COMPOSITION, YIELD AND FREEZING POINT OF COLOSTRUM AND MILK FROM HOLSTEIN × SAHIWAL COWS IN A COMMERCIAL DAIRY FARM IN BAY, LAGUNA, PHILIPPINES

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ABSTRACT

This study compared the milk components and freezing point of 184 colostrum and milk samples obtained on the 30th, 60th, and 90th day in lactation of 46 Holstein × Sahiwal cows on a commercial dairy farm in Bay, Laguna. Colostrum contained 4 times higher percent protein and 1.1–1.4 times higher percent fat but 1.66–1.95 times lower percent lactose than milk. The freezing point was not significantly different between colostrum and milk (*P*>0.05). The proportion of milk components and freezing point were not significantly different in milk collected on different days of lactation. Cows at higher parity had higher protein and lower percent lactose in colostrum, and higher percent fat in milk. In colostrum, percent fat was positively correlated with percent protein (r = 0.37) and SNF (r = 0.35). The proportion of the components of colostrum, however, was not significantly correlated to colostrum yield and freezing point (*P*>0.05). The protein, fat, and lactose yields were positively correlated with colostrum yield but not correlated with freezing point (*P*>0.05). In milk, percent protein was positively correlated with percent lactose (r = 0.53), SNF (r = 0.70), and total solids (r = 0.60), negatively correlated with freezing point (r = -0.72), but not correlated with percent fat (*P*>0.05). Milk yield was not significantly correlated to protein, fat, and lactose percent. The protein and lactose yields were highly correlated with milk yield and freezing point. The fat yield was moderately correlated with milk yield but not correlated with the freezing point. Milk freezing point was positively correlated with percent moisture and fat but negatively correlated with percent protein, lactose, SNF, and total solids.

Keywords: colostrum, freezing point, Holstein × Sahiwal cows, milk composition

INTRODUCTION

Cows' milk is an important source of many essential nutrients such as high-quality proteins, calcium, fat-soluble vitamins and carotenoids, bioactive peptides, essential fatty acids, sphingolipids as well as other compounds with many benefits to human health (Rodríguez-Alcala *et al*., 2017). Colostrum – The first secretion of the mammary gland produced after calving, has also been used for human consumption as a functional food

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alternative or in medicinal therapies. Colostrum contains bioactive components with immune-enhancing properties such as immunoglobulins, lactoferrin, lysozyme, lactoperoxidase, α-lactalbumin, β-lactoglobulin, fat that carries important vitamins, and polyunsaturated fatty acids (Puppel *et al*., 2019). Colostrum also has potential probiotic properties and immunomodulator, antioxidant, and anticancer activities (Ceniti *et al*., 2022). However, the protein, fat, and lactose components in colostrum and milk have also been associated with possible human health problems such as heart diseases, weight gain, and obesity (Haug *et al*., 2007), hypercholesterolemic effects of certain fatty acids (Masek *et al*., 2014), lactose intolerance and milk protein allergy especially in children (Pereira, 2014).

In general, colostrum contains less lactose and more fat, protein, peptides, non-protein nitrogen, ash, vitamins and minerals, hormones, growth factors, cytokines, and nucleotides than mature milk (McGrath *et al*., 2016). However, the composition of colostrum is variable due to breed, season, production system, parity, pre-partum diet, dry-period length, vaccination of the dam, delayed colostrum collection, abortions, or health status of the cow (Puppel *et al*., 2019). Milk composition is likewise inconsistent and depends on the stage of lactation, age, breed, nutrition, energy balance, and health status of the udder (Haug *et al*., 2007). Furthermore, most reports reviewed dealt with comparisons during the transition of colostrum and mature milk (not more than 30 days after calving) obtained from different cows belonging to one or a few breeds of dairy cattle.

