



Diversity in Physio-Chemical Attributes of Milk from Various Cow Breeds in Haryana

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Article History	Abstract
Received: 06 June 2023 Revised: 05 Sept 2023 Accepted: 21 Oct 2023	<i>This research paper presents a comparative analysis of the physio-chemical properties of milk from four different breeds of cows in Haryana, namely Sahiwal, Tharparkar, Red Sindhi, and Cross-breed. The study aimed to evaluate various parameters including fat content, solid not fat (SNF), total solids, protein content, density, lactose content, titratable acidity, freezing point, pH, and specific gravity. A total of 80 cows, 20 from each breed were selected for the study, and milk samples were collected twice a day, in the morning and evening. The analysis revealed significant differences among the four cow breeds in terms of their milk composition. The Sahiwal breed exhibited the highest fat content (4.71), while the Red Sindhi had the lowest (3.97). Similarly, variations were observed in SNF, total solids, proteins, density, lactose, titratable acidity, freezing point, pH, and specific gravity across the different breeds. The findings of this research contribute to a better understanding of the physio-chemical characteristics of milk from different cow breeds in Haryana. These results can assist in breed selection for improved milk production, processing, and product development. Furthermore, the data obtained can serve as a valuable resource for dairy industry stakeholders, regulatory bodies, and researchers in the field of dairy science and technology. Future studies could explore the relationship between physio-chemical properties and milk yield, as well as investigating the impact of these variations on the processing and quality of dairy products. Additionally, exploring the influence of environmental factors and management practices on milk composition could further enhance our understanding of the subject.</i> Keywords: Milk, Cow Breeds, Physio-Chemical Properties, Haryana
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1. Introduction

The physio-chemical properties of milk play a vital role in determining its nutritional value, suitability for processing, and overall quality (Drackova et al., 2008; Enb et al., 2009). Milk composition can vary significantly among different breeds of cows, which can have implications for dairy industry stakeholders, farmers, and consumers (Arora et al., 2013). Understanding these variations is crucial for optimizing milk production, processing, and product development (Kuchroo & Malik, 1976). In the context of Haryana, a state in India renowned for its dairy farming, this research paper presents a comparative analysis of the physio-chemical properties of milk from four distinct cow breeds: Sahiwal, Tharparkar, Red Sindhi, and Cross-breed.

Haryana is recognized as one of the leading milk-producing regions in India, and the selection of cow breeds for dairy farming is a critical decision for farmers (Chauhan et al., 2012). Each breed possesses distinct genetic traits, which can influence milk composition and quality (Dubey & Gupta, 1990). By conducting a comprehensive analysis of key parameters such as fat content, solid not fat (SNF), total solids, proteins, density, lactose content, titratable acidity, freezing point, pH, and specific gravity, this study aims to shed light on the variations in milk properties among these four breeds (Kanwal et al., 2004; Lingathurai et al., 2009).

The selected cow breeds represent a mix of indigenous and crossbred animals commonly found in Haryana. Sahiwal, known for its high milk yield and adaptability to harsh climatic conditions, is a popular indigenous breed (Kamble, 2001). Tharparkar, another indigenous breed, is valued for its high milk solids content and tolerance to heat stress (Juma & Alsafar, 1970). Red Sindhi, originally from the Sindh region, is recognized for its robustness and adaptability (Laxminarayan & Dastur, 1968). The Cross-breed category represents a hybrid population resulting from crossbreeding between indigenous and exotic breeds, with potential variations in milk composition due to heterosis (Ghule et al., 2016).

This research involves the collection of milk samples from 20 cows of each breed, with milk collection performed twice a day, in the morning and evening. By analyzing the physio-chemical properties of milk, a comprehensive comparison can be made, highlighting any significant differences among the breeds (Mahmood & Usman, 2010). The findings of this study can provide valuable insights into breed selection, milk processing techniques, and product development strategies in Haryana's dairy industry (Imran et al., 2008).

The objectives of this research paper are to assess the variations in milk composition among the selected cow breeds, identify any breed-specific trends in the physio-chemical properties, and generate data that can contribute to informed decision-making in dairy farming and processing. Moreover, the study aims to serve as a valuable resource for researchers, dairy industry stakeholders, and regulatory bodies involved in promoting milk quality and enhancing dairy sector productivity in Haryana (Legesse et al., 2017).

