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Effect of Non Genetic Factors on Milk Yield and Milk Quality Traits in Jersey Crossbred Cattle

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A B S T R A C T

Present study was conducted on 116 lactating Jersey crossbred cattle maintained at Nandini Semen Station farm, Hessarghatta, Bengalauru, Veterinary college and research institute, Namakkal, and those maintained by farmers in surrounding areas of Namakkal, Tamilnadu. About 30 ml of milk samples were collected from lactating animals to estimate Somatic cell count (SCC) by digital somatic cell counter on same day of milk collection. California mastitis test (CMT) and Electrical conductivity (EC) meter were used for snapshot test. In California mastitis test out of 464 quarters screened 359 were normal (77.37%) while 105 were affected sub-clinically or clinically (22.63%) in different stages of lactation, seasons and parity respectively. The ANOVA test revealed that the effect of various seasons was strongly significant on TDMY ($P \leq 0.01$) and moderately significant on ($0.01<P \leq 0.05$) on somatic cell count. Higher test day milk yield were recorded during winter season (12.71 ± 0.71 Kg) than summer season (8.19 ± 0.55 Kg). The effect of parity on test day milk yield was found to be moderately significant ($0.01<P\leq0.05$). Higher Fat percent was observed during first (4.75 ± 0.17 %) and lower during fifth (4.28 ± 0.18%) parity. Higher solid not fat percentage were observed during second stage of lactation (9.21 ± 0.11%) and it was lower during third stage (9.06 ± 0.11%). Effect of season had moderately significant on ($0.01<P\leq 0.05$) with front right quarter in quarter wise electrical conductivity meter test.

Introduction

Cattle population of India is 190.9 million which mainly comprises of crossbred and indigenous animals. Milk production contribution of crossbred or exotic to total milk production (165.4 million tonnes in the year 2016-17) was 25.4 percent respectively during (BAHS, 2017). Although crossbred cows produce more milk, they are more susceptible to hot and humid climatic conditions, and as compared to indigenous cows they are more vulnerable to production diseases. Jersey breed is the second most important breed of dairy after Holstein-Friesian. It is a small breed of dairy cattle, with mature live weight ranging from 360 to 540 kg. Originally bred on the British Channel Island of Jersey, the breed is popular for the high butterfat content of its milk and the low maintenance costs incurred due to its lower bodyweight, as well as its genial disposition. In addition, Jerseys can thrive on locally produced feed. They can tolerate high temperatures; heifers mature more quickly than those of other breeds and can be mated at 13 to 15 months; they produce an average herd milk yield of 3500 to 5000 kg. Jersey is an ideal breed for crossbreeding with *Bos indicus* to produce a hardy, disease-tolerant, dairy-type cow which does not need a high plane of nutrition to produce reasonable milk yield and is suited to dairying in the communal areas (Missanjo *et al.*, 2013). The fat and solid not fat content in Jersey milk are 5.2 and 9.4 percent respectively (Guha, 1973). Sattar *et al.*, (2004) reported that under British rule Jerseys were transported to India and crossbred with Asian breeds to improve the quality of milk produced by domestic breeds and the practice of importing purebred Jerseys for cross-breeding continues to this day. Daily milk yield of pure Jersey is 20 litters, whereas crossbred Jersey cow gives 8-10 litters of milk per day. In India this breed has acclimatized well especially in the hot and humid areas.

