted at the Mantaro Experimental Station, located in the Mantaro District, Jauja Province, in the Junín region of Peru (Figure 1). The station is located at an elevation of 3320 meters above sea level, with an average temperature ranging from 4°C to 8°C and an average precipitation of 749 mm (Senamhi, 2023). The research was carried out over two distinct periods of the year, namely the rainy season (April-June) and the dry season (July-September, 2023).

The Mantaro Experimental Station serves as a pivotal research site due to its strategic location within the Junín region, offering insights into the ecological dynamics and agricultural practices pertinent to the area. The station's altitude, coupled with its unique climatic conditions characterized by relatively low temperatures and moderate precipitation, makes it an ideal setting for studying the effects of seasonal variations on agricultural productivity and ecosystem functioning.

Animal and study design

Samples of milk (n = 60) were collected from 60 female cattle, comprising 30 Brown Swiss and 30 Holstein cows aged 6 years, all animals were from their fourth calving (Figure 2b). The animals were divided into two groups, including 15 for the rainy season and 15 for the dry season, for both breeds. Milk samples (500 ml) were collected once at 6:00 a.m. (Figure 2c). The animals were grazed on alfalfa (Figure 2a) and supplemented with commercial feed (Corina, Peru), which contained 14 % CP and 2.7 Mcal. Provided twice daily, in the morning before and evening after grazing. The feed was assessed at the Laboratory of Animal Nutrition of the Facultad de Zootecnia at the Universidad Nacional del Centro del, Perú. The physicochemical characteristics of the milk were evaluated with the Lactoscan (Figure 2e), which uses ultrasound methodology to determine temperature, fat content, density, fat solids, protein content, freezing point, salts, total solids, lactose, and pH (Figure 2f).

Data collection

For the laboratory analysis of milk samples, the following milk sample collected, an aliquot of approximately 120ml was obtained using a sample holder for its corresponding analysis in the Lactoscan Model SP of Peru (Figure 2e). Before operating and running the samples with the lactoscan equipment, calibration, and configuration were carried out using cow milk samples considered as standards (Alinezhad et al., 2024). This operation was performed in triplicate to enhance the reliability and accuracy of the results. Once the equipment was calibrated and standardized, the physical-chemical analysis of the samples was conducted, and the results and readings were visualized on a personal computer. It is worth mentioning that the parameters and standards for milk collection were followed (Bardales et al., 2024). Sampling was carried out both in the morning and in the afternoon, depending on the milking and milk storage schedule, the distance from the livestock facilities, as well as the time of samples collection in the field. To analyze each milk sample values, such as fat, non-fat solids, density, lactose, protein, pH, total solids, freezing point, and salts were considered.

Statistical analysis

The analyzed data were recorded and organized in Microsoft Excel. Seasonal (rain and dry season) differences were performed using analysis of variance (ANOVA). A comparison test was then performed. Values of $p < 0.05$ were considered significant and all statistical analyses were performed using CRAN R software (Team et al., 2018).