Information on the components and freezing point of colostrum and milk may be used to improve the manufacturing and processing of dairy products, whose nutritional value will not only conform to the government or country dietary guidelines but also promote their benefits to human health as nutraceuticals (Jenkins and McGuire, 2006). However, such information from adapted breeds is scarce in the Philippines, where the dairy cattle population in 2020 is 24,755 heads out of the national cattle inventory of 2.596 million heads. In the same year, a total of 26.71 million liters (LME) of milk valued at 1.2 billion pesos were produced from different dairy cattle breeds or crossbreeds (NDA, 2021). In this regard, this study compared the composition, yield, and freezing point of colostrum and subsequent milk collected on the 30th, 60th, and 90th day of lactation of Holstein × Sahiwal cows on a commercial dairy farm in Bay, Laguna, Philippines.

MATERIALS AND METHODS

This study was conducted at the Institute of Animal Science (IAS), College of Agriculture and Food Science (CAFS), University of the Philippines Los Baños (UPLB) in compliance with the requirements of the UPLB Institutional Animal Care and Use Committee with Assigned Protocol No. 2019-0034.

A total of 184 colostrum and mature milk samples were collected from 46 Holstein × Sahiwal cows that calved within a one-year period (i.e., 03 February 2020 to 21 February 2021) at the Real Fresh Dairy Farm in Bay, Laguna, see Table 1. Cows were managed to fulfill all welfare requirements and were kept in individual parturition pens about 2 weeks before calving. Cows were fed with forage and commercial lactating feed concentrates.

Approximately 500 ml of colostrum obtained within 24 hr after calving and mature milk samples collected by hand or milking machine on the 30th, 60th, and 90th day of lactation, were placed in PET plastic bottles, and immediately frozen at –20°C until further analysis. The MilkoScan Mars (FOSS Analytical A/S, Hillerod, Denmark) using the

Table 1. Simple descriptive statistics for composition, freezing point, and test-day yield of colostrum and milk from Holstein × Australian Friesian Sahiwal crossbred cows.

	N	Average ± S.D.	Range of Values
Colostrum			
% Moisture	46	79.63 ± 7.65	65.91 – 92.43
% Protein	46	3.33 ± 2.28	0.07 – 8.70
% Fat	46	11.95 ± 6.12	0.74 – 23.14
% Lactose	46	2.67 ± 1.05	0.18 – 4.66
% Solids non-fat	46	16.24 ± 4.99	6.47 – 25.31
% Total solids	46	20.37 ± 7.65	7.57 – 34.09
Protein yield, kg	46	0.609 ± 0.581	0.033 – 2.835
Fat yield, kg	46	0.172 ± 0.190	0.002 – 0.764
Lactose yield, kg	46	0.120 ± 0.086	0.010 – 0.438
Freezing point	46	-0.471 ± 0.096	-0.688 – -0.295
Colostrum yield, kg	46	4.74 ± 3.27	1.16 – 15.74
Mature milk*			
% Moisture	138	89.20 ± 1.84	81.44 – 95.47
% Protein	138	2.99 ± 0.64	0.90 – 6.54
% Fat	138	2.62 ± 1.33	0.81 – 9.92
% Lactose	138	4.37 ± 0.77	1.55 – 6.50
% Solids non-fat	138	8.17 ± 1.64	1.39 – 15.64
% Total solids	138	10.80 ± 1.84	4.53 – 18.56
Protein yield, kg	138	0.489 ± 0.187	0.038 – 1.055
Fat yield, kg	138	0.425 ± 0.243	0.035 – 1.413
Lactose yield, kg	138	0.730 ± 0.287	0.033 – 1.470
Freezing point, °C	138	-0.467 ± 0.80	-0.689 – -0.147
Test-day milk yield, kg	138	16.56 ± 5.66	1.23 – 28.82
Other cow data			
Age at first calving, years	46	2.52 ± 0.58	1.67 – 4.25
Age at calving, years	46	4.63 ± 2.92	1.92 – 12.24
Parity	46	2.74 ± 2.22	1 – 8
Calf birth weight, kg	46	32.34 ± 3.18	23.62 – 39.60

*Milk obtained on the 30th, 60th, and 90th day of lactation.