Mastitis is the inflammation of the mammary gland resulting mainly from the invasion of contagious or environmental pathogens into the teat canal. Based on the severity of the inflammatory response, mastitis manifests itself in clinical or sub-clinical forms both leading to substantial economic losses (Owen *et al.*, 2000). Subclinical infection although lacking clinical symptoms, are characterized by reduced milk secretion and altered milk composition (Kitchen, 1981; Fox *et al.*, 1985; Harmon, 1994). Within few hours after the invasion of pathogenic microorganisms in the udder, somatic cell counts (SCC) in milk increase in response to activated inflammatory mediators (Schmitz *et al.*, 2004). The enhanced paracellular diapedesis of leukocytes through the epithelium causes reduced tight junction integrity (Stelwagen *et al.*, 1999) and hence exchange of constituents between blood and milk. Lactose, which is synthesized exclusively by mammary epithelial cells, partially leaks into blood circulation through the damaged blood-milk barrier (Mielke *et al.*, 1985). Furthermore, microbial toxins and enzymes from damaged cells cause injury of secretory cells (Kitchen, 1981). Therefore, the ability of the mammary epithelium to synthesize and secrete the major specific milk constituents is reduced (Schultz 1977; Fox *et al.*, 1985; Eberhart *et al.*, 1987), while the secretion of other proteins like lactoferrin is simultaneously up-regulated (Schmitz *et al.*, 2004). The concentration of caseins is reduced in infected quarters due to reduced secretion and due to destruction by blood-borne proteases like plasmin (Politis *et al.*, 1992). Simultaneously, the amount of blood borne components, such as serum albumin and sodium (Na^+) and chloride (Cl^-) ions increase in milk of infected quarters (Kitchen 1981; Harmon 1994; Zank and Schlatterer 1998). Increased Na^+ and Cl^- ion concentrations cause an elevation of electrical conductivity (Wheelock *et al.*, 1966). Therefore the goal of present study is to investigate milk quality traits like fat and solid not fat from the normal as well as sub clinically infected quarters of variable severity in order to possibly provide indicative parameters for early detection of mammary infection in addition to somatic cell counts (SCC) in various non-genetic factors like seasons, parity and stages of lactation in Jersey crossbred cattle.

Materials and Methods

Milk collection

About 30 ml of milk samples were collected from lactating animals to estimate the somatic cell count (SCC). California mastitis test (CMT) and electrical conductivity meter (EC) were used for snapshot test. SCC was estimated by digital somatic cell counter on the same day of milk collection.

California Mastitis Test (CMT)

The test is based upon the amount of cellular nuclear protein present in the milk sample. CMT reflects the SCC level quite accurately (Mellenberger and Roth, 2000) and is a reliable indicator of the severity of infection. The CMT reagent dissolves or disrupts the outer cell wall and the nuclear cell wall of any leukocyte, which are primarily fat (detergent dissolves fat).

DNA is now released from the nuclei and together forms a stringy mass. As the number of leukocytes increase in a quarter, the amount of gel formation will increase linearly. The CMT provides only an indication of somatic cell count, not an exact value. CMT was carried out to screen the animals as follows:

Electrical conductivity

Electrical conductivity meter (Draminski® Electronics in Agriculture) was used to measure the electrical conductivity of milk. When a cow is exposed to an intramammary infection, the electrical conductivity of the milk increases due to an increased concentration of Na+ and Cl caused by destruction of tight junctions and the active ion- pumping system (Norberg, 2005).

Principle

The test is based on the ionic changes which occur during Intra mammary inflammations (IMI). Since the sodium and chloride concentrations increase in milk, the electrical conductivity of milk increases which can be detected by an Electrical conductivity meter.

Interpretation of electrical conductivity meter test

Readings below 250 units

This was a clear indication of a rapid increase in the severity of infection as subclinical or impending clinical mastitis.

Readings between 250 and 300 units

It triggers warning signals to the operator that regular monitoring is necessary. If the figures in this category are only in one quarter and are at least 50 points below the lowest of the other quarters then this is a chance of mastitis infection present in the low numbered quarter.

Readings above 300 units

Most commonly the reading between 330-360 units indicates the normal samples.

For cows with 1-2 lactations the readings generally average 390 units, whereas for the cows with more than three lactations, the reading observed is 320 units.

Somatic cell count

Somatic cell count (SCC) was measured through digital reader Port check (PortaSCC®).

Fat and solid not fat

Both Fat and Solid Not Fat from the collected milk samples were estimated on the same day by Ekomilk milk analyser (Everest ™ Instruments PVT. LTD).

Test day milk yield

Test day milk yield was recorded while collecting the milk samples from lactating Jersey crossbred cattle. AM and PM methodology was used during collection of samples (Bhasin, 1982).

Season

Seasonal variation in the somatic cell count was adjusted by classifying the day of milk collection in to three seasons as summer (March- June), Rainy (July- October) and winter (November- February).

Stage of lactation

The 305 days milk yield was divided into three stages *viz.*, 1^{st} stage (7-90 days), 2^{nd} stage (91-180 days) and the 3^{rd} stage (181-305 days)

Parity

Adjustment of data for the parity was done by recording the parity of each animal as 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} parity.