By gaining a better understanding of the physio-chemical characteristics of milk from different cow breeds, farmers can make informed decisions regarding breed selection, feeding practices, and milk processing techniques. Additionally, consumers can be assured of milk products that meet their preferences and nutritional requirements. This research endeavors to bridge the knowledge gap and provide a foundation for future studies exploring the relationship between physio-chemical properties, milk yield, and the impact of environmental factors on milk composition (Liang et al., 2013).

2. Materials And Methods

Selection of Cow Breed:

The selection of cow breeds for this research was based on the following criteria:

1. **Genetic Diversity:** The inclusion of cow breeds with diverse genetic backgrounds allows for a comprehensive analysis of milk properties. (Smith et al., 2005)
2. **Regional Significance:** Cow breeds selected for this study are of particular relevance to the Haryana region, known for its dairy farming. (Singh et al., 2018)
3. **Indigenous Breeds:** The inclusion of indigenous cow breeds, such as Sahiwal and Tharparkar, highlights the importance of preserving local genetic resources. (Singh et al., 2019)
4. **Cross-Breed Representation:** The presence of cross-bred cows in the study ensures a broader understanding of milk composition, considering the potential impact of hybridization. (Ranjhan, 2001)
5. **Practical Applicability:** The selected cow breeds are widely utilized in the local dairy industry, making the findings of this study directly relevant and applicable to dairy farmers and stakeholders. (Verma et al., 2016)
6. **Comparative Analysis:** By comparing multiple cow breeds, the research aims to identify similarities and differences in the physio-chemical properties of their milk, contributing to the existing body of comparative dairy research. (Rathore et al., 2020)

By considering these criteria for breed selection, the research aims to provide comprehensive insights into the physio-chemical properties of milk from various cow breeds in Haryana, contributing to the knowledge base of the local dairy industry and supporting evidence-based decision-making.

Sample Collection:

A total of 80 milk samples were collected, with 20 samples from each of the four selected cow breeds: Sahiwal, Tharparkar, Red Sindhi, and Cross-breed (Arora et al., 2013). The total duration of the experiment was 60 days. The sampling process followed a structured approach to capture the variations in milk properties across the different breeds.

The sampling was conducted in three districts of Haryana: Sonipat, Panipat, and Karnal. These districts were chosen based on their significance in dairy farming and the availability of the selected cow breeds in the region (Lingathurai et al., 2009). By sampling cows from multiple districts, we aimed to capture potential variations in milk properties that could arise from geographic and environmental factors.

The milk samples were collected twice a day, once in the morning and again in the evening (Mahmood & Usman, 2010). This approach accounted for any potential diurnal variations in milk composition and ensured a comprehensive assessment of the physio-chemical properties throughout the day. By collecting samples at these specific times, we aimed to capture the natural fluctuations that may occur in milk composition due to factors such as feeding patterns, cow physiology, and milking intervals.

The sample collection process adhered to strict hygiene standards and best practices to maintain the integrity of the samples (Enb et al., 2009). Each sample was carefully collected using sterile containers and labeled with appropriate identifiers to ensure traceability and accurate record-keeping (Legesse et al., 2017).

Furthermore, the selection of 20 cows from each breed ensured a representative sample size, allowing for robust statistical analysis and reliable conclusions (Imran et al., 2008). By including a sufficient number of samples from each breed, we aimed to account for individual variations within the breed and minimize any potential bias.

Sample Preparation:

To maintain the integrity of the samples and facilitate reliable measurements of physio-chemical properties, a standardized procedure was followed for sample preparation (Enb et al., 2009). Upon collection, the milk samples were immediately transferred to a controlled laboratory environment to minimize any potential degradation or changes in composition (Drackova et al., 2008). The samples were stored at appropriate temperatures to maintain their freshness and prevent bacterial growth (Legesse et al., 2017).

To ensure homogeneity and consistency, the milk samples underwent thorough mixing and agitation (Mahmood & Usman, 2010). Gentle but thorough stirring or swirling of the samples was performed to distribute any fat globules or solid particles uniformly. This step aimed to minimize any variations in the milk composition that may have occurred due to natural separation or settling during collection and transportation (Arora et al., 2013).

To remove any extraneous matter or impurities, the samples were carefully filtered using sterile filter papers or similar filtration methods (Imran et al., 2008). This process helped eliminate particulate matter and ensured that the subsequent analysis focused solely on the milk's physio-chemical properties.

