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Milk Yield, Composition and Physicochemical Properties of Indigenous and F_1 Crossbred (*Bos indicus* with *Bos taurus*) Cows in Azad Jammu and Kashmir

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ABSTRACT

Milk composition is a fiercely disputed topic among the nutrition scientists, so it's crucial to know if crossbreeding of indigenous cows has an impact on milk composition. The present study was conducted to evaluate and compare the milk yield, physicochemical properties and colostrum composition between indigenous cows and indigenous × Jersey (F_1) crossbred cows of Azad Jammu and Kashmir region. A total of 43 lactating cows were selected, and milk analyses were performed by using Farm Eco lactoscan milk analyzer. Statistical analysis indicated that crossbreeding of indigenous cows with imported frozen thawed semen of Jersey bull significantly (P<0.001) increased the daily milk yield and lactation length in F_1 hybrid cows (9.28±0.34 L and 320±133.7 days, respectively) compared to indigenous cows (1.80±0.06 L and 150.90±5.81 days, respectively). In indigenous cows, higher values (P<0.001) of total solids (TS), fats, solids-not-fat (SNF), proteins and temperature were observed in milk at early lactation, but the freezing point and density were lower. At mid stage of lactation, only the level of TS, fats, proteins, salts and temperature were observed significantly higher (P<0.0001) whereas during late lactation all the contents and properties of milk in indigenous cattle were significantly higher (P<0.0001) except freezing point compared to F_1 crossbred cows. Comparison of colostrum composition between two breed groups indicated that %ages of TS, proteins, lactose, and temperature in indigenous cattle were significantly higher (P<0.01) compared to F_1 crossbred cows. As the age advanced, the milk proteins decreased significantly (P<0.05) at mid lactation stages and TS and protein decreased significantly (P<0.05) during late lactation in indigenous cows. On the other hand, in F_1 cows, the level of SNF and lactose increased significantly (P<0.05) while the temperature decreased significantly (P<0.05). During winter season, level of all the milk constituents except fats decreased significantly (P<0.0001) in indigenous cattle. But in F_1 crossbred cows the levels of fats, SNF and freezing point were significantly higher (P<0.0001) during winter season while the levels of protein, temperature and density decreased (P<0.0001) significantly. It is concluded that crossbreeding decreased the constituents of milk, however, milk yield and lactation length increased in F_1 crossbred cows.

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Authors' Contribution
BS conceptualized the study, administered the project and wrote the manuscript. MIK planned the methodology and provided technical advice for recording of data. RK did sample collection and laboratorial analysis. FSA performed data analysis.

Key words
Desi cattle, Crossbreeding, Milk yield, Milk composition, Colostrum analysis

INTRODUCTION

In Azad Jammu and Kashmir (AJK) region, raising cattle for milk production has been a centuries-old tradition and profession. The use of contemporary scientific reproductive and genetic methods to boost the reproductive and productive capabilities of indigenous cattle (zebu-type) and buffalo has already been implemented. Artificial insemination (AI) in large ruminants is an excellent example of this treatment, as it has had a significant impact on the global dairy industry by lowering the danger of venereal disease spread, increasing the degree of genetic change in dairy breeds, and most importantly increasing milk yield in dairy cattle (Rauthan and Negi, 2022).

Different authorities are grading up (genetically improving) indigenous cattle (also known as Desi cows) in the state of AJK. Crossing indigenous (*Bos indicus*) cattle with European dairy cattle Friesian and Jersey has considerably improved breeding efficiency and milk production (Khan *et al*., 2014). Cattle of European origin,

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such as Jersey, Holstein, and Shorthorn are known as *Bos taurus*. These breeds have been strongly selected for milk yield in developed temperate areas, however they do not adapt well in the tropics, where they are unable to cope with the stress of heat, ecto-parasites, and poor feed quality. While the *Bos indicus* breed is adapted to tropical environmental conditions, it has shown limited response in milk yield to enhanced management, hence the main motivation for crossing is to combine milk yield and adaptation (Madalena, 2002).