Fourier-transform infrared spectroscopy (FTIR) technology was used to determine percent protein, percent fat, percent lactose, percent solids non-fat (SNF), percent total solids, and freezing point (°C). The protein, fat, and lactose yield were each computed as Component yield = % Component × Colostrum or test-day milk yield (kg). Other cow and calf data were also recorded including colostrum/test-day milk yield, age at first calving, age at calving, parity, and calf birth weight.

Pearson product-moment correlation coefficients among the proportion and yield of components (moisture, protein, fat, lactose, solids non-fat (SNF), and total solids) and freezing point, were determined separately for colostrum and mature milk samples using the CORR procedure (SAS, 2009).

The general least squares procedures for unbalanced data (SAS, 2009) were used to examine the principal sources of variation affecting each colostrum or mature milk component and freezing point. Statistical significance was set at $P<0.05$. The mathematical model was as follows: $y_{ijk} = \mu + MType_i + Parity_j + e_{ijk}$, where y_{ijklm} is the proportion of components and freezing point of colostrum and mature milk samples, μ is the overall mean, $MType_i$ is the fixed effect for the ith type of milk (i.e., colostrum and mature milk collected on the 30th, 60th, and 90th day of lactation), $Parity_j$ is the jth covariate effect of parity (number of lactations), and e_{ijk} is the error term. Age at first calving, age at calving, and calf birth weight had no significant effects on the proportion and yield of milk components and thus were not included in the final statistical model.

RESULTS

Percent protein in bovine colostrum was positively correlated with protein yield (r = 0.63). Percent fat was positively correlated with fat yield (r = 0.70). However, percent lactose was not correlated with lactose yield (Table 2). Percent protein was positively correlated with percent fat (r = 0.37), while percent lactose was negatively correlated with percent protein (r = -0.86) and percent fat (r = -0.39). Percent total solids in bovine colostrum was positively correlated with percent protein (r = 0.93) and percent fat (r = 0.61), but negatively correlated with percent lactose (r = -0.80). Protein yield was positively correlated with fat yield (r = 0.76), and lactose yield (r = 0.43). Lactose yield was also positively correlated with fat yield (r = 0.47).

The freezing point was not correlated to the proportion and yield of the components of bovine colostrum ($P>0.05$).

Percent protein in cows' milk was positively correlated with protein yield (r = 0.30). Percent fat was positively correlated with fat yield (r = 0.73). Percent lactose was also correlated with lactose yield (r = 0.52), see Table 3. Percent protein was not correlated with percent fat ($P>0.05$). Percent lactose was positively correlated with percent protein (r = 0.53) but negatively correlated with percent fat (r = -0.18). Percent total solids in cows' milk was positively correlated with percent protein (r = 0.69), percent fat (r = 0.55), and percent lactose (r = 0.52). Protein yield was positively correlated with fat yield (r = 0.41), and lactose yield (r = 0.94). Lactose yield was also positively correlated with fat yield (r = 0.42).

For mature milk, freezing point was positively correlated with percent fat (r = 0.17), but negatively correlated with total solids (r = -0.59), percent protein (r = -0.72), and percent lactose (r = -0.94). The freezing point was also negatively correlated with protein yield (r = -0.45) and lactose yield (r = -0.46), but not correlated with fat yield ($P>0.05$).

Colostrum yield was positively correlated with protein yield (r = 0.84), fat yield (r = 0.76), and lactose yield (r = 0.83), but not correlated to percent protein, percent fat, and percent lactose ($P>0.05$). Protein yield was positively correlated with age at calving (r = 0.40) and parity, but not correlated to age at first calving and calf birth weight ($P>0.05$). Both fat yield and lactose yield were not correlated with age at first calving, age at calving, parity, and calf birth weight. On the other hand, age at first calving, age at calving, and parity were positively correlated with percent protein (r = 0.32, 0.34, and 0.34, respectively), but negatively correlated with percent fat (r = -0.35, -0.32, and -0.29, respectively), see Table 2.