The standardized sample preparation protocol applied to all the collected milk samples aimed to minimize variability and ensure consistency in the subsequent physio-chemical analysis. By employing these rigorous procedures, we sought to obtain reliable and representative data on the milk properties of the selected cow breeds from Sonipat, Panipat, and Karnal districts in Haryana.

Sample Analysis:

The sample analysis for the physio-chemical properties of the milk samples was conducted at the esteemed National Dairy Research Institute in Karnal, Haryana (Hofi et al., 1966). The institute's state-of-the-art facilities and expertise ensured accurate and reliable measurements of the various parameters.

To assess the composition of the milk samples, key parameters such as fat content, protein content, lactose content, density, freezing point, solid not fat (SNF), and total solids were analyzed (Ghule et al., 2016). The Milk Analyzer, specifically the Lacto Scan, was utilized for the analysis of fat, protein, lactose, density, freezing point, SNF, and total solids. This instrument employs advanced technology to provide precise and efficient measurements of these parameters.

The pH of the milk samples was determined using a digital pH meter, which offers high accuracy and sensitivity in measuring the acidity or alkalinity of the samples (Chandra & Roy, 1977). The pH measurement provides valuable information about the milk's acidity level, which can influence its taste, shelf life, and processing characteristics.

For the determination of specific gravity, the methodology prescribed in the BIS Handbook (IS: 1103-1965) was followed (Ghosh & Anantakrishnan, 1964). Specific gravity is an important parameter that indicates the density of the milk and can provide insights into its composition and quality.

Titrateable acidity, a measure of the acidity level in the milk, was determined as per the guidelines outlined in the BIS Handbook (IS 1479-1961) (Altman & Dittmer, 1961). This analysis helps evaluate the milk's freshness and can indicate the presence of any undesirable changes or microbial activity.

The utilization of specialized equipment and adherence to standard methodologies ensures the accuracy and reliability of the sample analysis. The National Dairy Research Institute's expertise and commitment to quality contribute to the robustness of the results obtained for the physio-chemical properties of the milk samples. By employing these advanced analytical techniques and following established standards, the research aims to provide comprehensive insights into the physio-chemical characteristics of the milk from the selected cow breeds in Sonipat, Panipat, and Karnal districts of Haryana.

Parameters observed during experiment

Gross chemical compositions

- a) Fat
- b) Solid Not Fat (SNF)
- c) Total solids
- d) Protein
- e) Lactose
- f) Density

Physio-chemical properties

- a) Titrateable acidity
- b) Freezing Point
- c) pH
- d) Specific Gravity

All samples were analysed by using Lacto scan at NDRI, Karnal whereas, for Fat, SNF, Acidity, pH and Specific Gravity samples were also analysed manually at NDRI, Karnal.

Data Analysis:

The collected data from the physio-chemical analysis of the milk samples were subjected to rigorous statistical analysis. The statistical analysis was conducted following the guidelines outlined by Snedecor and Cochran (1994), ensuring a robust and reliable assessment of the results.

To compare the data among the different cow breeds, various statistical tools were employed. Analysis of Variance (ANOVA) was utilized to evaluate the differences and similarities in the physio-chemical properties of the milk samples across the four selected breeds: Sahiwal, Tharparkar, Red Sindhi, and Cross-breed. ANOVA helps determine if there are statistically significant variations between the groups being compared.

The average or mean values of the physio-chemical properties were calculated to obtain a representative measure of the central tendency for each parameter within each cow breed. This allowed for a clear understanding of the average composition of the milk samples from the different breeds.

In statistical analysis, it is crucial to establish the significance of the observed differences. In this study, a significance level of $P < 0.05$ was chosen, indicating that any differences observed between the breeds were considered statistically significant if the probability of such differences occurring by chance alone was less than 5%. This threshold provides a reliable basis for determining the significance of the findings.

By employing these statistical tools and adhering to the guidelines of Snedecor and Cochran (1994), the research aims to provide robust and scientifically valid conclusions regarding the comparative analysis of the physio-chemical properties of milk from the selected cow breeds in Haryana.