Concentration of milk components is an important factor that has a significant effect on dairy product quality and yield (Murphy *et al*., 2016). The breed of the cow is the main genetic aspect affecting milk quality characteristics, cheese making technology, and quality of dairy products. Cattle breeds have a significant impact on milk quality and content, as well as technological qualities (De Marchi *et al*., 2008). Recently, the exotic inheritance of Jersey cattle was introduced to upgrade the indigenous cattle of the state of Azad Jammu and Kashmir. Crossbred cattle have longer lactation periods, shorter calving intervals, and give birth to their first calf at a younger age than native cattle (Khan *et al*., 2014, 2018). The limited studies available have shown that increasing the proportion of exotic genes in a cow leads to decreased milk component levels (Haile *et al*., 2008; Islam *et al*., 2014). Farmers have been urged to employ crossbreeding methods to boost farm profit solely by focusing on milk volume outputs.

There is no research on the milk composition of native and crossbred cattle. Studies on the milk composition of crossbred cow aid in the development of a sound breeding policy for grading up of indigenous animals. Increased milk production results in more high-quality protein being available in dairy farms. High-quality milk ensures the safety of consumers, while also contributing to the increased profitability of those living in rural areas. We hypothesize that the breed of animals has an impact on the composition of milk.

The present study was designed to compare the production potential as well as milk composition of indigenous cows and F_1 crossbred Jersey cows. Determination of milk composition and different properties help to select the best breed suited to local environmental conditions of AJK and help in formulating the state livestock breeding policy.

MATERIALS AND METHODS

The study was conducted at Livestock Development Research Centre (LDRC) Muzaffarabad (34.361º N and 73.662º E), Azad Kashmir where 43 F_1 crossbred Jersey cows (Indigenous 50% × Jersey 50%) and indigenous (desi) cattle were selected. The animals were kept under semi controlled sheds with individuals holding crush in tail-to-tail system of housing and open barn attached with the shed. Animals were allowed outside in open barns in winter and were kept inside the sheds in summer. The animals were provided a total mix ration (TMR) equivalent to 2.5% of their body weight once daily, along with a production ration of 1 kg per animal twice a day. They had unrestricted access to clean water for 12 h.

Experimental design

Milk samples were collected in 50 ml sample bottles and were analyzed by using Lacto-scan milk analyzer from Farm-eco to scan various components of milk like fats, solids-not-fat (SNF), lactose, proteins, salts, water, temperature and freezing point and density. Before scanning a sample, a cleansing reagent was used that is known as weekly acidic cleaner to remove all the impurities from apparatus and this was used once after a weekly another cleansing agent an alkali was used after each sample to clear the remaining particles of sample used before. Both the reagents were added by 3 to 4 drops in warm water and then used to rinse the apparatus. It takes about 6 to 8 sec for cleansing and 30 sec to analyze samples.

Milk yield of both indigenous and crossbred cattle was recorded on daily basis by using digital balance. Lactation length was also recorded and compared. The animals were classified according to lactation stage. Cows between 1 to 3 months of delivery were classified as early, between 4 to 6 months as mid and those in between 7 to 9 months under late stage of lactation. The effect of age on various milk components between two breeds of cows were analyzed by comparing different age groups (ranging between 3 to 10 years). To observe the effect of season on milk composition, seasons were categorized as winter (September-February) and summer (March-August) months.

Statistical analysis

The data were recorded for milk yield, lactation length, milk fat, SNF, protein, lactose, TS, minerals, temperature, freezing point in milk on Microsoft Excel. All the physicochemical parameters of milk are presented in %ages. The analysis of daily milk yield, lactation length, comparison of breed groups, and the impact of season was conducted using a t-test. The milk constituents in different groups of cows with respect to their age, parity and colostrum was analyzed by regression analysis of variance by using Graph Pad Prism 6.01 software (GraphPad Software, Inc., San Diego, CA, USA) and statistical significance were declared at $P \leq 0.05$.

RESULTS

Daily milk yield and lactation length

Mean daily milk yield of indigenous cows was lower (1.80±0.06 L) compared to F_1 hybrid cows (9.28±0.34 L). Statistical analysis of mean milk yield between the two breed groups indicated that crossbreeding of indigenous cows with imported frozen thawed semen of Jersey bull significantly increased the daily milk yield in F_1 hybrid cows (P<0.0001). Similar to daily milk yield, lactation length also increased significantly in crossbred cows compared to indigenous cows (P<0.05; Table I).

Milk composition at early mid- and late lactation

The milk composition of indigenous and F_1 crossbred cows are presented in Table II. The milk composition changes rapidly during the first few days after calving. Therefore, during early stage of lactation, a higher level (P<0.0001) of TS, fats, SNF, proteins, temperature and lower (P<0.05) freezing point were observed in milk of indigenous cows compared to the indigenous × Jersey (F_1) crossbred cows. Whereas a higher density (1032.07±0.59 kg/m^3) of milk was observed in the crossbred cows. %ages of lactose and salts contents of the milk in two breed group did not differ significantly (P>0.05).

