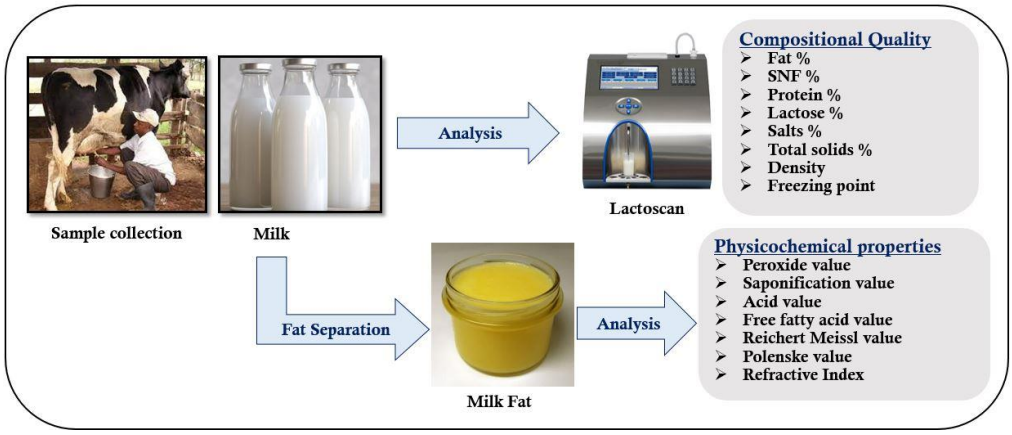
The comparison of compositional quality of milk and physicochemical properties of milk fat of indigenous cattle breed of Sri Lanka with locally reared pure European cattle breeds

W.A.Y.A. Wickramaarachchi[1, 2], G.S.A. Senanayake[1]* and R.A.U.J. Marapana[1]

[1]*Department of Food Science and Technology, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.*
[2]*Faculty of Graduate Studies, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.*

Date Received: 15-10-2024 Date Accepted: 25-12-2024



Abstract

As an essential dietary ingredient, milk fat (MF) has a major impact on the nutritional value, economics, and physical and chemical characteristics of milk and dairy products. The purpose of this research study was to examine and contrast the compositional quality of milk and physicochemical characteristics of milk fat of the Sri Lankan indigenous cow breed with that of locally raised Ayrshire and Holstein-Friesian pure European cattle breeds. Three random samples of milk from each breed of Ayrshire and Holstein-Friesian were gathered from the Nuwara Eliya district, and indigenous cow's milk samples were collected from the Jaffna district, Sri Lanka. For compositional analysis, the Bulgarian MCCW Lactoscan equipment was used. To analyze physicochemical properties, a cream separator was used to separate the fat. The standard AOCS procedures were used to analyze physiochemical properties: Free fatty acid value (FFA), acid value (AV), saponification value (SV), peroxide value (PV), Polenske value (P) and Reichert Meissl value (RMV). The AOAC method was used to analyze the Refractive Index (IR). The evaluated parameters showed significant differences ($p<0.05$) according to Minitab one-way ANOVA. According to the study of the compositional quality of milk, locally bred pure European cow breeds had higher percentages of protein, fat, lactose, SNF, total solids and salts in milk than the native Sri Lankan bovine breed. The highest levels of PV (1.40 meqO_2/kg), AV (0.67 mg KOH/g), and FFA (0.34) were found from milk fat of local indigenous cow breeds, whereas Holstein-Friesian milk fat had the lowest levels. The Ayrshire milk fat had the highest SV (236.50 mg KOH/g) and RMV (28.97), whereas the Indigenous cattle breed had the lowest. Holstein-Friesian milk fat had the greatest P (1.87), while Ayrshire milk fat had the lowest (1.57). In all the three breeds, IR (1.46) was nearly identical. This study revealed that, milk of locally raised pure European cattle breeds are better in quality than the local indigenous breed. Highest PV, AV and FFA observed in the local breed revealed that milk fat of local varieties are more susceptible to oxidation than that of locally raised European breeds.

Keywords: *Holstein-Friesian, Ayrshire, Indigenous cow breed, Milk composition, Physicochemical characteristics.*

**Correspondence: suraji@sjp.ac.lk*

1. Introduction

Milk is widely recognized as one of the most comprehensive single foods available and is essential to both children's and adults' diets. (Fantuz et al., 2016). In human diets, fresh milk and dairy products, including ice cream, yogurt, and milk powder are important sources of protein, fat, and energy, forming a significant part of daily nutrition. With 85% of the world's milk supply coming from cows, cow's milk is the most consumed type (Gantner et al., 2015). The main factor influencing the quality of dairy products is the raw milk quality. High quality dairy products can be made exclusively from good quality raw milk only (Kumar et al., 2018). Therefore, it is crucial to compare the raw milk quality of local indigenous breeds with that of locally raised European ones. The composition of milk varies greatly and is not always the same. Even within the same species, across breeds and between individual animals, there are significant variations. Furthermore, depending on nutrition and temperature, the composition may fluctuate daily (Kumar et al., 2018). Therefore, in the dairy industry, it is fundamental to have a proper understanding of the average milk composition of commonly reared cattle breeds.

Fats and oils are vital nutrients for both humans and animals, providing a dense source of energy at 9 Kcal per gram. They significantly contribute to food quality by improving texture and mouthfeel, adding flavor, supplying essential nutrients, and enhancing caloric density. Additionally, they may help to create a sense of fullness after meals (Babayan et al., 1959). Milk fat is one of the costliest constituents in milk, making its characterization essential to ensure consistent and well-defined quality (Jensen, 2002). Milk fat also exhibits a delightful flavor and aroma, provides a high calorie content, and serves as a rich supply of vital nutrients, including fatty acids (FA) and fat-soluble vitamins (Huth and Park.; 2012, Sharma et al., 2020). Therefore, for the progress of the dairy industry, having a sound knowledge on physicochemical parameters of the MF portion of different cattle breeds is essential.