Cows' test-day milk yield was positively correlated with protein yield (r = 0.85), fat yield (r = 0.53), and lactose yield (r = 0.89), but not correlated to percent protein, percent fat, and percent lactose (P>0.05). Protein yield was negatively correlated with age at first calving (r = -0.22) and parity, but not correlated to age at calving, parity, and calf birth weight (P>0.05). The fat yield was not correlated with age at first calving, age at calving, parity, and calf birth weight. On the other hand, age at first calving, age at calving, parity, and calf birth weight were correlated with percent protein (r = 0.22, 0.25, 0.23, and -0.26, respectively), but not correlated with percent fat and percent lactose (P>0.05), see Table 3.

Percent protein and fat were the most variable of the components of colostrum and mature milk with a coefficient variation (CV) of 58.70% and 56.87%, respectively, followed by percent lactose (CV = 21.18%), and percent moisture (CV = 4.70%), see Table 4. The proportion and yield of the different components were significantly different (P<0.01) between colostrum and milk obtained on the 30th, 60th, and 90th day of lactation. Differences in freezing point, however, were small.

Parity had significant effects on milk components suggesting that Holstein × Sahiwal cows at higher parity had higher protein and SNF percent (and lower percent lactose) in colostrum, and higher percent fat in milk.

DISCUSSION

Colostrum yield (4.74 kg) was lower than test-day milk yield (14.52–17.65 kg/d), see Table 5. Nonetheless, the quantity of colostrum produced by a cow is still much higher than the requirement of the calf (McGrath *et al*., 2016). For Holstein × Sahiwal cows used in this study, the mature milk yield collected on the 30th, 60th, and 90th day in lactation was about 3.06–3.72 times higher than in colostrum. By comparison, Ontsouka *et al*. (2003) reported that milk yield about a month after calving was only 2.02 times higher compared to the colostrum yield of Red Holstein × Simmental cows in Switzerland.

Bovine colostrum usually contains more protein (14.9%) than mature milk (3.1%) Ceniti *et al*. (2022). The large difference in protein concentration is because colostrum is rich in immunoglobulins that are needed in the development of the immune system of the newborn calf. Colostrum is thus the sole source of initially acquired immunity for the calf. It contains elevated levels of immunoglobulins – IgG, IgA, and IgM (Stelwagen *et al*., 2009), which comprise 70–80% of the total protein in colostrum (McGrath *et al*., 2016).

For Holstein × Sahiwal cows used in this study, percent protein was higher in colostrum (11.95%) than in mature milk (2.95–3.05%), i.e., 3.92–4.05 times higher in colostrum than in mature milk. Percent protein was not significantly different in cows' milk collected on the 30th, 60th, and 90th day of lactation. However, protein yield was only 1.17–1.39 times higher in colostrum than in milk. By comparison, Ontsouka *et al*. (2003) reported that the concentration of milk protein was about 1.60 times higher in colostrum compared to later in lactation in Red Holstein × Simmental cows. The high total protein concentration in colostrum was largely due to high amounts of IgG. The lower protein concentration in mature milk was likely in part due to dilution resulting from increased milk production. Morrill *et al*. (2012) reported a higher average protein content of colostrum (12.5–12.6%) in Holstein and Jersey herds in the U.S.

Table 2. Pearson correlation coefficients among the composition, yield, and freezing point of bovine colostrum and their relationships with cow and calf records.

	Colostrum Parameters									
	% Moisture	% Protein	% Fat	% Lactose	% Solids Non-Fat	% Total Solids	Protein Yield	Fat Yield	Lactose Yield	Freezing Point
% Moisture	–	-0.93**	-0.61**	-0.81**	-0.90**	-1.00**	-0.61**	-0.47**	ns	ns
% Protein		–	0.37*	-0.86**	0.96**	0.93**	0.63**	0.35*	ns	ns
% Fat			–	-0.39**	0.35*	0.61**	0.32*	0.70**	ns	ns
% Lactose				–	-0.80**	-0.80**	-0.54*	-0.35*	ns	ns
% Solids non-fat					–	0.90**	0.65**	0.38*	ns	ns
% Total solids						–	0.61**	0.47**	ns	ns
Protein yield							–	0.76**	0.43**	ns
Fat yield								–	0.47**	ns
Lactose yield									–	ns
Colostrum yield	ns	ns	ns	ns	ns	ns	0.84**	0.76**	0.83**	ns
Age at first calving	ns	0.32*	ns	-0.35*	ns	ns	ns	ns	ns	0.36*
Age at calving	ns	0.34*	ns	-0.32*	0.34*	ns	0.40**	ns	ns	0.36*
Parity	ns	0.34*	ns	-0.29*	0.35*	ns	0.38**	ns	ns	ns
Calf birth weight	ns	ns	ns	ns	ns	ns	ns	ns	ns	-0.32*