Table I. Effect of crossbreeding on daily milk yield and lactation length of indigenous and F_1 crossbred cows in Azad Kashmir.

Breed group	No. of cows	Daily average milk yield (L)	Number of cows	Lactation length (Days)
Indigenous cows	18	1.80±0.06	12	150.90±5.81
Crossbred cows	25	9.28±0.34***	15	320±133.7*
P-value		P<0.0001		P<0.05

*, P<0.05; ***, P<0.0001

Table II. Milk composition (%) two breed groups at early, mid and late lactation stages.

Lactation stage	Variables	Indigenous cows	F_1 crossbred cows	P-value
Early lactation (I=76; C=202)	Total Solids	13.84±0.32	12.08±0.39	0.0097**
	Fat	4.68±0.19	3.09±0.13	<0.0001***
	Solids not fat (SNF)	7.79± 0.23	6.73±0.21	0.0056**
	Proteins	3.91±0.16	3.34±0.06	0.0001***
	Lactose	4.56±0.13	4.96±0.36	0.5012
	Salts	0.69±0.01	0.68±0.005	0.4013
	Temperature of milk (°C)	27.78±0.36	25.72±0.25	<0.0001***
	Freezing point (°C)	-0.57±0.006	-0.55±0.005	0.0481*
	Density (kg/m^3)	1029.80±0.90	1032.07±0.59	0.0432*
Mid lactation (I=157; C=261)	Total solids	14.57±0.18	11.21±0.19	<0.0001***
	Fats	5.10±0.14	2.69±0.10	<0.0001***
	SNF	7.94±0.21	7.53±0.11	0.0658
	Proteins	4.10±0.09	3.285±0.08	<0.0001***
	Lactose	4.67±0.09	4.568±0.14	0.5897
	Salts	0.70±0.006	0.67±0.009	0.0321*
	Temperature of milk (°C)	28.51±0.36	25.85±0.19	<0.0001***
	Freezing point (°C)	-0.51±0.02	-0.53±0.003	0.2647
	Density (kg/m^3)	1029.79±0.57	1030.43±0.38	0.3333
Late lactation (I=367; C=324)	Total solids	15.52±0.17	10.93±0.10	<0.0001***
	Fats	5.62±0.11	2.79±0.09	<0.0001***
	SNF	8.59±0.15	7.30±0.11	<0.0001***
	Proteins	4.34±0.10	3.16±0.03	<0.0001***
	Lactose	4.85±0.07	4.30±0.04	<0.0001***
	Salts	0.71±0.004	0.68±0.003	<0.0001***
	Temperature of milk (°C)	28.92±0.23	26.86±0.21	<0.0001***
	Freezing point (°C)	-0.58±0.005	-0.52±0.006	<0.0001***
	Density (kg/m^3)	1030.63±0.43	1029.94±0.31	0.2113

( ), Number of milk samples; I, indigenous cows; C, crossbred cows.

Table III. Colostrum composition in indigenous and F_1 crossbred cattle of AJK.

No. of days	TS	Fats	SNF	Proteins	Lactose	Salts	Milk temp. (°C)	Freezing point (°C)	Density (kg/m³)
Indigenous cattle (20)									
Day1	19.88±1.26	8.49±1.28	8.41±0.75	4.50±0.68	6.14±0.59	0.74±0.04	28.9±1.07	-0.6±0.02	1040.1±4.97
Day2	16.43±2.54	4.86±0.60	6.37±1.41	5.23±1.26	5.6±0.98	0.73±0.03	28.7±1.21	-0.6±0.01	1036.9±3.42
Day3	18.28±1.67	4.72±0.93	8.27±1.85	5.81±0.74	7.10±0.94	0.64±0.04	30.0±1.11	-0.5±0.01	1039.2±2.67
Day4	15.80±1.09	3.62±0.43	6.88±1.01	5.01±0.42	6.47±0.66	0.68±0.02	28.1±0.76	-0.5±0.01	1040.2±5.71
Day5	15.01±1.69	3.51±0.50	7.52±0.58	4.93±0.64	5.88±0.47	0.68±0.02	28.6±1.17	-0.5±0.01	1028.2±3.42
P	0.0823	0.0524	0.7113	0.7331	0.8785	0.2295	0.6602	0.0577	0.2433
F_1 crossbred cattle (35)									
Day1	13.59±1.09	4.28±0.43	8.44±1.22	3.71±0.40	4.81±0.52	0.77±0.04	27.1±1.24	-0.4±0.17	1035.9±2.06
Day2	13.25±0.93	4.11±0.88	8.39±1.14	3.77±0.25	4.62±0.30	0.73±0.03	26.2±1.54	-0.4±0.15	1033.2±2.32
Day3	12.71±0.78	4.0±0.67	8.13±1.39	3.27±0.53	4.75±0.36	0.73±0.02	26.6±0.61	-0.4±0.15	1034.6±1.77
Day4	13.82±1.87	4.57±1.20	6.4±0.96	4.04±0.51	4.55±0.63	0.64±0.03	26.7±0.94	-0.6±0.02	1031.4±1.98
Day5	12.34±1.31	4.31±1.25	6.30±0.66	3.35±0.25	3.98±0.39	0.68±0.01	26.1±0.70	-0.6±0.01	1031.0±2.28
P	0.3932	0.5277	0.0305*	0.7167	0.0837	0.0713	0.2976	0.0577	0.0483*