European cattle breeds are typically recognized for their significantly high milk yield and fat content. The Ayrshire breed, which hails from southwest Scotland's Ayrshire region, is celebrated globally for its adaptability, strong health, and efficient milk production (Zinnatov et al., 2024). In addition to its high milk protein and fat content, the Ayrshire breed is well-known for its exceptional milk output (Ryabova et al., 2023; Zinnatov et al., 2024). Ayrshire cows generate milk with a well-balanced composition of fat and protein, making it ideal for various dairy products like cheese, butter, and yogurt. According to Komlyk and Grishina (2024), Ayrshire milk typically has a fat percentage ranging from 3.9% to 4.7%, and it is renowned for its excellent flavor and high quality (Komlyk and Grishina, 2024). Holstein-Friesian cattle, originating from the Netherlands and Germany, are among the most widely favored dairy breeds globally because of their outstanding milk production capabilities (Hayes et al., 2009). They possess exceptional milk-producing characteristics, such as high milk yield, well-formed udders, and efficient feed conversion (Miglior et al., 2017). Genetic advancements and widespread breeding initiatives have enabled Holstein-Friesians to thrive in a variety of climates and dairy farming systems around the world. Their adaptability, coupled with sophisticated management practices, plays a significant part in the worldwide dairy business, establishing Holstein-Friesians as a key breed in commercial dairy farming (Vilr and Niaz, 2024).

Although indigenous cattle breeds have long been acknowledged as important sources of animal genetic material, they are still not well studied and documented (Silva et al., 2021). In general, they have adapted successfully to the tough local environment. However, their output performance tends to be lower in comparison to crossbred or exotic species (Silva et al., 2021; Wijeweera et al., 2014). The composition of milk fatty acids (FA) is influenced by various factors such as genetic variation (Soyeurt et al., 2006), breed (Soyeurt et al., 2006; Stoop et al., 2009), stage of lactation (Palladino et al., 2010), diet (Dewhurst et al., 2006) and season (Heck et al., 2009; Schwendel et al., 2015). Of these, breed has the most substantial impact on the FA composition (Arnould and Soyeurt, 2009; Sanjayaranj et al., 2022). Furthermore, several authors have shown that the genetic makeup of cows from different breeds determines the variations in the chemical composition and physicochemical properties of their milk **(**Czerniewicz et al., 2006; Heck et al., 2009) and can primarily be attributed to the variations in dairy fat.

*Correspondence: suraji@sjp.ac.lk

Physicochemical characteristics of diary fat collectively offer a thorough understanding of its quality, affecting sensory attributes, shelf life, nutritional value, and its suitability for diverse dairy products. Therefore, the ultimate aim of this research study was to examine and compare the compositional quality of milk: protein, fat, lactose, SNF, total solids, salts, density and the freezing point, and physicochemical properties; FFA, AV, SV, PV, P, RMV and IR, of dairy fat obtained from indigenous cattle breed of Sri Lanka with locally raised pure European breeds: Ayrshire and Holstein-Friesian. Findings of this study will not only enhance our understanding of the milk fat quality of these breeds but also provide valuable information for dairy farmers, processors, and consumers aiming to optimize milk production and utilization. The ultimate goal is to ensure the production of high-quality milk that meets the nutritional and sensory preferences of consumers while maintaining the sustainability and resilience of dairy farming systems.

2. Methodology

Milk samples from indigenous cattle were gathered from local dairy producers in the Jaffna district of Sri Lanka, and milk samples from locally raised European cow breeds: Ayrshire and Holstein-Friesian, were gathered from the Nuwara Eliya district. Three samples from each breed were randomly gathered during the early mornings of December 2023. Following the sample collection, they were promptly taken to the food analysis laboratory of the Department of Food Science and Technology of the University and kept at 4 °C. The milk cream separator (Brand: LAWKIM, Model No: LM200LK3072PK) was used to separate the fat after the milk was heated to 40 °C. Then, the samples were kept at -20 °C storage until analyzed. The samples were taken for analysis after being melted at 40 °C.

2.1 Compositional analysis of cattle milk

The Bulgarian MCCW Lactoscan equipment was used to determine the physical properties of milk, such as density and the freezing point, as well as its chemical composition, which included the percentages of protein, fat, lactose, SNF, total solids and salts.

2.2 Analysis of the Chemical properties of milk fat

2.2.1 Peroxide value

PV was calculated following the standard procedure outlined by the American Oil Chemists' Society, specifically AOCS Cd 8b-90 (97). Approximately 5 ± 0.5 g of each sample was placed in separate 250 ml conical flasks, dissolved in 10 ml of chloroform, and combined with 15 ml of glacial acetic acid in a fume hood. Subsequently, 1 ml of saturated Potassium Iodide (KI) was added, and the mixtures were stored in the dark for 5 minutes. Following this, 75 ml of distilled water was introduced, and the mixture was shaken thoroughly before being titrated with 0.01 N Sodium thiosulfate ($Na_2S_2O_3$) solution until obtaining a straw colour. Thereafter, a small quantity of 1% starch was added to the sample, and titration proceeded until the disappearance of the blue colour. For each sample, the same process was carried out three times. Additionally, a blank test was conducted.