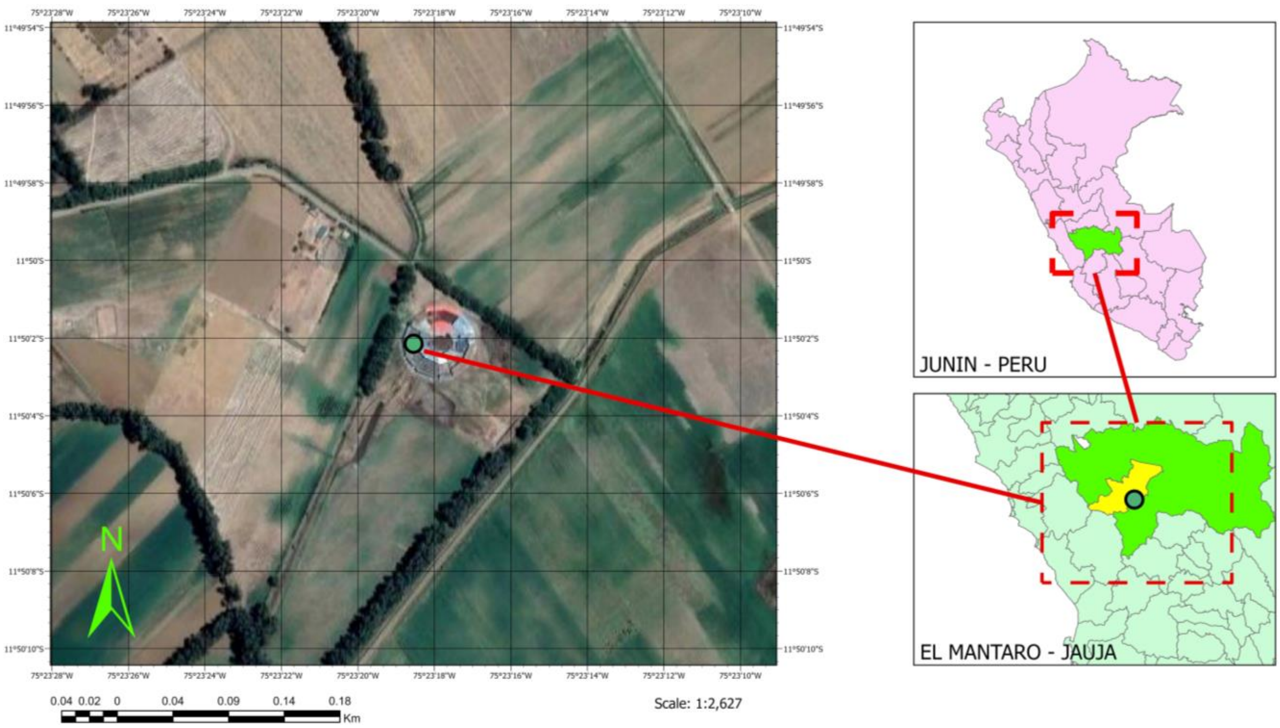


Figure 1. Location of study in Peru, specifically in the Junín region and within Junín, the research focused on El Mantaro, located in the province of Jauja