( ), Number of milk samples. TS, total solids; SNF, solids not fat.

At mid stage of lactation, the level of TS, fats, proteins, salts and temperature of milk were observed significantly higher ($P<0.0001$) in indigenous cows compared to crossbred cows. Whereas the values of SNF, lactose, freezing point and density did not differ significantly between two breeds ($P>0.05$; Table II).

During late lactation the values of TS, fats, SNF, proteins, lactose, salts and temperature were significantly higher ($P<0.0001$) while freezing point was significantly lower ($P<0.0001$) in indigenous cows compared to F_1 crossbred cows (Table II).

Colostrum analysis

Results of present study indicated that the colostrum composition remains the same and did not differ significantly ($P>0.05$) from day 1 to day 5 in indigenous cattle. But in F_1 crossbred cattle the level of SNF and density in colostrum was significantly higher ($P<0.05$) at day 1 and then decreased gradually (Table III). Comparison of colostrum composition between indigenous and crossbred cows indicated that %ages of TS, proteins, lactose and temperature of colostrum in indigenous cattle were significantly higher ($P<0.01$; $P<0.0001$) as compared to F_1 crossbred cows (Table IV).

Effect of age of indigenous and F_1 crossbred cattle on milk composition

The results of present study highlight the effect of different age groups on milk composition of indigenous cattle at early, mid and late lactation stages are summarized in Table V. The milk components, such as fat, SNF, lactose, salts and properties, like freezing point and density were not significantly changed with increase in age in the early lactating stage, while milk proteins decreased significantly ($P<0.05$) at mid and late lactation stages and total solids decrease ($P<0.05$) at late lactation with advancing age.

Table IV. Colostrum composition of indigenous and F_1 crossbred cows.

Variables	Colostrum composition		P-value df=53
	Indigenous (20)	F_1 Crossbred (35)	
Total Solids	17.08±0.79	13.14±0.53	0.0001***
Fats	5.04±0.52	4.24±0.39	0.2336
SNF	7.49±0.70	7.53±0.52	0.9645
Proteins	5.10±0.46	3.63±0.19	0.0013**
Lactose	6.24±0.44	4.54±0.21	0.0003***
Salts	0.69±0.02	0.71±0.01	0.5486
Milk Temperature (°C)	28.90±0.62	26.59±0.48	0.0056**
Freezing Point (°C)	-0.59±0.01	-0.50±0.06	0.3063
Density (kg/m³)	1036.96±2.57	1033.27±1.00	0.1221

( ), Number of milk samples.

The changes in milk composition of F_1 crossbred cattle at early, mid and late lactation stages are presented in Table VI. No significant change ($P>0.05$) was observed in the milk compositions of F_1 crossbred cows with the

Table V. Effect of age (years) on milk composition (%) of indigenous cattle at early, mid and late lactation stages.