The following formula was used to get the PV. S –Volume of the 0.01 N $Na_2S_2O_3$ used for the sample (ml), B - Volume of the 0.01 N $Na_2S_2O_3$ used for the blank (ml), N – Normality of the accurately standardized $Na_2S_2O_3$, W – Weight of the sample (g).

$$PV = \frac{(S-B)\times N\times 1000}{W} \qquad \text{---------- (01)}$$

2.2.2 Saponification value

Saponification value was analyzed using AOCS Cd 3-25 (02), the standard approach outlined by the AOCS. About 2.0 g of the oil sample was weighed into a round bottomed flask. Subsequently, 25 ml of 0.5N ethanoic potassium hydroxide (KOH/EtOH) was pipetted out to the flask. Then a

*Correspondence: suraji@sjp.ac.lk

condenser was fixed and heated for about 1.5 hours on a water bath. The mixture was shaken occasionally while refluxing. Afterwards, a few drops of phenolphthalein indicator were added, and the hot solution was titrated with 0.5 N Hydrochloric acid (HCl). Additionally, a blank test was also conducted. The procedure was triplicated for every sample. The following formula was used to calculate the *SV*. *B* – Volume (ml) of HCl required for the blank (titration), *S* – Volume (ml) of HCl required for the sample (titration), *N* – Normality of the accurately standardized HCl solution, *W* – Sample weight (g).

$$SV = \frac{(S-B)\times N\times 56.1}{W} \qquad \text{---------- (02)}$$

2.2.3 Acid value and free fatty acid value

AV and FFA were analyzed using the standard AOCS procedure, AOCS Cd 3d-6. Roughly 2.5 g of oil was measured in to 250 ml conical flask, and it was dissolved in 50 ml of hot ethyl alcohol neutralized freshly. Thereafter, about 1 milliliter of phenolphthalein indicator was added. After boiling for approximately five minutes, the mixture was titrated while still warm, against a standard 0.1N potassium hydroxide (KOH) solution while being vigorously shaken. The same procedure was triplicated for every sample.

The following formulae were used to determine the AV and FFA, respectively. *V* – Volume (ml) of 0.5 M standard KOH required for the sample, *N* – Normality of accurately standardized KOH solution, *W* – Weight of the sample (g), *AV*– Acid Value.

$$AV = \frac{V\times N\times 56.1}{W} \qquad \text{---------- (03)}$$

$$FFA = AV \div 2 \qquad \text{---------- (04)}$$

2.2.4 Reichert Meissl value and Polenske value

RMV and PV were analyzed using the standard AOCS procedure: AOCS Cd 5-40. Initially, about 5 g of the fat sample was accurately weighed in to the flask of the apparatus. Then 20 grams of glycerol (about 16 ml) and 2 ml of concentrated Sodium hydroxide solution was added to it using a burette. The flask was gently heated over an open flame until the fat melted and was continuously shaken until the fat saponified and the liquid turned completely clear. Overheating was prevented during the process. Then the sample was allowed to cool to about 90 °C. Then, 90 ml of boiled distilled water was added to the solution and mixed by shaking. If the solution is opaque or darker than a transparent yellow, saponification was repeated on a fresh test portion. Then 0.1 g pumice powder was added and 50 ml of sulfuric acid was added. The flask was then connected to the distillation kit. The flame was adjusted to gather 110 ml of distillate in 19 to 21 minutes. When the first drop emerged at the distill head's condenser end, it was considered that the distillation had begun. The distillate in the graduate flask was collected. The flame was extinguished as soon as the distillate precisely reached the flask's 110 ml mark, and a beaker was swiftly used in its stead. Then, the Graduated flask was stoppered and it was placed in a water bath that was held at 15°C. This was done for 10 minutes, keeping the 110 ml graduation 1 cm below the water level in the bath. Thereafter, the graduated flask was taken out of the water bath and outside was dried. In order to mix the contents, the flask was inverted four or five times without shaking, being careful not to wet the stopper with the insoluble acids. A dry, plain filter paper was then used to filter the liquid (the filtrate should be transparent). After pipetting 100 milliliters of filtrate, five drops of phenolphthalein were added. After that, a 0.1N sodium hydroxide solution was used for the titration. Additionally, a blank test was also conducted.

Following the titration of the soluble volatile acids, the distill head was detached, and 15 ml of water at 15 °C that had been boiled for 15 minutes was used to rinse the condenser. Then the washing

*Correspondence: suraji@sjp.ac.lk

in the beaker was collected. A graduated flask was rinsed with this liquid and was poured into the filter and was allowed all of it to pass through. This operation was repeated twice more, (15 ml of water x 2). The last wash should be collected separately and should require not more than one drop of alkali solution for neutralization. The aqueous washings were rejected. On a dry, clean flask, the funnel was set up. Three separate washings of the condenser, measuring cylinder, 110 ml flask with stopper, and filter paper with 15 ml of ethanol were used to dissolve the water-insoluble fatty acids. The washing was collected in the beaker. Following the addition of 5 drops of phenolphthalein to the beaker, a 0.1N sodium hydroxide solution was used to titrate the mixture.