3. Results and Discussion

Gross chemical composition (Cattle breeds)

Fat

The result obtained in the present investigation for fat content in the milk of Tharparkar, Crossbred, Red Sindhi and Sahiwal along with their statistical analysis are presented in Table-2.1. It has been revealed that percentage fat content among the different breeds of cow: - the milk of Tharparkar,

Crossbred, Red Sindhi and Sahiwal in morning ranges 4.40, 4.14, 3.98, 4.71 respectively, whereas in evening it ranges 4.21, 4.07, 3.97, and 4.57 respectively.

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	4.40 ^c ± 0.12	4.14 ^a ± 0.08	3.98 ^a ± 0.07	4.71 ^b ± 0.07
Evening	4.21 ^c ± 0.12	4.07 ^a ± 0.06	3.97 ^a ± 0.09	4.57 ^b ± 0.06
Total	4.30 ± 0.12	4.10 ± 0.05	3.98 ± 0.06	4.64 ± 0.04

^{a,b,c} Mean values with different superscripts in a row differ significantly (P<0.05)

Table 2.1

Variations of fat (%) in Morning and Evening in different breeds of cow

The average fat content percentage was significantly (P<0.05) higher in Sahiwal among the different breeds which is 4.71 in morning and 4.57 in evening. It is followed by Tharparkar having average fat content percentage 4.40 and 4.21, crossbred 4.14 and 4.07, Red Sindhi 3.98 and 3.97 in morning and evening respectively. The high to low trend of fat percentage observed in the milk of these four breeds are as follows: Sahiwal, Tharparkar, Crossbred and Red Sindhi.

The average percentage of total fat content was also significantly (P<0.05) higher in Sahiwal (4.99) among the different breeds followed by Tharparkar (4.64), Crossbred (4.10) and Red Sindhi (3.98). The finding in this study shows the amount of fat in Crossbred was similar with the data reported by Sharma *et al.* (2002) which found overall mean fat percentage was 4.59. In his study the effect of fat percentage was also varied due to seasonal influences in milk composition of cross-bred cow of sub-Himalayan region. The study was carried by fifty samples from each season that were collected from a herd of Jersey, Red Sindhi, Local, cross-bred cows during summer (April-June), rainy (July-September) and winter (November-February) and analysed the fat, TS and SNF content. The Fat content was higher in winter (4.648±0.079%), lower in rainy season (4.442±0.0561%) that is quite comparable with summer (4.494±0.067%).

Solid Not Fat (SNF)

In the present investigation, the data obtained for SNF content in the milk of Tharparkar, Crossbred, Red Sindhi, and Sahiwal along with their statistical analysis are presented in Table-2.2.

The result illustrated percentage SNF content in the milk of Tharparkar, Crossbred, Red Sindhi and Sahiwal in morning ranges 9.15, 8.69, 8.90, 9.20 respectively, whereas in evening it ranges 9.08, 8.53, 8.78, 9.10 respectively. The average SNF content was significantly (P<0.05) higher in Sahiwal and Tharparkar among the different breeds, which is 9.20, 9.15 respectively in morning and 9.10, 9.08 in evening. It was followed by Red Sindhi having average SNF content percentage 9.10 and 8.48, crossbred 8.69 and 8.53 in morning and evening respectively.

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	9.15 ^c ± 0.06	8.69 ^a ± 0.06	8.90 ^a ± 0.04	9.20 ^b ± 0.07
Evening	9.08 ^c ± 0.05	8.53 ^a ± 0.06	8.78 ^a ± 0.04	9.10 ^b ± 0.06
Total	9.11 ± 0.05	8.61 ± 0.05	8.84 ± 0.04	9.15 ± 0.06

^{a,b,c} Mean values with different superscripts in a row differ significantly (P<0.05)

Table 2.2

Variations of SnF(%) in Morning and Evening in different breeds of cow

The average percentage of total SNF content was significantly (P<0.05) higher in Sahiwal (9.20) and Tharparkar (9.16) among the different breeds followed by Red Sindhi (8.79), Crossbred (8.60). Conclusively, high to low trend of SNF percentage observed in the milk of these four breeds are as follows:

Sahiwal, Tharparkar, Red Sindhi and Crossbred.

The SNF content observed in present investigation in milk of Crossbred, Red Sindhi, Sahiwal are in agreement with the result reported by Imran *et al.* (2008) whereas, SNF content is at lower side than reported by Ceballos *et al.* (2009). The SNF content observed in Crossbred, Sahiwal milk are in conformity with results reported by Pavel and Guvan (2011).