ns means the correlation coefficient (r) is not significantly different from zero ($P>0.05$).
*Correlation coefficient (r) is significantly different from zero ($P<0.05$).
**Correlation coefficient (r) is highly significantly different from zero ($P<0.01$).

Table 3. Pearson correlation coefficients among the composition, yield, and freezing point of bovine milk obtained on the 3^{0th}, 60^{th}, and 90^{th} day of lactation and their relationships with cow and calf records.

	Mature Milk Parameters									
	% Moisture	**% Protein**	**% Fat**	**% Lactose**	**% Solids Non-Fat**	**% Total Solids**	**Protein Yield**	**Fat Yield**	**Lactose Yield**	**Freezing Point**
% Moisture	–	-0.69**	-0.55**	-0.52**	-0.53**	-1.00**	-0.20*	-0.32**	ns	0.59*
% Protein		–	ns	0.53**	0.70**	0.69**	0.30**	ns	ns	-0.72**
% Fat			–	-0.18*	ns	0.55**	ns	0.73**	ns	0.17*
% Lactose				–	0.74**	0.52**	0.47**	ns	0.52**	-0.94**
% Solids non-fat					–	0.90**	0.37**	ns	0.33**	-0.79**
% Total solids						–	0.20*	0.32**	ns	-0.59**
Protein yield							–	0.41**	0.94**	-0.45**
Fat yield								–	0.42**	ns
Lactose yield									–	-0.46**
Test-day milk yield	ns	ns	ns	ns	ns	ns	0.85**	0.53**	0.89**	ns
Age at first calving	ns	ns	0.22*	ns	ns	ns	-0.22*	ns	-0.24**	ns
Age at calving	ns	ns	0.25**	ns	ns	ns	ns	ns	ns	ns
Parity	ns	ns	0.23**	ns	ns	ns	ns	ns	ns	ns
Calf birth weight	ns	ns	-0.26**	ns	ns	ns	ns	ns	ns	ns

ns means the correlation coefficient (r) is not significantly different from zero ($P>0.05$).
*Correlation coefficient (r) is significantly different from zero ($P<0.05$).
**Correlation coefficient (r) is highly significantly different from zero ($P<0.01$).

Table 4. Mean square F test results for the effects of milk type and covariate effect of parity on the composition, yield, and freezing point of colostrum and milk from Holstein × Australian Friesian Sahiwal crossbred cows.

	Milk type	Parity	Regression coefficient ($b_{y.x}$)	Coefficient of variation (%)
% Moisture	**	*	-0.33 ± 0.14	4.70
% Protein	**	*	0.25 ± 0.10	58.70
% Fat	**	*	0.13 ± 0.05	56.87
% Lactose	**	*	-0.07 ± 0.03	21.18
% Solids non-fat	**	ns	-	28.06
% Total solids	**	*	0.34 ± 0.14	30.94
Protein yield	**	ns	-	63.51
Fat yield	**	ns	-	63.85
Lactose yield	**	ns	-	42.07
Colostrum/ test-day milk yield	**	ns	-	37.08
Freezing point	**	*	0.006 ± 0.003	18.02

b is the regression of parity on colostrum/milk components and freezing point.
ns refers to no significant effect of the independent variable (*P*>0.05).
*refers to highly significant effect of the independent variable (*P*<0.05).
**refers to highly significant effect of the independent variable (*P*<0.01).

Table 5. Composition, yield, and freezing point of bovine colostrum and of milk collected on different days of lactation.