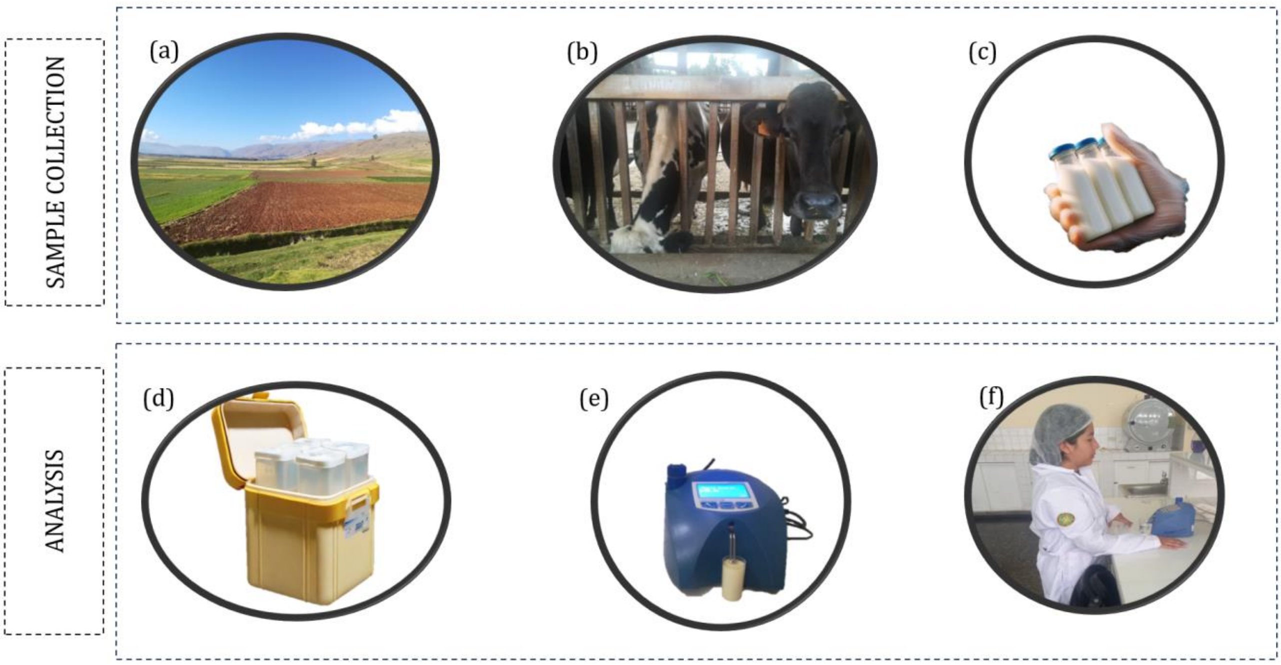
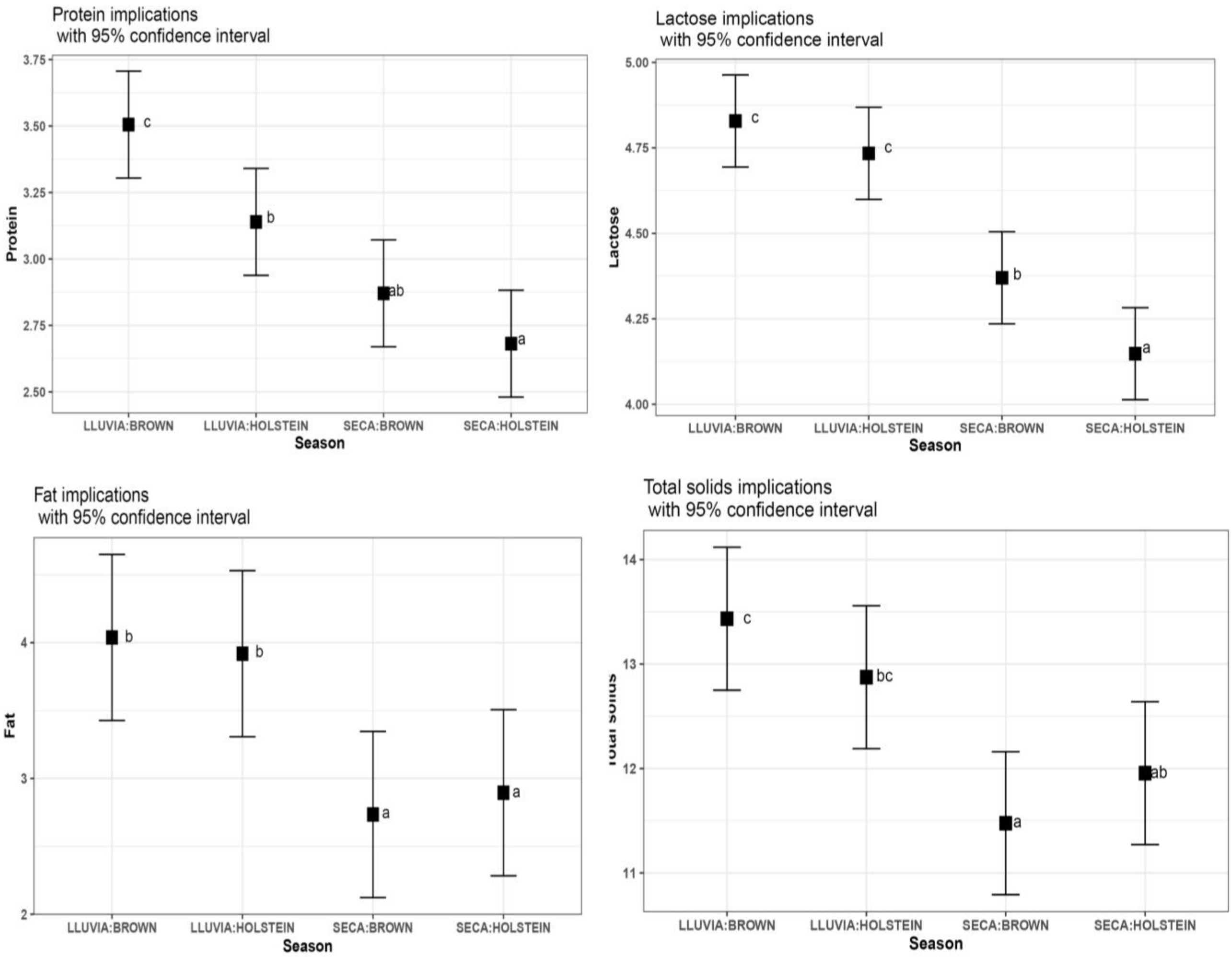