The analysis was done using the following model:

$$Y_{ijkl} = \mu + P_i + S_j + C_k + e_{ijkl}$$

Where,

μ = overall mean for the herd / population

Y_{ijkl} = TDMY, TDFP, TDSNF and Test day SCC and EC of animal belonging to i^{th} Parity, j^{th} Stage of Lactation, k^{th} effect of season

P_i = Effect of i^{th} parity (where i =1 to 5)

S_j = Effect of j^{th} stage of lactation (where j = 1, 2, 3)

C_k = Effect of k^{th} season (where k=1, 2, 3)

e_{ijklm} = Random error associated with Y_{ijklm} observation, and assumed to be NID $(0, \sigma^2 e)$

Results and Discussion

In the present study, three tests *viz.*, CMT, electrical conductivity (EC) of milk and somatic cell count (SCC) were carried out for detection of subclinical or clinical mastitis. Information on the cow's number and cow's TDMY (Kg) for each test day was taken and the SCC of the corresponding cows were estimated. Data were subjected to descriptive statistical analysis. Results on continuous measurements are presented as Mean ± SE and results on categorical measurements are presented in relative proportion as percentage. Results on continuous measurements were presented on Mean ± SD (Min-Max) and results on categorical measurements were presented in Number (%). Significance was assessed at 5 % level of significance. The following assumptions on data were made:

Assumptions

1. Dependent variables should be normally distributed, 2. Samples drawn from the population should be random, and Cases of the samples should be independent. Chi-square/ Fisher Exact test was used to find the significance of study parameters on categorical scale between two or more groups.

Significant figures

\+ Suggestive significance (P value: $0.05<P<0.10$)

* Moderately significant (P value: $0.01<P \le 0.05$)

** Strongly significant (P value: $P \le 0.01$)

Statistical software

The Statistical software namely SAS 9.3 and SPSS 16 were used for the analysis of the data.

Effect of season on TDMY, SCC, TDF, TDSNF and EC

The ANOVA test revealed that the effect of various seasons was strongly significant on TDMY (P ≤ 0.01). Higher test day milk yield was recorded during winter season (12.71 ± 0.71 Kg) than summer season (8.19 ± 0.55 Kg) (Table 4). The lower milk yield observed during summer season could be due to decrease in the total consumption of feed and environmental stress during summer. The results were in contrast with those reported by Borkowska and Janus (2001) who reported a higher milk yield in summer as compared to winter season.

Effect of season on somatic cell count was found to be moderately significant (0.01<P ≤ 0.05). Higher SCC values were observed during rainy season (0.63 ± 0.05 million cells/ml) and lower during winter season (0.40 ± 0.06 million cells/ml). The higher SCC value could be due to more exposure of teat ends to pathogenic microorganisms present in surrounding area of animals during rainy season.

The effect of season on fat and solid not fat percentage was not significant. Higher fat percentage was recorded during winter season (4.62 ± 0.12 %) and lower during summer season (4.47 ± 0.09 %) in Jersey crossbred cattle. Misra (2000) reported a higher fat percent (4.47 %) in summer season, as compared to monsoon (4.36 %) and winter (4.32 %) in Jersey and HF crossbreds. However results were in contrast to the findings of Hasanuzzaman *et al.*, (2002), who reported high fat percent in winter (January) and lowest fat percent in summer (June) (Table 2).

Higher solid not fat percentage was observed during winter season (9.28 ± 0.13 %) whereas it was lower during summer season (9.04 ± 0.10 %). Quarter wise electrical conductivity revealed moderately significant effect (0.01<P ≤ 0.05) with front right quarter in Jersey crossbred cattle (Table 4).

Effect of stage of lactation on TDMY, SCC, TDF, TDSNF and EC

The ANOVA test revealed that the effect of stage of lactation on TDMY was found to be + Suggestive significance (P value: 0.05<P<0.10). Higher test day milk yield was observed during third stage of lactation (10.68 ± 0.69 Kg) and lower during first stage of lactation (8.44 ± 0.67 Kg). Saravanan *et al.*, (2015) reported a significant (P ≤ 0.05) effect of stage of lactation on lactation milk yield in Deoni cattle. Stage of lactation had non-significant effect on somatic cell count. Higher somatic cell count was observed during second stage of lactation (0.56 ± 0.05 million cells/ml) while lower during first stage of lactation (0.50 ± 0.05 million cells/ml) (Table 1).