	Colostrum	30-d Milk	60-d Milk	90-d Milk
% Moisture	79.62 ± 0.60[b]	89.62 ± 0.60[a]	89.11 ± 0.60[a]	88.86 ± 0.60[a]
% Protein	11.95 ± 0.45[a]	2.95 ± 0.45[b]	2.97 ± 0.45[b]	3.05 ± 0.45[b]
% Fat	3.33 ± 0.23[a]	2.37 ± 0.23[b]	2.59 ± 0.23[b]	2.92 ± 0.23[ab]
% Lactose	2.67 ± 0.12[b]	4.43 ± 0.12[a]	4.42 ± 0.12[a]	4.29 ± 0.12[a]
% Solids non-fat	16.24 ± 0.42[a]	8.27 ± 0.42[b]	8.15 ± 0.42[b]	8.09 ± 0.42[b]
% Total solids	20.37 ± 0.60[a]	10.38 ± 0.60[b]	10.89 ± 0.60[b]	11.14 ± 0.60[b]
Freezing point, °C	–0.471 ± 0.012[a]	–0.473 ± 0.012[a]	–0.467 ± 0.012[a]	–0.461 ± 0.012[a]
Protein yield, kg/d	0.61 ± 0.05[a]	0.51 ± 0.05[b]	0.52 ± 0.05[b]	0.44 ± 0.05[c]
Fat yield, kg/d	0.17 ± 0.03[b]	0.40 ± 0.03[a]	0.45 ± 0.03[a]	0.42 ± 0.03[a]
Lactose yield, kg/d	0.12 ± 0.04[c]	0.79 ± 0.04[a]	0.78 ± 0.04[a]	0.62 ± 0.04[b]
Colostrum/ test-day milk yield, kg	4.74 ± 0.74[c]	17.52 ± 0.74[a]	17.65 ± 0.74[a]	14.52 ± 0.74[b]

[abc]Least-square means in the same row with different letter superscripts are significantly different (*P*<0.05).

Among all milk constituents, fat has the greatest economic value because it is directly connected with the flavor and chemical-physical properties of milk and dairy products (Samkova *et al*., 2012). In a recent review by Ceniti *et al*. (2022), colostrum contains more fat (6.7%) than mature milk (4.0%). A very wide range (1.0–21.7%) of the average fat content of colostrum (5.6%), however, has been reported by Kehoe *et al*. (2007) and Morrill *et al*. (2012). Fat content was greatest in colostrum samples collected from Holstein and Jersey cattle during their first lactation (Morrill *et al*., 2012).

In this study, percent fat was higher in colostrum (3.33%, ranging from 0.74–23.14%) than in mature milk collected on the 30th, 60th, and 90th day of lactation (2.37–2.92%). Percent fat was not significantly different in cows' milk collected on the 30th, 60th, and 90th day of lactation. While percent fat was about 1.14–1.40 times higher in colostrum than in milk, the fat yield was 2.35–2.65 times higher in milk than in colostrum. By comparison, Ontsouka *et al*. (2003) reported that percent fat in colostrum was 1.22 times higher than in milk of Red Holstein × Simmental cows.

Lactose is the most representative carbohydrate and primary source of energy for the calf (Claeys *et al*., 2014). The lactose content is lower in early postpartum milking, changing inversely to other constituents (Kehoe *et al*., 2007; Morill *et al*., 2012).

In this study, percent lactose was lower in colostrum (2.67%) than in mature milk (4.29–4.43%). Percent lactose was not significantly different in cows' milk collected on the 30th, 60th, and 90th day of lactation. Percent lactose was about 1.61–1.66 times higher in cows' milk than in colostrum. Milk contained 2.35–6.58 times more lactose than colostrum. This is in agreement with Ceniti *et al*. (2022) who reported that colostrum contains less lactose (2.5%) than mature milk (5.0%). While Morrill *et al*. (2012) reported a very wide range (1.2–4.6%) of average lactose content of colostrum (2.9%), Ontsouka *et al*. (2003) reported that percent lactose in milk was 1.14 times higher than in colostrum of Red Holstein × Simmental cows.