Then, the following formula was used to determine the Reichert Meissl value. A – Volume in ml of the standard NaOH solution required for the test, B - Volume in ml of the standard NaOH solution required for the blank, N – Normality of the standard NaOH solution.

$$RMV = (A - B) \times N \times 11 \qquad \text{---------- (05)}$$

To determine the Polenske value, the following equation was used. V - Volume in ml of the standard NaOH solution required for the test, N - Normality of the standard NaOH solution.

$$P = 10 \times V \times N \qquad \text{---------- (06)}$$

2.3 Analysis of the Physical properties

2.3.1 Refractive index

The method specified by the 'AOAC (Association of Official Analytical Chemists) 17th edition, 2000, Official method', was used to analyze the IR. To get rid of impurities and moisture residues, the sample was melted and then filtered using filter paper. The sample's full dryness was ensured. Before inserting the fat sample, it should be heated up to 40 °C. The refractometer's temperature was set to the appropriate level. The prisms should be dry and clean. The oil sample was put in a few drops on the prism. The prisms were closed and allowed to stand for 1-2 min. To read as clearly as possible and determine the IR, the device and lighting were adjusted. To ensure that the test sample and instrument had the same temperature, the instrument was left to stand for a few minutes prior to reading. Between readings, prisms were cleaned using a soft cloth, following a cotton pad wet with solvent, to remove the oil. (e.g. toluene, trichloroethylene, pet ether).

2.4 Statistical Analysis

A completely randomized design with three replications was utilized in this study. The results are all shown as the means ± standard deviation. The Minitab '17 analytical software's one-way analysis of variance (ANOVA) was applied to differentiate the quality of milk fat from the three selected breeds with respect to PV, SV, AV, FFA, RMV, P and IR. P-value < 0.05 was utilized to indicate significant differences.

3. Results and Discussion

Lack of rules causes milk to be adulterated and consumers to be supplied with low quality milk, resulting in the compositional quality of milk being neglected. The graph in Figure 01 below shows the variation of the chemical composition of milk among the three breeds: local indigenous and locally raised Ayrshire and Holstein-Friesian.

The fat content varied between 3.48 ±0.07 and 5.53 ±0.01%, with locally grown Ayrshire cattle milk showing the highest value and the native Sri Lankan cattle breed reporting the lowest. Additionally, the protein content varied between 3.18 ±0.07 and 3.38 ±0.01%, with locally grown Ayrshire cattle milk showing the highest value while the native Sri Lankan cattle breed reporting the lowest. According to the graph, it can be clearly observed that the percentages of protein, fat, SNF, lactose, salts, and total solids are higher in locally developed pure European cattle breeds than in the native Sri Lankan cattle breed. The Ayrshire cattle breed ranks the top in all the test parameters. According to Ryabova et al. (2023) and Zinnatov et al. (2024) also Ayrshire breed is well known for

*Correspondence: suraji@sjp.ac.lk

its high fat and protein content (Ryabova et al., 2023; Zinnatov et al., 2024). Additionally, it was observed that the protein, lactose, SNF and salt percentages were almost similar for the two European breeds reared locally.

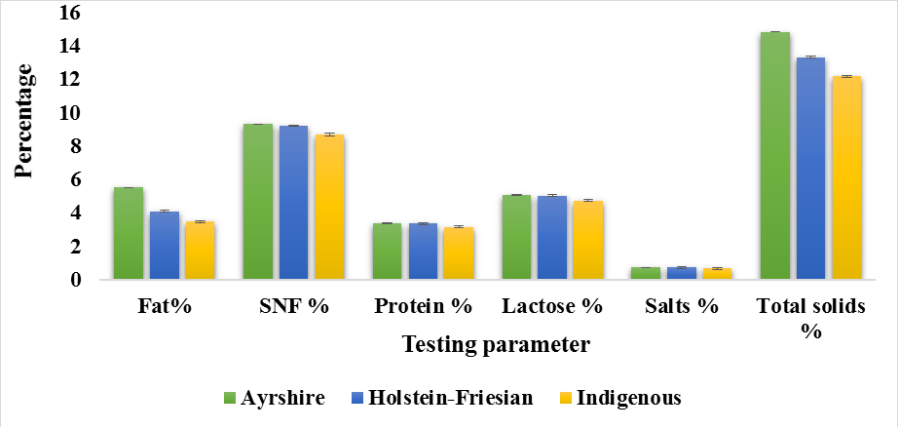


Figure 01: Fat, SNF, protein, lactose, salts and total solid percentages of milk.

The variation of physical properties: density and the freezing point of milk of the three cattle breeds is shown in the graphs below.

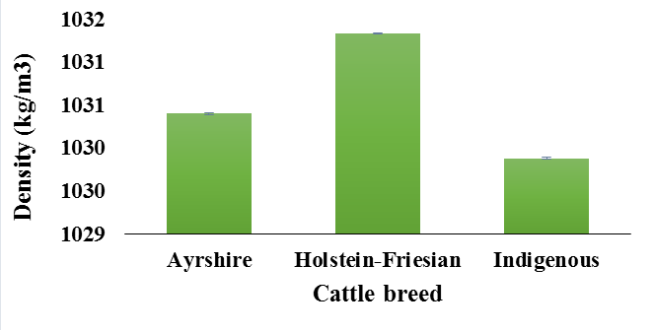


Figure 02: Densities of Ayrshire, Holstein-Friesian and Sri Lankan indigenous cattle milk.

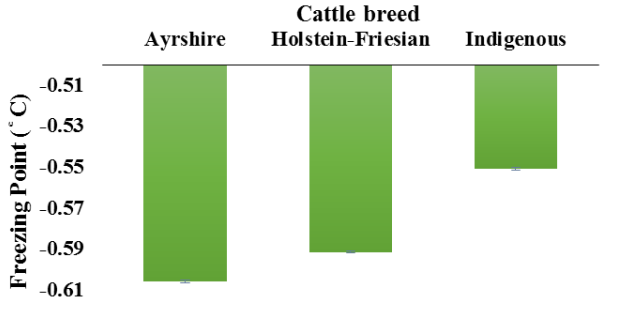


Figure 03: Freezing points of Ayrshire, Holstein-Friesian and Sri Lankan indigenous cattle milk.