Figure 2. Methodology procedure for data collection. a: Grazing forage, b: Research animals, c: Milk samples, d: Refrigeration for sample transport, e: Lactoscan, f: Sample analysis.

RESULTS

In Graph 1, significant differences in the interaction between Brown Swiss and Holstein breeds and seasons (rainy and dry) are evident ($p < 0.05$). Variations are noticeable in the protein content (%), with the rain: Brown interaction showing a value of 3.50 ± 0.36 %, whereas rain: Holstein displayed 3.14 ± 0.05 %. Additionally, differences between the rainy and dry seasons, with values of 3.32 ± 0.31% and 2.77 ± 0.35%, respectively, were observed. In terms of lactose content (%), significant statistical differences were observed, with higher yields during the rainy season. The values were 4.83 ± 0.23 for rain: Brown and 4.73 ± 0.23 for rain: Holstein, respectively. However, there were statistical differences between dry: Brown and dry: Holstein with 4.37 ± 0.20 and 4.14 ± 0.10, respectively ($p < 0.05$). Furthermore, statistical differences were observed between the rainy and dry seasons, with values of 4.78 ± 0.23% and 4.26 ± 0.19%, respectively ($p < 0.05$). Regarding fat content (%), significant differences are also found in the rain: Brown and rain: Holstein" interactions with values of 4.04 ± 1.15 and 3.92 ± 1.13, respectively, as well as in "dry: Brown" and "dry: Holstein with 2.74 ± 0.59 and 2.89 ± 0.70, respectively ($p < 0.05$). As for total solids, slight differences are observed between the rain: Brown and rain: Holstein interactions, with values of 13.43 ± 0.87% and 12.87 ± 1.01%, respectively, and similarity between dry: Brown and dry: Holstein, with values of 12.87 ± 1.01% and 11.48 ± 0.48%, respectively. Additionally, significant differences between rainy and dry seasons are noted, with values of 13.15 ± 0.97% and 11.72 ± 1.11%, respectively ($p < 0.05$).

Regarding density percentage, as detailed in Table 1, no statistically significant differences were observed, suggesting a similar behavior for both the interaction between breeds and seasons ($p > 0.05$). Concerning non-fat solids (%), similarities were found between the rain: Brown and rain: Holstein interactions, with values of 9.07 ± 0.77% and 9.08 ± 0.97%, respectively; similarly, similarities were observed between the dry: Brown and dry: Holstein interactions, with values of 8.01 ± 0.67% and 8.29 ± 0.49%, respectively. Regarding freezing point, salts, and pH, no significant differences were detected in the interactions between breeds and seasons ($p > 0.05$).



Graph 1. Averages of protein, lactose, fat, and total solids in the interaction of cow's milk with rainy and dry seasons, and breed (Brown Swiss, and Holstein) in Perú. Equal letters do not show significant differences ($p > 0.05$)

Table 1. Mean physicochemical yields of milk in two breeds (Brown Swiss, and Holstein), and seasons (rainy and dry)

Performance	Rainy season		Dry season		P-value
	Brown Swiss	Holstein	Brown Swiss	Holstein	
Physicochemical					
Density (%)	1.0296 ± 0.0034[a]	1.0292 ± 0.0039[a]	1.0309 ± 0.0036[a]	1.0308 ± 0.0035[a]	0.5581
Non-fat solids (%)	9.07 ± 0.77[a]	9.08 ± 0.97[a]	8.01 ± 0.67[b]	8.29 ± 0.49[b]	0.0021
Freezing point	-0.56 ± 0.03[a]	-0.53 ± 0.03[a]	-0.57 ± 0.04[a]	-0.57 ± 0.05[a]	0.0923
Salts (%)	0.69 ± 0.05[a]	0.66 ± 0.04[a]	0.72 ± 0.05[a]	0.73 ± 0.08[a]	0.0832
pH	6.51 ± 0.29[a]	6.60 ± 0.19[a]	6.78 ± 0.09[a]	6.77 ± 0.41[a]	0.0721

[a,b] Equal superscript letters in the same row do not differ significantly from each other at 95%.