As an indicator of milk quality, the freezing point is determined primarily to prove milk adulteration with water and to determine the amount of water in it. As milk is more diluted, the freezing point will elevate closer to zero (Otwinowska-Mindur *et al*., 2017). Other than the presence of extraneous water in milk, the freezing point is also affected by the water-soluble components of milk, in large part due to lactose content, which can be responsible for 53.8% of the reduction in freezing point (Zagorska and Ciprovica, 2013).

This study found no significant correlation of freezing point with percent and yield of the different components in colostrum. However, freezing point of mature milk was positively correlated with percent fat (r = 0.17) but negatively correlated with percent protein (r = -0.72), percent lactose (r = -0.94), percent SNF (r = -0.79), and percent total solids (r = -0.59). This implies that the freezing point of milk depends upon the concentration of water-soluble components, mainly lactose, and protein. By comparison, Zagorska and Ciprovica (2013) cited the concentration of lactose as the main factor influencing the freezing point of milk samples obtained from a conventional dairy herd in Latvia. On the other hand, Kedzierska Matysek *et al*. (2011) showed that breed differences in freezing point were mainly due to the protein content of milk from Polish Holstein-Friesian Black-White and Red-White, Simmental, Jersey, Polish Red, and Polish Black-White.

The freezing point was not significantly different between colostrum and mature milk (P>0.05), and among mature milk obtained on the 30th, 60th, and 90th day of lactation (P>0.05). While the freezing point of colostrum is not commonly studied, a lower freezing point of milk (–0.533ºC) was reported by Otwinowska-Mindur *et al*. (2017). Other than the breed, stage of lactation and dairy cow's nutrition, Zagorska and Ciprovica (2013) reported that the freezing point may vary by climatic conditions and regional, and seasonal influences in different countries. For example, the freezing point of milk was lower in the US (–0.550°C to –0.512°C), UK (–0.539°C), Italy (–0.528°C), Switzerland (–0.526°C), Czech Republic (–0.523°C), and the Netherlands (–0.521°C). A lower range of values was reported in Poland (–0.540°C to –0.570°C), Estonia (–0.550°C and –0.497°C), Latvia (–0.640°C to –0.494°C), and Germany (–0.531°C to –0.468°C).

The mean freezing point of colostrum was –0.471°C and ranged from –0.461°C to –0.473°C in mature milk of Holstein × Sahiwal cows. The high freezing point of milk found in this study can be due to the slightly higher percent moisture (88.86–89.62%) and lower percent total solids (8.09–8.27%) compared to approximately 87% water and 13% total solids commonly found in milk (Kedzierska-Matysek *et al*., 2011).

Since healthy cows produce colostrum in excess of the calf's need, colostrum may be used in the manufacture of health-promoting food ingredients (especially protein) and nutraceuticals. However, the production of colostrum in commercial quantities will be limited as the amount of colostrum produced by a cow is less than 1% of the total milk that may be produced in one lactation period. Colostrum will only be available for a short period at the beginning of lactation. Hence, a consistent supply of colostrum will only be possible in a year-round calving system practiced on a large dairy farm. As found in other researches, breed and parity are just a few of the many factors that may influence the composition of colostrum. These factors may be manipulated to attain higher than average levels of the components of colostrum, although improvements in the composition of colostrum by the genetic selection of cows may not be viable. Nonetheless, this study contributes to the information on inter-breed differences that may be used in the choice of indigenous and universally used breeds and crossbreeds to produce colostrum-based products in local dairy farms.

In conventional dairy production, changes in mature milk component percentages are achieved by selecting sires for high yields of milk. This is because milk yield is positively correlated to the yield of fat and protein. Although protein and fat percentages are more highly heritable than the yield of milk and components, milk yield is negatively correlated to fat and protein percent. Increases in fat and protein percentages are thus likely to be very slow and not likely to be achieved through genetic selection alone. Similar crossbred herds under a high level of management are more likely to improve component levels by focusing on increasing milk yield, which will increase the total amount of fat and protein produced.

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