According to Fox et al. (2015), at 20°C, milk has a density of about 1,030 kgm^{-3}. They further state that the mean density of Ayrshire cattle breed is 1031.70 kgm^{-3} and Holstein milk is 1033.00 kgm^{-3} (Fox et al., 2015). In our study also we observed a greater density value (1031.34 kgm^{-3}) for locally reared Holstein-Friesian cattle milk than that of Ayrshire breed (1030.41 kgm^{-3}). Densities varied between 1029.89 to 1031.34 kgm^{-3}, with locally grown Holstein-Friesian cattle breed reporting the highest, and the native breed reporting the lowest.

One crucial determinant of milk quality is its freezing point. Its primary purpose is to demonstrate that milk has been adulterated with water and to quantify the amount of water present (Wangdi et al., 2014). According to Henno et al. (2008) also, one of the quality parameters used to ensure high-quality milk is its freezing point. In this study, the freezing point of the three selected breeds, varied between -0.55 to -0.61 °C, with the lowest (-0.61 °C) being reported from the Ayrshire cattle breed reared locally. The other European breed, Holstein- Friesian also showed near freezing

*Correspondence: suraji@sjp.ac.lk

point value (-0.59 °C). The highest freezing point was recorded from Sri Lankan indigenous cattle breed.

The results obtained for physiochemical properties of milk fat (IR, P, RMV, FFA, AV, SV and PV) are given in Table 01. Results revealed significant differences *($p<0.05$)* in the SV, AV, FFA, RMV and P of the milk fat of Indigenous, Ayrshire and Holstein-Friesian cattle breeds. It was clear that the highest Peroxide value (1.40 ± 0.00 meqO2/kg), AV (0.67 ± 0.00 mg KOH/g) and FFA value (0.34 ± 0.00) was recorded from local indigenous milk fat while the highest saponification value (236.50 ± 0.22 mg KOH/g), Reichert Meissl Value (28.97 ± 0.06) and Refractive Index (1.46 ± 0.00) were recorded as significantly high ($p \leq 0.05$) in milk fat of the Ayrshire breed. Only the Polenske value (1.87 ± 0.06) was recorded as highest in milk fat of Holstein-Friesian cattle breed.

Table 01: Physicochemical characteristics of indigenous cattle breed of Sri Lanka with locally reared pure European cattle breeds: Ayrshire and Holstein-Friesian.

Physicochemical property	**Cattle breed**		
	Indigenous	**Ayrshire**	**Holstein-Friesian**
Peroxide value ($meqO_2/kg$)	1.40 ± 0.00^{a}	0.80 ± 0.00^{b}	0.80 ± 0.00^{b}
Saponification value (mgKOH/g)	224.95 ± 0.28^{b}	236.50 ± 0.22^{a}	227.91 ± 0.25^{c}
Acid value (mg KOH/g)	0.67 ± 0.00^{a}	0.45 ± 0.00^{b}	0.42 ± 0.00^{c}
Free fatty acid value	0.34 ± 0.00^{a}	0.22 ± 0.00^{b}	0.21 ± 0.00^{c}
Reichert Meissl value	28.46 ± 0.06^{b}	28.97 ± 0.06^{a}	27.68 ± 0.06^{c}
Polenske Value	1.83 ± 0.58^{a}	1.57 ± 0.06^{b}	1.87 ± 0.06^{a}
Refractive Index (at 40°C)	1.46 ± 0.00^{a}	1.46 ± 0.00^{a}	1.46 ± 0.00^{a}

- *Values are given as means with the standard deviation with each determination performed in triplicate.*
- *Significant differences are indicated by different letters (a-c) in the same row.*

The PV of dairy fats ranged from 0.80 – 1.40 $meqO_2/kg$ with the highest being reported for local indigenous cattle breed. European breeds raised locally showed similar PVs of 0.80 $meqO_2/kg$ each. Peroxide value is a crucial measure used to assess the early stages of oxidation. PV measures a temporary product of oxidation. It quantifies the total hydro peroxide (HP) content and is widely utilized to monitor lipid oxidation during the processing and storage of oils (Gotoh et al., 2007; Hori et al., 2019). Hydro-peroxide is referred to as the "first oxidative product" and is typically measured by its PV. The composition of fatty acids and their level of unsaturation determine how quickly hydro-peroxides are produced and accumulated (Garg et al., 2022). During the oxidation process, this initial product breaks down, leading to the formation of "secondary oxidative products" like aldehydes, ketones, and alcohols. These secondary products are responsible for the toxicity associated with oxidized lipids (Gotoh et al., 2006). When PV surpasses a critical threshold, edible oils can develop a rancid flavor and may pose a risk of food poisoning (Gotoh et al., 2011). Fresh oils typically have a peroxide value of less than 1 $meqO_2/kg$. Values exceeding 10 $meqO_2/kg$ indicate oil spoilage (Naseri et al., 2018). Bovine milk is susceptible to lipolysis and oxidation when exposed to heat treatments

*Correspondence: suraji@sjp.ac.lk

and during storage in the dairy industry (Dias et al., 2020). Therefore, the comparatively high PV in local Indigenous milk fat is possibly resulting from the greater presence of unsaturated fatty acids, since the storage conditions were similar for all the breeds.