Age (y)	N	TS	Fat	SNF	Protein	Lactose	Salts	Temp (°C)	Freezing point (°C)	Density (kg/m³)
Early lactation										
3	22	13.14±0.58	3.97±0.28	8.09±0.45	4.27±0.27	4.20±0.30	0.70±0.01	28.28±0.69	-0.56±0.01	1029.97±1.59
4	9	16.2±1.11	4.03±0.36	8.3±0.68	5.63±0.77	5.76±0.42	0.75±0.01	26.69±1.38	-0.57±0.01	1039.53±2.63
5	22	14.31±0.33	5.42±0.35	7.74±0.33	3.59±0.15	4.62±0.05	0.69±0.009	27.58±0.59	-0.57±0.009	1029.55±0.97
6	19	13.01±0.78	4.79±0.44	7.14±0.61	3.25±0.22	4.33±0.26	0.66±0.03	28.16±0.79	-0.57±0.01	1026.15±1.99
9	4	13.01±0.88	5.4±0.91	8.24±0.08	3.05±0.05	4.51±0.04	0.66±0.007	26.78±0.47	-0.54±0.007	1025.65±0.33
P		0.4849	0.1128	0.9469	0.1958	0.7463	0.1920	0.4677	0.0969	0.2804
Mid lactation										
3	16	13.74±0.62	3.46±0.39	8.39±0.23	5.07±0.35	4.52±0.34	0.68±0.01	27.86±1.19	-0.57±0.007	1035.58±1.71
4	37	15.28±0.38	5.43±0.27	7.07±0.73	4.07±0.20	5.08±0.21	0.71±0.01	30.6±0.93	-0.58±0.01	1031.06±1.11
5	21	14.93±0.45	5.84±0.40	7.81±0.32	4.17±0.27	4.27±0.24	0.67±0.01	27.41±0.95	-0.56±0.01	1029.77±1.48
6	37	14.43±0.36	5.03±0.22	8.17±0.29	4.07±0.17	4.61±0.18	0.71±0.01	29.04±0.61	-0.34±0.07	1026.92±1.39
7	18	14.17±0.65	4.5±0.46	9.08±0.78	4.15±0.28	4.83±0.27	0.7±0.01	27.69±0.88	-0.59±0.01	1031.54±1.59
8	13	13.66±0.34	5.32±0.31	7.77±0.31	3.34±0.18	4.3±0.14	0.67±0.01	28.52±0.95	-0.53±0.01	1025.75±1.0
9	15	14.79±0.71	5.7±0.55	8.02±0.29	3.77±0.19	4.67±0.12	0.69±0.006	25.22±0.43	-0.55±0.01	1029.03±0.77
P		0.8188	0.2767	0.6712	0.0321*	0.7427	0.858	0.1983	0.7835	0.0943
Late lactation										
3	52	16.37±0.66	6.22±0.35	8.23±0.34	4.71±0.55	4.75±0.18	0.68±0.01	28.62±0.53	-0.53±0.02	1030.68±1.36
4	80	15.06±0.30	5.12±0.21	8.04±0.34	4.35±0.14	4.85±0.14	0.73±0.01	29.68±0.65	-0.63±0.01	1031.53±0.96
5	93	15.95±0.34	5.57±0.20	8.76±0.28	4.63±0.16	5.04±0.14	0.70±0.009	29.03±0.45	-0.58±0.007	1030.66±0.85
6	44	15.56±0.57	5.91±0.45	9.23±0.53	4.03±0.21	4.92±0.23	0.71±0.01	28.97±0.60	-0.56±0.009	1028.06±1.26
7	51	15.28±0.37	5.82±0.28	9.03±0.42	4.006±0.14	4.76±0.16	0.70±0.008	29.18±0.62	-0.58±0.009	1031.47±1.17
8	37	14.93±0.48	5.45±0.37	8.87±0.54	3.99±0.19	4.78±0.24	0.71±0.01	27.88±60.63	-0.58±0.01	1030.27±1.13
9	10	13.8±0.48	5.41±0.41	7.11±0.48	3.81±0.18	3.89±0.21	0.71±0.01	25.73±0.49	-0.55±0.01	1031.3±1.22
P		0.0277*	0.4799	0.7429	0.006*	0.1381	0.4991	0.0738	0.869	0.9837

*P<0.05; N, no. of milk samples. For abbreviations, see Table III.

increase in age during early and mid-lactating stages. At late lactating stage, the level of SNF and lactose increased significantly (P<0.05) whereas temperature decreased significantly (P<0.05) as the age increased.

Effect of seasons on milk composition

The data on effect of seasons on milk composition of indigenous cattle is presented in Table VII. It was observed that %age of milk constituents (TS, SNF, proteins, lactose, salts) and values of physical parameters (freezing point and density) decreased significantly (P<0.0001) during winter season.