California Mastitis Test (CMT)

CMT Score	Interpretations
N	Healthy Quarter
S	Early Subclinical Mastitis
G	Subclinical Mastitis
M	Clinical Mastitis

N- No thickening, homogeneous, S- Slight thickening. Reaction disappears in 10 seconds, G- Distinct thickening, no gel formation and M- Thickens immediately, begins to gel, levels in the bottom of cup.

Table.1 CMT findings in association with stage of lactation in Jersey crossbred cattle

CMT	Stage of lactation			Total (n=116)	P value
	Lactation 1 (n=40)	Lactation 2 (n=38)	Lactation 3 (n=38)		
FL					
G	6(15%)	6(15.8%)	3(7.9%)	15(12.9%)	0.848
M	1(2.5%)	0(0%)	1(2.6%)	2(1.7%)	
N	30(75%)	27(71.1%)	30(78.9%)	87(75%)	
S	3(7.5%)	5(13.2%)	4(10.5%)	12(10.3%)	
FR					
G	1(2.5%)	1(2.6%)	2(5.3%)	4(3.4%)	0.811
M	0(0%)	1(2.6%)	0(0%)	1(0.9%)	
N	30(75%)	31(81.6%)	30(78.9%)	91(78.4%)	
S	9(22.5%)	5(13.2%)	6(15.8%)	20(17.2%)	
HL					
G	2(5%)	3(7.9%)	2(5.3%)	7(6%)	0.703
M	2(5%)	0(0%)	0(0%)	2(1.7%)	
N	30(75%)	32(84.2%)	31(81.6%)	93(80.2%)	
S	6(15%)	3(7.9%)	5(13.2%)	14(12.1%)	
HR					
G	6(15%)	3(7.9%)	4(10.5%)	13(11.2%)	0.924
N	29(72.5%)	30(78.9%)	29(76.3%)	88(75.9%)	
S	5(12.5%)	5(13.2%)	5(13.2%)	15(12.9%)	

FL- Front left teat
FR- Front Right teat
HL-Hind left teat
HR-Hind right teat
B- Blind teat
N- No thickening, homogeneous.
S- Slight thickening. Reaction disappears in 10 seconds.
G- Distinct thickening, no gel formation.
M- Thickens immediately, begins to gel, levels in the bottom of cup.

Table.2 CMT findings in association with Season in Jersey crossbred cattle

CMT	Season			Total (n=116)	P value
	Summer (n=51)	Rainy (n=35)	Winter (n=30)		
FL					
G	8(15.7%)	5(14.3%)	2(6.7%)	15(12.9%)	0.887
M	1(2%)	1(2.9%)	0(0%)	2(1.7%)	
N	37(72.5%)	26(74.3%)	24(80%)	87(75%)	
S	5(9.8%)	3(8.6%)	4(13.3%)	12(10.3%)	
FR					
G	3(5.9%)	1(2.9%)	0(0%)	4(3.4%)	0.299
M	0(0%)	1(2.9%)	0(0%)	1(0.9%)	
N	42(82.4%)	24(68.6%)	25(83.3%)	91(78.4%)	
S	6(11.8%)	9(25.7%)	5(16.7%)	20(17.2%)	
HL					
G	1(2%)	5(14.3%)	1(3.3%)	7(6%)	0.332
M	1(2%)	0(0%)	1(3.3%)	2(1.7%)	
N	43(84.3%)	26(74.3%)	24(80%)	93(80.2%)	
S	6(11.8%)	4(11.4%)	4(13.3%)	14(12.1%)	
HR					
G	7(13.7%)	2(5.7%)	4(13.3%)	13(11.2%)	0.281
N	40(78.4%)	25(71.4%)	23(76.7%)	88(75.9%)	
S	4(7.8%)	8(22.9%)	3(10%)	15(12.9%)	