The finding in this study shows the amount of SNF was similar with the data reported by Chauhan *et al.* (2012), who observed that the mean SNF content presented was 8.02±0.25% in summer, 8.88±0.32% in monsoon and 8.29±0.23% in winter respectively.

Total Solids

The result obtained in the present investigation for total solids content in the milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.3.

It has been revealed that percentage total solids content in the milk of Tharparkar, Crossbred, Red Sindhi, and Sahiwal in morning ranges from 13.42, 12.84, 14.23, 13.89 respectively, whereas in evening it ranges as 13.25, 12.62, 14.10, 13.74 respectively. The average total solids content was significantly ($P < 0.05$) higher in Red Sindhi and Sahiwal among the different breeds, which is 14.23, 13.89 respectively in morning, and in evening 14.58 and 13.74 respectively. It is followed by Tharparkar having average total solids content percentage 13.42 and 13.25, crossbred 12.84 and 12.62 in morning and evening respectively.

The high to low trend of total solids percentage observed in the milk of these four breeds are as follows: Red Sindhi, Sahiwal, Tharparkar and Crossbred.

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	13.42 ^c ± 0.12	12.84 ^a ± 0.08	14.23 ^a ± 0.07	13.89 ^b ± 0.07
Evening	13.28 ^c ± 0.10	13.62 ^a ± 0.06	14.10 ^a ± 0.05	13.74 ^b ± 0.06
Total	13.35 ± 0.11	13.23 ± 0.07	14.16 ± 0.06	13.81 ± 0.06

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P < 0.05$)

Table 2.3

Variations of Total Solids (%) in Morning and Evening in different breeds of cow

The average percentage of total solids content was also significantly ($P < 0.05$) higher in Red Sindhi (14.16) and Sahiwal (13.81) among different breeds followed by Tharparkar (13.35), Crossbred (13.23). The findings of the present study is in agreement with that of Heimei *et al.* (2011), Lingathurai *et al.* (2009), Chauhan *et al.* (2012) and Rao and Ramamurthy (1973) which found that the average composition of cow milk and reported average TS content as 13.3%.

Proteins

The result obtained in the present investigation for protein content in the milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.4.

According to this results protein content percentage in the milk of Tharparkar, Crossbred, Red Sindhi, and Sahiwal in morning ranges 3.38, 3.31, 3.40, 3.45 whereas, in evening it ranges as 3.31, 3.19, 3.35, 3.39 respectively. The average protein content was significantly ($P < 0.05$) higher in Sahiwal among the different breeds which is 3.45 in morning and 3.39 in evening. It is followed by Red Sindhi 3.40 and 3.35, Tharparkar 3.38 and 3.31, Crossbred 3.31 and 3.19 in morning and evening respectively.

The high to low trend of total protein percentage observed in the milk of these four breeds are as follows Sahiwal, Red Sindhi, Tharparkar and Crossbred.

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	3.38 ^c ± 0.04	3.31 ^a ± 0.08	3.40 ^a ± 0.04	3.45 ^b ± 0.07
Evening	3.31 ^c ± 0.06	3.19 ^a ± 0.06	3.35 ^a ± 0.04	3.39 ^b ± 0.06
Total	3.34 ± 0.05	3.25 ± 0.07	3.38 ± 0.04	3.42 ± 0.06

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P < 0.05$)

Table 2.4

Variations of Proteins (%) in Morning and Evening in different breeds of cow

The average percentage of total protein content was also significantly ($P < 0.05$) higher in Sahiwal (3.42) among different breeds followed by Red Sindhi (3.38), Tharparkar (3.34), Cross Breed (3.25).

The findings of the present study is in agreement with that of Lingathurai *et al.* (2009), Heimei (2011), Arora *et al.* (2013), and Rao and Ramamurthy (1973), Sahai (1996).

Lactose

The result obtained in the present investigation for Lactose content in the milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.5. The result illustrated that the lactose content percentages in morning ranges 4.68 in Tharparkar milk, 4.77 in Crossbred milk, 4.96 in Red Sindhi milk and 5.11 in Sahiwal milk, whereas in evening it ranges as 4.52, 4.70, 4.95, 5.05 respectively.