DISCUSSION

Regarding protein (%), superior results were observed during the rainy season for both cow breeds. According to Toni et al. (2011) and Morton et al. (2016), protein percentage values ranged from 3.0 to 3.2% in Holstein cow's milk and reached 3.5% in Brown Swiss cow's milk. These values were recorded 7 days postpartum in cows fed concentrate-based diets. Similarly, Yang et al. (2013), reported milk protein values of 3.10 %, in Holstein, and 3.51 % for Brown Swiss cows fed a concentrated diet meeting their nutritional needs and undergoing seasonal changes. These similarities stem from the use of Holstein breeds and a concentrated feeding system tailored to the animals' requirements, along with samples collected from adult cows experiencing seasonal variations between rainy and dry periods. The lactose percentages (4.78%) are similar to those reported by Costa et al. (2019), who compiled data from several countries, including New Zealand, Ireland, the United States, and Canada. The findings indicated that lactose percentages range from 4% to 4.9%, reflecting a standard expectation for lactose content in Brown Swiss and Holstein breeds. Regarding fat %, noticeable differences between seasons exist, with values of 3.98 ± 1.11 % for rainy (Brown Swiss) and 2.81 ± 0.63 % (Holstein) for dry. These values slightly exceed those reported by Toni et al. (2011), who found milk fat results of 3.91% in Holstein. The variance could be attributed to dietary intake differences, with the current research utilizing grazing with alfalfa compared to solely concentrated feed. The disparity between the rainy season's impacts on Brown and Holstein breeds is attributed to breed physiology (Golan and Assaraf, 2020), with Brown Swiss showing higher nutrient content than Holstein (Stocco et al., 2018). Holstein breed characteristics are more reflected in milk quantity (Braunschweig et al., 2000). Differences observed between rainy and dry seasons could be attributed to better quality and quantity of green forage during the rainy season, a significant factor in milk production compared to the dry season, where feed scarcity occurs.

In milk density, freezing point, salts, pH, and uniformity in milk composition no notable differences were observed between breeds and seasons, that could be attributed to various factors. Firstly, physiological stability may have influenced it, given that the studied animals were of similar ages (Pereira et al., 2008; Madhusoodan et al., 2019). Additionally, genetic adaptations could have played a significant role; being native to the study region (Casey and Van Niekerk, 1988), cows likely developed inherent resistance to abrupt changes in temperature and climate (Sutarno and Setyawan, 2016). Furthermore, consistent management and nutrition practices may have contributed to maintaining uniformity in milk composition (Zhou et al., 2022). All animals were fed and managed consistently, minimizing potential variations in milk quality (Zhu et al., 2018). Measures (similar management, feeding, milking machine, personnel, and sanitation) were implemented to control environmental factors that could have influenced the results, ensuring a controlled environment for the study. These combined factors likely contributed to maintaining stability in milk quality in terms of density, freezing point, salt content, and p/ for both Brown Swiss and Holstein cows, during the two seasons of the year.

CONCLUSION

The results reveal significant differences in protein, lactose, fat, and total solids contents between Brown Swiss and Holstein breeds, as well as between rainy and dry seasons. These disparities reflect the influence of the interaction between breed physiology and seasonal conditions on milk composition. Furthermore, they underscore the impact of environmental factors specific to each season on milk quality. Uniformity (density percentage, freezing point, salts percentage, and pH) in milk composition suggests stability influenced by factors, including physiological similarities, genetic adaptations, consistent management practices, and controlled environmental conditions. The obtained results underscore the resilience and consistency of milk quality in both breeds across the different seasons. It is recommended to conduct a study on the other breeds, such as Simmental, which has recently seen a rise in breeding in the central region of Peru.