Table.3 CMT findings in association with Parity in Jersey crossbred cattle

CMT	Parity					Total (n=115)	P value
	Parity 1 (n=15)	Parity 2 (n=33)	Parity 3 (n=35)	Parity 4 (n=18)	Parity 5 (n=14)		
FL							
G	1(6.7%)	2(6.1%)	6(17.1%)	2(11.1%)	4(28.6%)	15(13%)	0.327
M	0(0%)	1(3%)	0(0%)	0(0%)	1(7.1%)	2(1.7%)	
N	11(73.3%)	28(84.8%)	26(74.3%)	14(77.8%)	7(50%)	86(74.8%)	
S	3(20%)	2(6.1%)	3(8.6%)	2(11.1%)	2(14.3%)	12(10.4%)	
FR							
G	0(0%)	1(3%)	0(0%)	2(11.1%)	1(7.1%)	4(3.5%)	0.594
M	0(0%)	0(0%)	1(2.9%)	0(0%)	0(0%)	1(0.9%)	
N	12(80%)	26(78.8%)	27(77.1%)	15(83.3%)	10(71.4%)	90(78.3%)	
S	3(20%)	6(18.2%)	7(20%)	1(5.6%)	3(21.4%)	20(17.4%)	
HL							
G	1(6.7%)	2(6.1%)	4(11.4%)	0(0%)	0(0%)	7(6.1%)	0.434
M	0(0%)	1(3%)	1(2.9%)	0(0%)	0(0%)	2(1.7%)	
N	12(80%)	25(75.8%)	29(82.9%)	16(88.9%)	10(71.4%)	92(80%)	
S	2(13.3%)	5(15.2%)	1(2.9%)	2(11.1%)	4(28.6%)	14(12.2%)	
HR							
G	1(6.7%)	2(6.1%)	5(14.3%)	5(27.8%)	0(0%)	13(11.3%)	0.372
N	12(80%)	26(78.8%)	26(74.3%)	10(55.6%)	13(92.9%)	87(75.7%)	
S	2(13.3%)	5(15.2%)	4(11.4%)	3(16.7%)	1(7.1%)	15(13%)	

Table.4 Effect of different stages of lactation, seasons and parity on Test day Milk Yield (TDMY), SCC, quarter wise Electrical Conductivity, Fat and SNF in Jersey crossbred

Variables In JERSEY CB	No. of observations (116)	TDMY (kg) (Mean± SE)	SCC In millions cells/Ml	Electrical Conductivity				FAT (%)	SNF (%)
				FL	FR	HL	HR		
Stage of lactation									
1st stage	40	8.44±0.67	0.50±0.05	348.60±8.80	377.25±7.35	385.50±8.47	365.75±8.04	4.40±0.10	9.08±0.11
2nd stage	38	9.67±0.69	0.56±0.05	350.00±9.03	365.52±7.54	356.31±8.69	355.26±8.25	4.60±0.11	9.21±0.11
3rd stage	38	10.68±0.69	0.51±0.05	343.68±9.03	362.36±7.54	356.31±8.69	356.05±8.25	4.53±0.11	9.06±0.11
P-Value		0.072	0.740	0.873	0.3309	0.023*	0.597	0.433	0.593
Season									
SUMMER	51	8.19±0.55	0.53±0.04	343.13±7.75	358.43±6.35	359.80±7.66	355.68±7.10	4.47±0.09	9.04±0.10
RAINY	35	8.92±0.66	0.63±0.05	356.97±9.36	386.00±7.67	379.42±9.25	368.28±8.57	4.47±0.11	9.09±0.12
WINTER	30	12.71±0.71	0.40±0.06	343.66±10.11	365.33±8.28	362.33±9.99	354.33±9.26	4.62±0.12	9.28±0.13
P-Value		<.0001**	0.040*	0.478	0.022*	0.240	0.442	0.601	0.314
Parity									
1	15	11.10±1.09	0.44±0.09	336.66±14.37	372.66±12.04	369.33±14.22	366.66±12.92	4.75±0.17	9.18±0.18
2	33	8.97±0.73	0.52±0.06	360.00±9.69	376.36±8.12	380.00±9.58	368.78±8.71	4.49±0.11	8.92±0.12
3	35	9.86±0.71	0.48±0.06	341.54±9.41	372.57±7.88	352.57±9.30	354.57±8.45	4.55±0.11	9.25±0.12
4	18	10.97±1.00	0.66±0.08	351.11±13.12	356.66±10.99	367.22±12.98	335.00±11.79	4.49±0.16	9.01±0.16
5	15	7.00±1.13	0.58±0.09	342.14±14.88	351.42±12.47	366.42±14.71	373.57±13.37	4.28±0.18	9.33±0.19
P-Value		0.048*	0.369	0.587	0.365	0.376	0.133	0.463	0.256