The average Lactose content was significantly ($P<0.05$) higher in Sahiwal among different breeds which is 5.11 during morning and 5.05 in evening. It is followed by Red Sindhi 4.96 and 4.93, Crossbred 4.77 and 4.70 and Tharparkar 4.68 and 4.52. The average percentage of total lactose content was significantly ($P<0.05$) higher in Sahiwal (5.08) among different breeds followed by Red Sindhi (4.95), Crossbred (4.74) and then Tharparkar (4.60).

The high to low trend of total lactose percentage observed in the milk of these four breeds are as follows Sahiwal, Red Sindhi, Crossbred and Tharparkar.

These results are in agreement with findings of Heimei (2011), Sindhu and Singhal (1988) and Mahmood and Usman (2010) who found that the chemical compositions of milk samples of Cow milk from the different areas of Gujarat, Pakistan and reported protein content 3.37%, 4.36%.

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	4.68 ^c ± 0.10	4.77 ^a ± 0.06	4.96 ^a ± 0.06	5.11 ^b ± 0.06
Evening	4.52 ^c ± 0.08	4.70 ^a ± 0.06	4.93 ^a ± 0.04	5.05 ^b ± 0.06
Total	4.60 ± 0.09	4.74 ± 0.06	4.95 ± 0.05	5.08 ± 0.06

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P<0.05$)

Table 2.5

Variations of Lactose (%) in Morning and Evening in different breeds of cow

The findings in this study shows the amount of lactose was in similarity with the data reported by Arora *et al.* (2013) which observed that the mean lactose content percentage was 4.6%. Csiszter *et al.* (2012) which found Overall mean lactose percentage was 4.59.

Density

The result obtained in the present investigation for density of milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.6.

According to this results density of Tharparkar milk in morning ranges 30.03, in Crossbred milk 30.02, in Red Sindhi milk 30.13 and in Sahiwal milk 30.29, whereas in evening it ranges 29.07, 29.08, 29.06 and 29.07 respectively.

The average density of Sahiwal, Red Sindhi, Tharparkar and Crossbred milk was almost similar which is 30.29, 30.13, 30.03 and 30.02 respectively, during morning and in evening 29.07, 29.06, 29.07, and 29.08 respectively which shows non-significance differences ($P>0.05$). Statistical analysis showed that the

average differences of total density was also non-significance ($P>0.05$) in Sahiwal (29.68), Red Sindhi (29.59), Tharparkar (29.58) and Crossbred milk (29.53).

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	30.03 ^c ± 0.09	30.02 ^a ± 0.005	30.13 ^a ± 0.006	30.29 ^b ± 0.008
Evening	29.07 ^c ± 0.05	29.08 ^a ± 0.004	29.06 ^a ± 0.003	29.07 ^b ± 0.006
Total	29.58 ± 0.007	29.53 ± 0.004	29.59 ± 0.005	29.68 ± 0.007

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P<0.05$)

Table 2.6

Variations of Density (%) in Morning and Evening in different breeds of cow

The findings of the present study is in agreement with that of Chandrakar *et al.* (2018) who found overall milk density 31.27. He studied the quality of raw Cow milk and the effects of different lactations, stages of lactation and parity on milk components of Cows. The study was carried on total collected one hundred twelve milk samples, comprised of four different districts of varying lactation stages (early, mid and late) and from varying parity of (1, 2, 3, 4 and above) whose milk density was 29.23.

Physio-chemical properties

Freezing Point (°C)

The result obtained in the present investigation for freezing point of milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.7.

It revealed that Freezing point of the milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal in morning ranges from 0.570, 0.569, 0.570, 0.569 whereas, in evening it ranges 0.542, 0.538, 0.539, 0.539.

The average freezing point of Tharparkar and Red Sindhi milk was almost similar which is 0.570, 0.570 respectively during morning and in evening it was 0.542, 0.538 respectively, which shows non-significance differences ($P>0.05$). The freezing point of Crossbred and Sahiwal was 0.569, 0.569 respectively, during morning and 0.538, 0.539 in evening respectively. It was slightly less than milk of Tharparkar and Red Sindhi which was 0.570, 0.570 respectively during morning and 0.542, 0.538 in evening respectively with non-significance differences ($P>0.05$).

Statistical analysis showed that the average differences of total freezing point was also non-significance ($P>0.05$) in Tharparkar (0.556), Red Sindhi (0.554), Sahiwal (0.554) and Crossbred (0.553).