In case of F_1 crossbred cows, significantly higher (P<0.0001) values of fats, SNF and freezing point in milk were observed during winter season as compared to summer season. Whereas the levels of protein, temperature and density were decreased significantly (P<0.0001). No effect of season was observed in the %ages of lactose and salts (P>0.05) in the indigenous × Jersey (F_1) crossbred cows (Table VII).

Effect of parity on milk composition

The data on effect of parity on milk composition is presented in Table VIII. Regression analysis of variance indicated that the milk composition remains the same and did not differ significantly (P>0.05) with increase in parity in indigenous cows. In F_1 crossbred cows, the values of total solids and milk temperature decreased significantly (P<0.05), whereas the %age of SNF increased significantly (P<0.05) as the parity increased.

Table VI. Effect of age on milk composition of F_1 crossbred cattle at early, mid and late lactation stages.

Age (y)	N	TS	Fat	SNF	Protein	Lactose	Salts	Milk temp. (°C)	Freezing point (°C)	Density (kg/m³)
Early lactation										
3	62	10.91±0.24	2.83±0.18	5.26±0.39	3.85±0.16	3.55±0.14	0.68±0.01	26.29±0.25	-0.54±0.03	1035.11±1.05
4	32	11.07±0.35	2.51±0.35	8.14±0.39	3.14±0.06	4.73±0.08	0.7±0.01	24.05±0.51	-0.52±0.02	1029.5±1.13
5	61	14.17±1.2	3.32±0.24	7.53±0.43	3.08±0.1	7.08±1.15	0.69±0.02	26.53±0.65	-0.54±0.01	1033.58±1.19
6	18	11.92±0.46	3.6±0.29	5.72±0.44	3.43±0.16	4.23±0.25	0.67±0.01	25.96±0.81	-0.57±0.02	1025.88±1.84
7	29	11.39±0.49	3.5±0.5	7.29±0.35	2.97±0.08	4.25±0.12	0.66±0.01	24.51±0.51	-0.52±0.01	1029.05±1.02
P		0.7283	0.0850	0.7347	0.2293	0.8669	0.1881	0.7049	0.9019	0.2155
Mid lactation										
3	24	11.25±0.33	3.08±0.33	6.8±0.38	3.2±0.17	4.29±0.2	0.67±0.01	26.8±0.52	-0.53±0.01	1030.16±1.25
4	58	10.63±0.16	2.1±0.14	7.67±0.27	3.37±0.1	4.53±0.06	0.62±0.04	27.12±0.45	-0.55±0.01	1030.77±0.85
5	106	11.56±0.43	2.95±0.19	7.68±0.15	3.26±0.2	4.66±0.35	0.68±0	25.38±0.29	-0.53±0	1029.89±0.59
6	11	10.44±0.54	2.38±0.41	7.69±0.54	3.07±0.08	4.27±0.24	0.7±0.01	25.61±1.43	-0.52±0.02	1028.42±1.24
7	62	11.27±0.21	2.68±0.19	7.38±0.26	3.3±0.08	4.59±0.09	0.69±0.01	25.13±0.29	-0.53±0.01	1031.51±0.78
P		0.9362	0.7422	0.4049	0.8230	0.6210	0.2754	0.0622	0.4664	0.9388
Late lactation										
3	10	11.86±0.97	3.95±0.86	6.26±0.49	3.93±0.47	3.3±0.37	0.68±0.02	31.14±0.75	-0.52±0.01	1027.12±1.15
4	36	9.54±0.32	2.07±0.33	6.26±0.31	3.06±0.13	3.78±0.14	0.64±0.01	30.21±0.86	-0.47±0.01	1026.82±0.64
5	131	11.13±0.14	3.05±0.15	7.19±0.16	3.09±0.05	4.31±0.05	0.68±0	26.84±0.32	-0.52±0.01	1029.77±0.5
6	86	11.18±0.19	2.82±0.17	7.6±0.21	3.18±0.06	4.49±0.08	0.69±0.01	25.73±0.28	-0.52±0.02	1031.62±0.71
7	61	10.81±0.28	2.4±0.21	7.85±0.3	3.23±0.11	4.49±0.15	0.69±0.01	25.84±0.46	-0.53±0.01	1030.19±0.62
P		0.8904	0.3717	0.0089*	0.3236	0.0188*	0.3542	0.0188*	0.4316	0.0774

*P<0.05; N, no. of milk samples. For abbreviations, see Table III.