Harmon (1994) reported that generally SCC increases with advancing age and stage of lactation. Bhoite and Padekar (2002) revealed that milk yield declined with advancement of stage of lactation among Gir half-breds, whereas the difference in fat content in milk between different stages was non – significant.

Saravanan *et al.,* (2015) reported no effect of stage of lactation on SCC. Sawa *et al.,* (2000) studied the effect of stage of lactation on SCC and reported an upward trend of SCC along the course of lactation in HF cows. On the contrary, Antkowiak *et al.,* (2003) reported a lack of the effect of stage of lactation on SCC in milk of Jersey cows.

However, some researchers reported no significant effect of stage of lactation on mastitis (Sethi and Balaine, 1978; Patil *et al.,* 1995; Dhakal and Thapa, 2002).

Effect of stage of lactation on fat and solid not fat percentage was found to be non-significant. Higher fat per centage was observed during second stage of lactation (4.60 ± 0.11 %) and lower during first stage (4.40 ± 0.10 %). Bhoite and Padekar (2002) revealed that fat content in milk between different stages was non – significant in Gir half-breeds.

Higher solid not fat percentage were observed during second stage of lactation (9.21 ± 0.11 %), and it was lower during third stage (9.06 ± 0.11 %). Quarterwise electrical conductivity revealed moderately significant effect ($0.01<P \leq 0.05$) with hind left quarter in Jersey crossbred cattle.

Effect of parity on TDMY, SCC, TDF, TDSNF and EC

The effect of parity on test day milk yield was found to be moderately significant ($0.01<P \leq 0.05$). Higher mean test day milk yield was recorded in first parity (11.10 ± 1.09 Kg). An increasing trend of test day milk yield was recorded from second to fourth parity in Jersey crossbred however, lower test day milk yield was recorded in fifth parity (7.00 ± 1.13 Kg) in Jersey crossbred.

Parity had non-significant effect on somatic cell count. Higher SCC value was observed during fourth (0.66 ± 0.08 million cells/ml) and lower during first parity (0.44 ± 0.09 million cells/ml) in Jersey crossbred cattle.

In a study carried out by O'Brien *et al.,* (2009) in four counties *viz*., Cork, Kerry, Limerick and Tipperary, reported that the SCC increased with the increase in parity from 97,000 cells/ml in first parity to 1,99,000 cell/ml in sixth parity. Skrzypek *et al.,* (2004) also reported increased SCC with the advanced parities (Table 3).

Saravanan *et al.,* (2015) reported that SCC increases with increasing number of lactations in Deoni cows, whereas it was highest during fourth parity in HF mastitis animals.

Effect of parity on fat and solid not fat percentage was non-significant. Higher fat per cent was observed during first (4.75 ± 0.17 %) and lower during fifth (4.28 ± 0.18 %) parity in Jersey crossbred cows.

Rengarajan (2012) reported that fat percent was significantly ($P \leq 0.05$) higher during fifth parity in Deoni cattle, whereas no significant effect of parity on fat per cent was observed in HF crossbred cattle.

Higher solid not fat percentage was observed during fifth parity (9.33 ± 0.19 %) whereas lower during second parity (8.92 ± 0.12 %) in Jersey crossbred cattle. Quarterwise electrical conductivity revealed non-significant effect of parity in Jersey crossbred cattle.

In present study, it was concluded that California Mastitis, Electrical conductivity meter and Digital Somatic Cell Counter tests are the reliable indicators for the detection of early or subclinical stage of mastitis under field conditions. However, further study could be needed for early and accurate diagnosis of mastitis in large number of animals to reduce cost of milk production as it led towards huge economic losses in dairy sector by affecting milk yield and milk quality traits.

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