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	0.570 ^c $\pm$ 0.05	0.569 ^a $\pm$ 0.04	0.570 ^a $\pm$ 0.05	0.569 ^b $\pm$ 0.03
Evening	0.542 ^c $\pm$ 0.03	0.538 ^a $\pm$ 0.01	0.539 ^a $\pm$ 0.04	0.539 ^b $\pm$ 0.02
Total	0.556 $\pm$ 0.03	0.553 $\pm$ 0.02	0.554 $\pm$ 0.03	0.554 $\pm$ 0.01

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P<0.05$)

Table 2.7

Variations of Freezing Point (%) in Morning and Evening in different breeds of cow

The freezing point observed in present investigation in milk of Crossbred, Red Sindhi, Sahiwal are in agreement with the result reported by Di. Francia *et al.* (2007), whereas freezing point content is at lower side than the reported by Sahai (1996), which found that the data on various physio-chemical properties of Cow milk and the average reported values for freezing point was 0.522 °C.

Titrateable Acidity (%L.A.)

The result obtained in the present investigation for titrateable acidity content in the milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.8

It has been revealed that percentage titrateable acidity of the milk of Tharparkar, Crossbred, Red Sindhi and Sahiwal in morning ranges 0.168, 0.160, 0.164, 0.168, respectively, whereas in evening it ranges as 0.162, 0.152, 0.162, 0.166 respectively. The average value of titrateable acidity content percentage of Tharparkar and Sahiwal milk was almost similar which is 0.168, 0.168 respectively, during morning and 0.162, 0.166 in

evening respectively, which shows non-significance differences ($P>0.05$). The average percentage titrateable acidity significantly ($P<0.05$) higher in Red Sindhi milk, which is 0.164 in morning and 0.162 in evening. It is followed by crossbred having average titrateable acidity percentages 0.160 and 0.152 in morning and evening respectively.

The high to low trend of titrateable acidity percentage observed in the milk of these four breeds are as follows Tharparkar, Sahiwal, Red Sindhi and Crossbred.

The average percentage of total titrateable acidity was also significantly ($P<0.05$) higher in Sahiwal (0.167) among the different breeds followed by Tharparkar (0.165) Red Sindhi (0.163), Crossbred (0.156).

The findings of the present study is in agreement with that of Imran *et al.* (2008), Mishra and Pandey (2008), Abou Donia *et al.* (2010) and Mahmood and Usman (2010) observed physico-chemical parameters pooled Cow milk from different areas and found titrateable acidity 0.17% lactic acid and various researchers in India also observed physico-chemical properties of Cow milk the average compiled data were presented in dairy handbook showing average value for titrateable acidity 0.15% lactic acid.

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	0.168 ^c $\pm$ 0.03	0.160 ^a $\pm$ 0.03	0.164 ^a $\pm$ 0.05	0.168 ^b $\pm$ 0.07
Evening	0.162 ^c $\pm$ 0.03	0.152 ^a $\pm$ 0.03	0.162 ^a $\pm$ 0.02	0.166 ^b $\pm$ 0.04
Total	0.165 $\pm$ 0.03	0.156 $\pm$ 0.05	0.163 $\pm$ 0.04	0.167 $\pm$ 0.05

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P<0.05$)

Table 2.8

Variations of Titrateable Acidity (%) in Morning and Evening in different breeds of cow

pH

The result obtained in the present investigation for pH of the milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.9

It has been revealed that pH of the milk of Tharparkar, Crossbred, Red Sindhi and Sahiwal in morning ranges 6.62, 6.40, 6.57, 6.65 respectively, whereas in evening it ranges as 6.57, 6.41, 6.55, 6.63 respectively. The average morning and evening pH was significantly ($P<0.05$) higher in Sahiwal milk among the different breeds which is 6.65 in morning and 6.63 in evening. It is followed by Tharparkar having average pH 6.62 and 6.57, Red Sindhi 6.57 and 6.55, crossbred 6.40 and 6.41 respectively.

The high to low trend of pH observed of the milk of these four breeds are as follows Sahiwal, Tharparkar, Red Sindhi and Crossbred.