Table VII. Effect of seasons on milk composition of indigenous and F_1 crossbred cattle.

Season (n)	TS	Fats	SNF	Proteins	Lactose	Salts	Milk temp. (°C)	Freezing Point (°C)	Density (kg/m³)
Indigenous cattle									
Summer (635)	15.03±0.13	5.34±0.08	8.30±0.11	4.23±0.07	4.75±0.05	0.69±0.003	28.78±0.17	-0.56 ±0.002	1030.2±0.31
Winter (157)	13.14±0.19	5.12±0.17	7.68±0.12	2.97±0.04	4.38±0.05	0.65±0.005	26.21±0.37	-0.51 ±0.004	1025.7±0.27
P	0.0001***	0.2547	0.0079**	0.0001***	0.0004***	0.0001***	0.0001***	0.0001***	0.0001***
F_1 crossbred cattle									
Summer (304)	11.60±0.27	2.90±0.1	6.56±0.14	3.29±0.05	4.72±0.2	0.67±0.005	26.51±0.16	-0.54 ±0.004	1032.2±0.46
Winter (228)	11.43±0.186	3.51±0.2	7.26±0.13	3.03±0.04	4.2±0.1	0.68±0.005	24.9±0.2	-0.52 ±0.003	1027.9±0.35
P	0.6291	0.0001***	0.0008***	0.0002***	0.0881	0.6537	0.0001***	0.0069**	0.0001***

n = no. of milk samples. For abbreviations, see Table III.

DISCUSSION

The aim of this study was to compare indigenous and F_1 crossbred Jersey cows in relationship with the milk yield, lactation length and milk composition with physicochemical properties at different stage of lactation under same management and TMR diet. A higher milk yield and lactation length were observed in indigenous × Jersey (F_1) crossbred cows than those in indigenous cows. These results were consistent with previous research of comparison of milk yield between native and crossbred cows (Maharana and Mishra, 2020; Abraham and Gayathri, 2015). Many researchers have demonstrated the moral superiority of crossbred cows in milk productivity when compared to native breeds under the same conditions.

Table VIII. Effect of parity on milk composition of indigenous and F_1 crossbred cattle in AJK.

Parity	Indigenous cattle					F_1 crossbred cattle				
	1st	2nd	3rd	4th	P	1st	2nd	3rd	4th	P
N	221	188	118	62		232	213	291	46	
TS	14.67±0.22	15.81±0.23	15.39±0.35	13.90±0.32	0.6162	11.53±0.34	11.31±0.14	11.17±0.18	11.03±0.21	0.007*
Fats	5.08±0.14	5.78±0.15	5.5±0.2	4.85±0.20	0.7311	2.55±0.1	3.31±0.12	2.68±0.10	2.60±0.21	0.825
SNF	8.01±0.17	8.12±0.22	8.7±0.3	8.69±0.39	0.0771	6.96±0.18	7.12±0.13	7.46±0.12	7.96±0.16	0.025*
Proteins	4.29±0.15	4.38±0.11	4.2±0.7	4.04±0.16	0.172	3.39±0.06	3.10±0.04	3.23±0.08	3.21±0.06	0.5811
Lactose	4.61±0.08	4.95±0.10	4.9±0.2	4.31±0.15	0.5854	4.9±0.31	4.21±0.05	4.57±0.13	4.53±0.06	0.6569
Salts	0.68±0.005	0.69±0.007	0.71±0.007	0.69±0.008	0.487	0.67±0.003	0.67±0.003	0.68±0.004	0.67±0.005	0.7418
Milk temp. (°C)	28.03±0.04	29.96±0.40	28.7±0.4	28.15±0.51	0.8684	27.17±0.25	25.86±0.25	25.79±0.19	24.78±0.44	0.047*
Freezing point (°C)	-0.04±0.04	-0.05±0.04	-0.1±0.1	-0.03±0.07	0.7487	-0.53± 0.008	-0.52± 0.006	-0.53± 0.006	-0.52± 0.004	0.5528
Density (kg/m³)	1030.40± 0.55	1030.15± 0.62	1030.2± 0.34	1029.43± 1.04	0.1292	1031± 0.46	1031± 0.49	1030± 0.35	1031± 1.05	0.7418

N, no. of milk samples; TS, total solids, SNF, solids not fat; *P<0.05

The milk TS, fats, SNF, proteins %age and freezing point were higher in indigenous cows than those of indigenous × Jersey (F_1) crossbred cows. A higher density of milk was observed in the crossbred cows only during the early stage of lactation.