DECLARATIONS

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The research has been self-financed by the authors.

Availability of data and materials

All data from this study are available upon reasonable request from the authors.

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Authors' contributions

Estremadoyro Leonor Guzman supervised the investigation throughout the execution; Paucar Huaman Salome carried out the complete execution of the investigation; Jordan Ninahuanca Carhuas performed the statistical analysis; Salvador Ore Guzman edited the photographs, as well as their interpretation; Armando Aquino Tacza monitored the animals throughout the investigation; Maria Antonieta Flores Guillen was in charge of the analysis in the laboratory with the necessary equipment.; Edgar Garcia-Olarte collects samples and data for statistics. All the authors read and approved the final version of the manuscript.

Competing interests

The authors have not declared any conflict of interest.

Ethical considerations

Ethical issues (including plagiarism, consent to publish, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy) have been checked by all the authors.

REFERENCES

Alinezhad Z, Hashemi M, and Tavakoly Sany SB (2024). Concentration of heavy metals in pasteurized and sterilized milk and health risk assessment across the globe: A systematic review. Plos One, 19(2): e0296649. DOI: https://www.doi.org/10.1371/journal.pone.0296649

Anstalt SV (2013). Food and agriculture organization of the united nations. Oxford., UK, pp. 160-1666. Available at: http://gamla.uof.nu/gammal/FUOF/doc/Fagelinfluensan.doc

Bardales W, Murga L, Portocarrero-Villegas SM, Arista-Ruiz MA, Pinedo LS, Escobedo HD, Maraví C, Bobadilla LG, Vigo CN, and Pino MEM (2024). Physicochemical and sanitary parameters of bovine bulk milk processing centers in the amazon region, peru. Journal of Agriculture and Food Research, 16: 101125. DOI: https://www.doi.org/10.1016/j.jafr.2024.101125

Barłowska J, Szwajkowska M, Litwińczuk Z, and Król J (2011). Nutritional value and technological suitability of milk from various animal species used for dairy production. Comprehensive Reviews in Food Science and Food Safety, 10(6): 291-302. DOI: https://www.doi.org/10.1111/j.1541-4337.2011.00163.x

Braunschweig M, Hagger C, Stranzinger G, and Puhan Z (2000). Associations between casein haplotypes and milk production traits of Swiss brown cattle. Journal of Dairy Science, 83(6): 1387-1395. DOI: https://www.doi.org/10.3168/jds.S0022-0302(00)75007-7

Britt J, Cushman R, Dechow C, Dobson H, Humblot P, Hutjens M, Jones G, Ruegg P, Sheldon I, and Stevenson J (2018). Invited review: Learning from the future-A vision for dairy farms and cows in 2067. Journal of Dairy Science, 101(5): 3722-3741. DOI: https://www.doi.org/10.3168/jds.2017-14025

Casey N and Van Niekerk W (1988). The boer goat. I. Origin, adaptability, performance testing, reproduction and milk production. Small Ruminant Research, 1(3): 291-302. DOI: https://www.doi.org/10.1016/0921-4488(88)90056-9

Ceballos LS, Morales ER, de la Torre Adarve G, Castro JD, Martínez LP, and Sampelayo MRS (2009). Composition of goat and cow milk produced under similar conditions and analyzed by identical methodology. Journal of Food Composition and Analysis, 22(4): 322-329. DOI: https://www.doi.org/10.1016/j.jfca.2008.10.020

Costa A, Lopez-Villalobos N, Sneddon N, Shalloo L, Franzoi M, De Marchi M, and Penasa M (2019). Invited review: Milk lactose current status and future challenges in dairy cattle. Journal of Dairy Science, 102(7): 5883-5898. DOI: https://www.doi.org/10.3168/jds.2018-15955

Fox PF (2008). Milk: An overview. Milk proteins, Chapter 1, pp. 1-54. DOI: https://www.doi.org/10.1016/B978-0-12-374039-7.00001-5