SV ranged from 224.95 – 236.50 mgKOH/g with the highest being reported for the Ayrshire cattle breed reared locally while the lowest for local indigenous cattle breed. The SV is utilized to calculate a fat or oil's saponification number, reflecting the mean molecular weight of the triacylglyceride (TAG) in the sample. A lower SV indicates a longer or higher average fatty acid chain length. However, adulteration of fat or oil with unsaponifiable matter can decrease the saponification value (Abdulkadir et al., 2013). The highest SV of Ayrshire milk fat might be due to the prevalence of a high amount of short and medium chain FA. The AV quantifies the FFA in a fat or oil, determined by calculating amount of potassium hydroxide (in milligrams) needed to neutralize one gram of the FFA in the sample (Wenming et al., 2024). The amount of un-esterified FA in a lipid sample is determined analytically using AV and FFA to determine the sample's quality. The above results showing that the significantly high $(p \leq 0.05)$ FFA was noticed from the local Indigenous milk fat sample might be due to the hydrolysis of glyceraldehyde.

Dairy fat frequently has an RMV between 17 and 35, which is much greater than that of other fats and oils (Gandhi et al., 2014). In our study, the highest RMV (28.9667 ± 0.0635) was recorded from the milk fat of locally reared pure European cattle breed; Ayrshire while lowest (27.6833 ± 0.0635) was recorded from Indigenous cattle breed of Sri Lanka. In this case, butyric acid accounts for approximately three-fourths of the RMV, while caproic acid makes up roughly one-fourth Indigenous cattle breed of Sri Lanka. The Reichert Meissl value (RMV) is a significant indicator of the prevalence of short-chain fatty acids in diary fat, particularly caproic acid (6:0) and butyric acid (4:0) (Veena et al., 2021). Here, butyric acid accounts for approximately three-fourths of the RMV, while caproic acid makes up roughly one-fourth (Gandhi et al., 2014). Conversely, the lower chain volatile water-insoluble FA, specifically caprylic acid (C8:0) and capric acid (C10:0), are quantified by the Polenske value (Veena et al., 2021). This measurement is essential for differentiating between various fats, especially in confirming the purity of butterfat and identifying adulteration with non-dairy fats. The high concentration of short (C4: C10) chain FA in Ayrshire dairy fat may be the cause of the considerably elevated ($p < 0.05$) Reichert Meissl values.

Milk fats typically have low refractive indices due to their low degree of unsaturation. They contain a high proportion of saturated FA, particularly myristic acid and palmitic acid, and a lower amount of poly-unsaturated FA (Schennink et al., 2008). In this context, the relatively low refractive index of local Indigenous milk fat milk fat indicates a high content of saturated FA.

4. Conclusions

Variability in the compositional quality of milk and physicochemical characteristics of dairy fat of different cattle breeds are the result of genetic, physiological, nutritional and environmental factors. This study revealed that, European cattle breeds reared locally have better compositional quality than those of Sri Lankan indigenous cattle breed. Also, milk from European cattle breeds raised in Sri Lanka is more nutritious than that of native breeds. Additionally, this study revealed that among the three cattle breeds; local Indigenous and locally reared pure European cattle breeds: Ayrshire and the Holstein-Friesian, milk fat of the local indigenous cattle breed is more prone to oxidation.

5. Acknowledgement

The Research Council of the University of Sri Jayewardenepura, Nugegoda, Sri Lanka, provided the funding necessary to carry out the research. (Grant No.: ASP/ 01/ RE/ SCI/ 2022/026).

*Correspondence: suraji@sjp.ac.lk

6. References

Abdulkadir, A.G. and Jimoh, W.L.O., 2013. Comparative analysis of physico-chemical properties of extracted and collected palm oil and tallow. ChemSearch Journal, 4(2), pp.44-54.

Arnould, V.R. and Soyeurt, H., 2009. Genetic variability of milk fatty acids. Journal of Applied Genetics, 50, pp.29-39.

Babayan, V.K., Cochran, W.M., Coughlin, F.J., Jacob, W.A., Justice, J.D., Rini, S.J., Royce, H.D., Spannuth, H.T., Vander Wal, R.J. and Mattil, K.F., 1959. Composition of food fats and oils. Journal of the American Oil Chemists Society, 36(4), pp.181-182.

Bhavadharini, B., Dehghan, M., Mente, A., Rangarajan, S., Sheridan, P., Mohan, V., Iqbal, R., Gupta, R., Lear, S., Wentzel-Viljoen, E. and Avezum, A., 2020. Association of dairy consumption with metabolic syndrome, hypertension and diabetes in 147 812 individuals from 21 countries. BMJ Open Diabetes Research and Care, 8(1), p.e000826.

Czerniewicz, M., Kielczewska, K. and Kruk, A., 2006. Comparison of some physicochemical properties of milk from Holstein-Friesian and Jersey cows. Polish Journal of Food and Nutrition Sciences, 15(1), p.61.

Dewhurst, R.J., Shingfield, K.J., Lee, M.R. and Scollan, N.D., 2006. Increasing the concentrations of beneficial polyunsaturated fatty acids in milk produced by dairy cows in high-forage systems. Animal Feed Science and Technology, 131(3-4), pp.168-206.

Dias, F.F.G., Augusto-Obara, T.R., Hennebelle, M., Chantieng, S., Ozturk, G., Taha, A.Y., de Souza Vieira, T.M.F. and de Moura, J.M.L.N., 2020. Effects of industrial heat treatments on bovine milk oxylipins and conventional markers of lipid oxidation. Prostaglandins, Leukotrienes and Essential Fatty Acids, 152, p.102040.

Fantuz, F., Salimei, E. and Papademas, P., 2016. Macro-and micronutrients in non-cow milk and products and their impact on human health. Non-bovine milk and milk products, pp. 209-261.

Fox, P.F., Uniacke-Lowe, T., McSweeney, P.L.H., O'Mahony, J.A., Fox, P.F., Uniacke-Lowe, T., McSweeney, P.L.H. and O'Mahony, J.A., 2015. Physical properties of milk. Dairy chemistry and biochemistry, pp.321-343.