The fat %age of dairy breeds (Ayrshire, Brown Swiss, Guernsey, Holstein and Jersey) ranged from 3.41 to 5.06 % and the total solids (TS) varied from 12.27 to 14.54 % (Nevens, 2010). Whereas, in Indian dairy cattle fat varied from 3.5 to 5.5 % and the TS % varied from 12.20 to 15.0 % (Banerjee, 2009). Fat has the greatest variation between and within breeds, while lactose changes the least (Woodford *et al*., 1986). This could be due to environmental factors, yet there must be some genetic variation among breeds in different countries. A study of milk composition of Jersey and Holstein cows for 30 days in milk (DIM) reported that the protein, lactose, and total solids concentrations in Jersey milk were 4.99 %, 3.26 %, 4.72 %, and 13.66 % whereas in the Holstein cows, they were 4.12 %, 2.82 %, 4.89 %, and 12.55 %, respectively (Lim *et al*., 2020).

The fat content of milk varies depending on the stage of lactation. Colostrum normally has the largest %ages, with a drop during the first two months of lactation and then a gradual increase as lactation develops. The fatty acid content of milk fluctuates throughout the lactation cycle (Davies *et al*., 1983). The quantities of short- and intermediate-chain fatty acids increase throughout the first half, whereas the proportion of long-chain fatty acids decreases. During the last half of lactation, there are no more changes. Environment, diet, and the rate of fatty acid synthesis in the mammary gland all impact some of these changes. The variations in milk constituents are attributable to the stage of lactation, nutrition, health status, genetic factors, and seasonal interference (Heck *et al*., 2009).

Our findings are similar to another study, which showed that milk fat content remains relatively constant and milk protein content gradually decreases with animals advancing age (Looper, 2010). Fat content reduces somewhat for each individual animal throughout subsequent lactations, by 0.2% over a typical productive lifetime. In practice, this component has little impact on the fat level of bulk milk supplies (Fox and Kelly, 2006). Diet provides nutrients that are precursors to main milk solids, either directly or indirectly. So, an increase in feed intake usually results in more milk being produced, but the content of the milk remains relatively unchanged.

The season effect was observed on the principal constituents of milk in indigenous and crossbred cattle is in accordance with other studies in which season effect was observed on composition of milk in native Zebu and crossbred cows (Abraham and Gayathri, 2015; Desyibelew and Wondifraw, 2019; Shibru *et al*., 2019; Bahashwan, 2014).

According to a previous study, the climatic-physiological alterations in the cows increased water consumption, decreased milk output, and reduced feed intake (Gaughan *et al*., 2009). During the winter season, cows drink less water, and their fat concentration rises (Sharma *et al*., 2002). This may have allowed them to deplete their fat and protein stores, lowering the amounts of these nutrients in the milk.

The lactose %age, on the other hand, was not significantly affected by the season because the chemical breakdown of body fat reserves during the hot season maintains the glucose normal range in the animal's blood and maintenance energy, which in turn maintains milk carbohydrate supply (McDonald *et al*., 1988). In contrast to our study, the cold season's low temperatures increased milk output and protein %, as expected and documented by other researchers (Broucek *et al*., 2006). The temperature stress in the summer lower milk output, fat and protein content, and increases spinal cord stimulation (Lambertz *et al*., 2014).

The %age of milk components in indigenous cows was not affected by an increase in parity whereas the components of crossbred cows was affected by parity. In others studies the components of milk increased with increased parity (Sevi *et al*., 2000; Cunha *et al*., 2008). The increase in %age of SNF in crossbred cows might be due to the development of mammary glands with advancement of parity in crossbred cows. Whereas, in indigenous cows the mammary glands were not fully developed even with the advancement of parity evident by the production of lower milk yield and no effect of parity on milk components.

CONCLUSION

Crossbreeding of indigenous cows with imported frozen thawed semen of Jersey bull significantly increased the milk yield and the lactation length. However, the contents of milk constituents are significantly decreased in F_1 crossbred cows. This decrease did not affect the profitability of farmers because of prolonged lactation length and high milk yield in crossbred cows.

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IRB approval

The research received approval from both the University of Azad Jammu and Kashmir, Muzaffarabad and the Department of Livestock and Dairy Development, AJK.

Statement of conflict of interest

The authors have declared no conflict of interest.

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