Garcia-Olarte E, Carhuas J, Guillen M, Tacza A, and Ramos E (2024a). Physicochemical composition of criolla and criolla x saanen. Online Journal Animal Feed Research, 14(2): 116-123. DOI: https://www.doi.org/10.51227/ojafr.2024.14

Garcia-Olarte E, Carhuas JN, Palomino IH, Carhuamaca WR, and Rojas JLS (2024b). The productive and physico-chemical performance at two seasons of the year in trout (oncorhynchus mykiss). Veterinary Integrative Sciences, 22(2): 525-535. DOI: https://www.doi.org/10.12982/VIS.2024.037

Godfrey SS, Ramsay GC, Behrendt K, Wynn PC, Nordblom TL, and Aslam N (2019). Analysis of agribusiness value chains servicing small-holder dairy farming communities in punjab, pakistan: Three case studies. International Food and Agribusiness Management Review, 22(1): 119-136. DOI: https://www.doi.org/10.22434/IFAMR2017.0122

Golan Y and Assaraf YG (2020). Genetic and physiological factors affecting human milk production and composition. Nutrients, 12(5): 1500. DOI: https://www.doi.org/10.3390/nu12051500

Guajardo C, Velasco V, Astudillo R, Cáceres C, Cea C, Campos J, Ocampo M, and Seminario L (2020). Milk quality and dairy product development of a Normande cow herd in the region of Ñuble, Chile. Chilean Journal of Agricultural and Animal Sciences, 36(3): 190-197. DOI: http://www.doi.org/10.29393/chjaas36-17mqcg80017

Guetouache M, Guessas B, and Medjekal S (2014). Composition and nutritional value of raw milk. Issues in Biological Sciences and Pharmaceutical Research, 2350: 1588. DOI: http://www.doi.org/10.15739/ibspr.005

Hernandez AF, Buha A, Constantin C, Wallace DR, Sarigiannis D, Neagu M, Antonijevic B, Hayes AW, Wilks MF, and Tsatsakis A (2019). Critical assessment and integration of separate lines of evidence for risk assessment of chemical mixtures. Archives of Toxicology, 93: 2741-2757. DOI: https://www.doi.org/10.1007/s00204-019-02547-x

Kamboj S, Gupta N, Bandral JD, Gandotra G, and Anjum N (2020). Food safety and hygiene: A review. International Journal of Chemical Studies, 8(2): 358-368. DOI: https://www.doi.org/10.22271/chemi.2020.v8.i2f.8794

Loos TK and Zeller M (2014). Milk sales and dietary diversity among the Maasai. Agricultural Economics, 45(S1): 77-90. DOI: https://www.doi.org/10.1111/agec.12131

Madhusoodan AP, Sejian V, Rashamol VP, Savitha ST, Bagath M, Krishnan G, and Bhatta R (2019). Resilient capacity of cattle to environmental challenges–An updated review. Journal of Animal Behaviour and Biometeorology, 7(3): 104-118. DOI: https://www.doi.org/10.31893/2318-1265jabb.v7n3p104-118

Moore SS, Costa A, Penasa M, Callegaro S, and De Marchi M (2023). How heat stress conditions affect milk yield, composition, and price in Italian Holstein herds. Journal of Dairy Science, 106(6): 4042-4058. DOI: https://www.doi.org/10.3168/jds.2022-22640

Morton J, Auldist M, Douglas M, and Macmillan K (2016). Associations between milk protein concentration, milk yield, and reproductive performance in dairy cows. Journal of Dairy Science, 99(12): 10033-10043. DOI: https://www.doi.org/10.3168/jds.2016-11275

Narmilan A, Puvanitha N, Ahamed AS, and Santhirakumar S (2021). Relationship between temperature-humidity index and milk production of dairy cows in tropical climate. Asian Journal of Dairy and Food Research, 40(3): 246-252. DOI: https://www.doi.org/10.18805/ajdfr.DR-213

Pereira AM, Baccari F, Titto EA, and Almeida JA (2008). Effect of thermal stress on physiological parameters, feed intake and plasma thyroid hormones concentration in Alentejana, Mertolenga, Frisian, and Limousine cattle breeds. International Journal of Biometeorology, 52: 199-208. DOI: https://www.doi.org/10.1007/s00484-007-0111-x