Gandhi, K., Upadhyay, N., Aghav, A.D., Lal, D. and Sharma, V., 2014. Detection of palm olein and sheep body fat adulteration in ghee (clarified milk fat) using Reichert-Meissl (RM) value coupled with solvent fractionation technique. Indian Journal of Dairy Science, 67(5), pp.387-393.

Gantner, V., Mijić, P., Baban, M., Škrtić, Z. and Turalija, A., 2015. The overall and fat composition of milk of various species. Mljekarstvo: časopis za unaprjeđenje proizvodnje i prerade mlijeka, 65(4), pp.223-231.

Garg, A., Sharma, R., Dey, P. and Kumar, A., 2022. Food auto-oxidation: An overview. Antioxidants Effects in Health, pp.43-68.

Gómez-Cortés, P., Juárez, M. and de la Fuente, M.A., 2018. Milk fatty acids and potential health benefits: An updated vision. Trends in Food Science & Technology, 81, pp.1-9.

Gotoh, N., Watanabe, H., Osato, R., Inagaki, K., Iwasawa, A. and Wada, S., 2006. Novel approach on the risk assessment of oxidized fats and oils for perspectives of food safety and quality. I. Oxidized fats and oils induces neurotoxicity relating pica behavior and hypoactivity. Food and Chemical Toxicology, 44(4), pp.493-498.

Gotoh, N., Iwasawa, A.I., Watanabe, H., Osato, R. and Wada, S., 2007. Oxidation of fats and oils in instant noodles stored under various conditions. Journal of Food Lipids, 14(4), pp.350-365.

Gotoh, N., Miyake, S., Takei, H., Sasaki, K., Okuda, S., Ishinaga, M. and Wada, S., 2011. Simple method for measuring the peroxide value in a colored lipid. Food Analytical Methods, 4, pp.525-530.

Hanuš, O., Samková, E., Křížová, L., Hasoňová, L. and Kala, R., 2018. Role of fatty acids in milk fat and the influence of selected factors on their variability- A review. Molecules, 23(7), p.1636.

*Correspondence: suraji@sjp.ac.lk

Hayes, B.J., Bowman, P.J., Chamberlain, A.J. and Goddard, M.E., 2009. Invited review: Genomic selection in dairy cattle: Progress and challenges. Journal of Dairy Science, 92(2), pp.433-443.

Heck, J.M.L., Van Valenberg, H.J.F., Dijkstra, J. and Van Hooijdonk, A.C.M., 2009. Seasonal variation in the Dutch bovine raw milk composition. Journal of Dairy Science, 92(10), pp.4745-4755.

Henno, M., Ots, M., Jõudu, I., Kaart, T. and Kärt, O., 2008. Factors affecting the freezing point stability of milk from individual cows. International Dairy Journal, 18(2), pp.210-215.

Hori, K., Koh, F.H. and Tsumura, K., 2019. A metabolomics approach using LC TOF-MS to evaluate oxidation levels of edible oils. Food Analytical Methods, 12, pp.1799-1804.

Huth, P.J. and Park, K.M., 2012. Influence of dairy product and milk fat consumption on cardiovascular disease risk: a review of the evidence. Advances in nutrition, 3(3), pp.266-285.

Jenkins, T.C. and McGuire, M.A., 2006. Major advances in nutrition: impact on milk composition. Journal of Dairy Science, 89(4), pp.1302-1310.

Jensen, R.G., 2002. The composition of bovine milk lipids: January 1995 to December 2000. Journal of Dairy Science, 85(2), pp.295-350.

Komlyk, I. and Grishina, N., 2024. The relationship between the milk productivity of cows and their daughters in an Ayrshire herd in the conditions of North-West Russia. In E3S Web of Conferences (Vol. 510, p. 01039). EDP Sciences.

Kumar, D., Rai, D., Porwal, P. and Kumar, S., 2018. Compositional quality of milk and its contaminants on physical and chemical concern: a review. International Journal of Current Microbiology and Applied Sciences 7(5), pp.1125-1132.

Lim, S.H., Kim, H.R., Choi, S.J. and Moon, T.W., 2015. Lipid oxidation of sodium caseinate-stabilized emulsion-gels prepared using microbial transglutaminase. Food Science and Biotechnology, 24, pp.2023-2026.

Miglior, F., Fleming, A., Malchiodi, F., Brito, L.F., Martin, P. and Baes, C.F., 2017. A 100-Year Review: Identification and genetic selection of economically important traits in dairy cattle. Journal of Dairy Science, 100(12), pp.10251-10271.

Naseri, S., Mahmoudian, M.H., Yari, A.R., Molaghen, S. and Mahmoodian, Z., 2018. Evaluation of peroxide value and acid number of edible oils consumed in the sandwich and fast food shops of qom, Iran in 2016. Archives of Hygiene Sciences, 7(2), pp.91-97.

Ozturk, S. and Cakmakci, S., 2006. The effect of antioxidants on butter in relation to storage temperature and duration. European Journal of Lipid Science and Technology, 108(11), pp.951-959.

Palladino, R.A., Buckley, F., Prendiville, R., Murphy, J.J., Callan, J. and Kenny, D.A., 2010. A comparison between Holstein-Friesian and Jersey dairy cows and their F1 hybrid on milk fatty acid composition under grazing conditions. Journal of Dairy Science, 93(5), pp.2176-2184.