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	6.62 ^c ± 0.05	6.40 ^a ± 0.04	6.57 ^a ± 0.01	6.65 ^b ± 0.01
Evening	6.57 ^c ± 0.01	6.41 ^a ± 0.01	6.55 ^a ± 0.01	6.63 ^b ± 0.01
Total	6.60 ± 0.05	6.40 ± 0.04	6.56 ± 0.01	6.64 ± 0.01

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P<0.05$)

Table 2.9

Variations of pH (%) in Morning and Evening in different breeds of cow

The average total pH was also significantly ($P<0.05$) higher in Sahiwal (6.64) among the different breeds followed by Tharparkar (6.60) Red Sindhi (6.56) and Crossbred (6.40).

This study is in agreement with Nader *et al.* (1996), Sahai (1996), Silva *et al.* (1995) and Dubey *et al.* (1998) which found the values of average pH for Cow milk was recorded as 6.34 to 6.51. Sabahelkhier *et al.* (2012) observed the average values for pH of raw Cow milk obtained from Sudan was found to be 6.60 and various researchers in India also observed that the physio-chemical properties of raw Cow milk and the average compiled data were presented in dairy handbook showing average value for pH as 6.60. Mahmood and Usman (2010) which found that the physio-chemical parameters of Cow milk from different areas of Gujarat, Pakistan and found as pH 6.64. However, the findings of the present study is not in agreement with that of Ahmad *et al.* (2008), Imran *et al.* (2008) who found that the various physio-chemical properties of Cow milk was carried out from various areas in Pakistan and found pH 6.76.

Specific gravity

The result obtained in the present investigation for Specific gravity of the milk of Tharparkar, Crossbred, Red Sindhi, Sahiwal are presented in Table-2.10

It has been revealed that Specific gravity of the milk of Tharparkar, Crossbred, Red Sindhi and Sahiwal in morning ranges from 1.031, 1.030, 1.030, 1.029 whereas, in evening it ranges 1.028, 1.028, 1.028, 1.028. The average specific gravity of Tharparkar, Red Sindhi, Crossbred and Sahiwal milk was almost similar which is 1.031, 1.030, 1.030 and 1.029 respectively during morning and in evening it was 1.028, 1.028, 1.028, and 1.028 respectively, which shows non-significance differences ($P>0.05$).

Time/Breed	Tharparkar	Cross-Breed	Red Sindhi	Sahiwal
Morning	1.031 ^c ± 0.006	1.030 ^a ± 0.02	1.030 ^a ± 0.004	1.029 ^b ± 0.005
Evening	1.028 ^c ± 0.001	1.028 ^a ± 0.001	1.028 ^a ± 0.002	1.028 ^b ± 0.003
Total	1.030 ± 0.006	1.029 ± 0.002	1.029 ± 0.003	1.029 ± 0.004

^{a,b,c} Mean values with different superscripts in a row differ significantly ($P<0.05$)

Table 2.10

Variations of Specific Gravity (%) in Morning and Evening in different breeds of cow

Statistical analysis showed that the average differences of total specific gravity was also non-significance ($P>0.05$) in Tharparkar (1.030), Sahiwal (1.029), Red Sindhi (1.029) and Crossbred (1.029).

The findings in this study shows the specific gravity of Cow milk was similar with the data reported by Schneider *et al.* (1948), Mahmood and Usman (2010) and Rashida *et al.* (2004) which found overall average specific gravity as 1.037. These studies are in agreement with Asif *et al.* (2010) who observed no significant ($P>0.05$) differences between Cow breed that the physicochemical parameters of milk samples collected from Cow breed and its Specific gravity content was in a range of 1.000-1.033.

4. Conclusion

In conclusion, the results obtained from the comprehensive milk analysis of four different breeds of cows have provided valuable insights into the variations in nutrient contents among these breeds. The milk of Sahiwal cattle exhibited significantly higher average nutrient contents of fat, solid-not-fat (SNF), protein, lactose, titratable acidity, and density compared to the other breeds. Conversely, the milk of Tharparkar Cattle displayed significantly higher average nutrient contents of pH, specific gravity, and freezing point. Furthermore, the milk of Red Sindhi cattle demonstrated significantly higher average percentages of total solid contents among the cattle breeds investigated. These findings highlight the breed-specific variations in milk composition, indicating the potential for targeted utilization and specialized applications in the dairy industry based on the breed of the cow. Further research and exploration are warranted to delve deeper into the underlying factors contributing to these variations and their implications for milk quality and product development.

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