Rodriguez C, Saavedra G, and Gómez D (2015). Effect of stage of lactation on physicochemical quality of milk in Holstein and Norman cows. Zootecnia Tropical, 33(1): 23-35. Available at: https://www.cabidigitallibrary.org/doi/full/10.5555/20163008312

Sachs JD (2012). From millennium development goals to sustainable development goals. The Lancet, 379(9832): 2206-2211. DOI: https://www.doi.org/10.1016/S0140-6736(12)60685-0

Senamhi (2023). Datos hidrometeorológicos a nivel nacional en perú [Hydrometeorological data at the national level in Peru]. Available at: https://www.senamhi.gob.pe/?&p=estaciones

Stocco G, Cipolat-Gotet C, Gasparotto V, Cecchinato A, and Bittante G (2018). Breed of cow and herd productivity affect milk nutrient recovery in curd, and cheese yield, efficiency and daily production. Animal, 12(2): 434-444. DOI: https://www.doi.org/10.1017/S1751731117001471

Sutarno S and Setyawan AD (2016). The diversity of local cattle in Indonesia and the efforts to develop superior Indigenous cattle breeds. Biodiversitas Journal of Biological Diversity, 17(1): 275-295. DOI: https://www.doi.org/10.13057/biodiv/d170139

Team RC, Team MRC, Suggests M, and Matrix S (2018). Package stats. The R Stats Package.

Toni F, Vincenti L, Grigoletto L, Ricci A, and Schukken Y (2011). Early lactation ratio of fat and protein percentage in milk is associated with health, milk production, and survival. Journal of Dairy Science, 94(4): 1772-1783. DOI: https://www.doi.org/10.3168/jds.2010-3389

Vanga SK and Raghavan V (2018). How well do plant based alternatives fare nutritionally compared to cow's milk?. Journal of Food Science and Technology, 55(1): 10-20. DOI: https://www.doi.org/10.1007/s13197-017-2915-y

Vilca JC and Oyarce RR (2022). Somatic cells and nutritional composition of tank milk, Bongara Amazonas, Peru, 2021. Revista Científica UNTRM: Ciencias Naturales e Ingeniería, 5(1): 57-63. DOI: https://www.doi.org/10.25127/ucni.v4i3.809

Wankar AK, Rindhe SN, and Doijad NS (2021). Heat stress in dairy animals and current milk production trends, economics, and future perspectives: The global scenario. Tropical Animal Health and Production, 53(1): 70. DOI: https://www.doi.org/10.1007/s11250-020-02541-x

Wuletaw Z, Wurzinger M, Holt T, Dessie T, and Sölkner J (2011). Assessment of physiological adaptation of indigenous and crossbred cattle to hypoxic environment in Ethiopia. Livestock Science, 138(1-3): 96-104. DOI: https://www.doi.org/10.1016/j.livsci.2010.12.005

Yang L, Yang Q, Yi M, Pang Z, and Xiong B (2013). Effects of seasonal change and parity on raw milk composition and related indices in Chinese holstein cows in northern China. Journal of Dairy Science, 96(11): 6863-6869. DOI: https://www.doi.org/10.3168/jds.2013-6846

Zamberlin Š, Antunac N, Havranek J, and Samaržija D (2012). Mineral elements in milk and dairy products. Mljekarstvo: Časopis Za Unaprjeđenje Proizvodnje I Prerade Mlijeka, 62(2): 111-125. Available at: https://hrcak.srce.hr/83327

Zhou W, Li X, Su W, Zheng H, An G, Li Z, and Li S (2022). A study on the uniform distribution and counting method of raw cow's milk somatic cells. Micromachines, 13(12): 2173. DOI: https://www.doi.org/10.3390/mi13122173

Zhu Y, Wang J, and Wang C (2018). Research on the preparation, uniformity and stability of mixed standard substance for rapid detection of goat milk composition. Animal Science Journal, 89(5): 794-801. DOI: https://www.doi.org/10.1111/asj.12985

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