Pike, O.A. and O'Keefe, S., 2017. Fat characterization, in: Nielsen S.S. (Eds.) Food Analysis, Food Science Text Series. Springer, Cham, USA, pp.407-429. https://doi.org/10.1007/978-3-319-45776-5_23

Ryabova, A.E., Pozovnikova, M.V., Dementieva, N.V., Shcherbakov, Y.S., Tulinova, O.V., Romanova, E.A. and Azovtseva, A.I., 2023. Analysis of the genetic diversity of Ayrshire cattle in Russia. Message 2. Genome analysis based on data on the distribution of ROH patterns in Ayrshire cows. Ecological genetics, 21(3), pp.235-248.

Sanjayaranj, I., Lopez-Villalobos, N., Blair, H.T., Janssen, P.W., Holroyd, S.E. and MacGibbon, A.K., 2022. Effect of breed on the fatty acid composition of milk from dairy cows milked once and twice a day in different stages of lactation. Dairy, 3(3), pp.608-621.

Schennink, A., Heck, J.M., Bovenhuis, H., Visker, M.H., van Valenberg, H.J. and van Arendonk, J.A., 2008. Milk fatty acid unsaturation: genetic parameters and effects of stearoyl-CoA desaturase (SCD1) and acyl CoA: diacylglycerol acyltransferase 1 (DGAT1). Journal of Dairy Science, 91(5), pp.2135-2143.

**Correspondence: suraji@sjp.ac.lk*

Schwendel, B.H., Morel, P.C.H., Wester, T.J., Tavendale, M.H., Deadman, C., Fong, B., Shadbolt, N.M., Thatcher, A. and Otter, D.E., 2015. Fatty acid profile differs between organic and conventionally produced cow milk independent of season or milking time. Journal of Dairy Science, 98(3), pp.1411-1425.

Sharma, R., Gandhi, K., Battula, S.N. and Mann, B., 2020. Detection of milk fat adulteration, in: Truong, T., Lopez, C., Bhandari, B., Prakash, S. (Eds.) Dairy Fat Products and Functionality: Fundamental Science and Technology, Springer, Cham, Switzerland, pp.109-131. https://doi.org/10.1007/978-3-030-41661-4_6

Shingfield, K.J., Chilliard, Y., Toivonen, V., Kairenius, P. and Givens, D.I., 2008. Trans fatty acids and bioactive lipids in ruminant milk, in: Bösze Z. (Eds.), Bioactive Components of Milk, Springer, Switzerland, pp.3-65.

Silva, G.L.L.P., Punyawardena, B.V.R., Hettiarachchi, A.K., Hulugalla, W.M.M.P. and Lokuge, G.M.S., 2021. Assessing thermal neutral zones in Sri Lanka for ten different dairy cattle breeds and crosses: An approach using temperature humidity index (THI). International Journal of Livestock Production, 12(2), pp.112-121.

Silva, P., Jianlin, H., Hanotte, O., Chandrasiri, A.D.N. and Herath, H.M.S.P., 2010. Indigenous cattle in Sri Lanka: production systems and genetic diversity. Edited by NE Odongo, M. Garcia & GJ Viljoen, p.45.

Soyeurt, H., Dardenne, P., Gillon, A., Croquet, C., Vanderick, S., Mayeres, P., Bertozzi, C. and Gengler, N., 2006. Variation in fatty acid contents of milk and milk fat within and across breeds. Journal of Dairy Science, 89(12), pp.4858-4865.

Stoop, W.M., Bovenhuis, H., Heck, J.M.L. and Van Arendonk, J.A.M., 2009. Effect of lactation stage and energy status on milk fat composition of Holstein-Friesian cows. Journal of Dairy Science, 92(4), pp.1469-1478.

Veena, N., Hundal, J.S., Wadhwa, M. and Puniya, A.K., 2021. Factors affecting the milk yield, milk composition and physico-chemical parameters of ghee in lactating crossbred cows. Indian Journal of Dairy Science, 74(1), pp 68-73.

Vilr, M. and Niaz, S., 2024. Climate-Smart Livestock Breeding: A Study of Holstein-Friesian Cattle in Canada and Pakistan. International Journal of Agricultural Innovations and Cutting-Edge Research, 2(1), pp.34-47.

Wang, F., Chen, M., Luo, R., Huang, G., Wu, X., Zheng, N., Zhang, Y. and Wang, J., 2022. Fatty acid profiles of milk from Holstein cows, Jersey cows, buffalos, yaks, humans, goats, camels, and donkeys based on gas chromatography–mass spectrometry. Journal of dairy science, 105(2), pp.1687-1700.

Wangdi, J., Dema, T., Karma, M. and Bhujel, P., 2014. The compositional quality of cows milk in Bhutan. J. Issues ISSN, 2350, p.1588.

Wenming, C., Yuyang, Z., Tingting, W., Tong, L. and Guolong, Y., 2024. Determination of Free Fatty Acids in Foodstuff by Solid Phase Extraction and Gas Chromatography-Flame Ionization Detection Using H2SO4-MeOH Derivatization. Food Analytical Methods, 17(10), pp.1446-1454.

Wijeweera, W.P.S.N., Kalpani, P.G.M., Sudarshani, K.A.M. and Wegiriya, H.C.E., 2014. A study on Sri Lankan native cattle in Southern Province, Sri Lanka. Int. J. Environ. Sci. Technol, 3(6), pp.2184-2189.

Zinnatov, F., Yakupov, T., Kharisova, C., Kamaldinov, I., Mullakaev, O., Trubkin, A., Smolentsev, S., Hardina, E., Berezkina, G., Yakimova, V. and Yakimov, M., 2024. Breeding and productive qualities of Ayrshire cattle. In BIO Web of Conferences (Vol. 113, p. 02008). EDP Sciences. https://doi.org/10.1051/bioconf/202411302008

**Correspondence: suraji@sjp.ac.lk*