RESEARCH ARTICLE

Effect of Non-Genetic Factors on Milk Yield, Milk Constituents and Feed Efficiency in Lactating Kankrej Cows

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Abstract

A study was carried out to assess the effect of season and parity on milk yield, milk composition, feed efficiency and return over feed cost in lactating Kankrej cows. Forty-nine cows of first to fourth parity were randomly selected at three weeks postpartum with an average body weight of 441.10 kg. Milk yield was recorded daily during the monsoon, winter and summer seasons, while feed intake and milk composition were measured at weekly intervals. Season had no significant effect on milk yield; however, dry matter intake was higher in winter than in monsoon and summer. Feed efficiency was superior in the summer, followed by winter and monsoon. Milk fat, solids-not-fat, protein and lactose percentages were higher in summer. The higher return over feed cost observed during summer may be attributed to the well-known adaptability of Kankrej cattle to semi-arid, hot and dry environments, which helps maintain productivity and economic efficiency under elevated temperatures. Milk yield increased with parity, being highest in the third and fourth parities and lowest in the first. Parity did not affect dry matter intake, but feed efficiency increased linearly from first to fourth parity. Milk fat percentage was lowest in the first and highest in the fourth parity. Return over feed cost increased with advancing parity, with higher values in third and fourth parities, reflecting improved productive and economic efficiency in later lactations. It was concluded that season significantly affected feed intake, feed efficiency, milk composition and return over feed cost, whereas parity also significantly affected milk yield, milk fat, feed efficiency and return over feed cost in Kankrej cows.

Key words: Feed efficiency, Kankrej cow, Milk composition, Milk yield, Parity, Season.

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Introduction

Kankrej is one of the well-known dual-purpose cattle breeds of India, valued for both draught power and milk production. The breed derives its name from the Kankrej taluka of North Gujarat, with its breeding tract extending from the southern Rann of Kutch through Banaskantha to Ahmedabad and parts of Rajasthan, including Jodhpur and Barmer. The population of the Kankrej breed is 3.028 million, of which 1.945 million cattle are pure and 1.083 million are graded (Rathod *et al.,* 2020). Kankrej cattle are notable for their adaptability to semi-arid climates, disease resistance, draught ability and milk production. At the Livestock Research Station, Kamdhenu University, Sardarkrushinagar, the breed is maintained under a semi-intensive management system. The average milk yield of Kankrej cattle is about 1,738 kg with a calving interval of 450 days and fat content ranging from 2.9 to 4.2% (NBAGR, 2018). Under organized farm conditions, a standard 305-day lactation yield of 2,501 litres and a calving interval of 435 days has been achieved (Anonymous, 2023).

The productive and reproductive performance of cattle is influenced by both genetic and non-genetic factors. While genotype defines the inherent potential, environmental factors such as season, parity and period of calving cause significant variation in performance (Dhaware *et al.,* 2008; Ivanov *et al.,* 2017; Basak and Das, 2018). Feed efficiency is also markedly affected by these non-genetic factors, with season influencing milk composition and parity affecting milk components. Hence, it becomes essential to assess the impact of such factors for the precise evaluation of the genetic merit and management of indigenous breeds. The present study was undertaken to determine the effects of season and parity on milk yield, milk composition, feed efficiency and return over feed cost in lactating Kankrej cows.

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Materials And Methods

The study was carried out at the Livestock Research Station, Kamdhenu University, Sardarkrushinagar, Gujarat. A total of 49 lactating Kankrej cows from first to fourth parity were randomly selected three weeks postpartum, with an average body weight of 441.10 kg. Animals were fed individually with measured quantities of concentrate pellets, green fodder and dry fodder to meet nutrient requirements as per ICAR (2013) feeding standards. The leftover feed from each experimental animal was collected once on a weekly basis and subtracted from the quantity offered to calculate the total feed intake (kg/day). Dry matter intake (DMI), which represents the actual nutrient intake excluding moisture content, was calculated by multiplying the feed intake of each feed and fodder by its respective dry matter content (%) and summing across all dietary components offered to the animal. Since DMI is a key determinant of nutrient availability, it was used as a basis for evaluating feed efficiency and for interpreting its relationship with milk yield and milk composition in lactating cows.

Proximate composition of feeds and fodders was determined according to AOAC (2007) procedures to characterize the nutritional profile of the diet offered to the experimental animals. The analysis revealed that concentrate pelleted feeds had low moisture content and relatively high levels of crude protein and nitrogen-free extract (NFE), indicating greater nutrient density. In contrast, green fodders exhibited high moisture content with moderate crude protein and elevated crude fibre levels, while dry roughages such as wheat straw and jowar hay were low in crude protein and high in fibre, reflecting comparatively lower nutritive value. Among the green fodders, lucerne showed a notably higher crude protein content. Considering that dietary nutrient composition, particularly crude protein, fibre fractions and energy components, plays a crucial role in influencing milk yield, milk composition and feed efficiency, the data presented in Table 1 provide a relevant nutritional basis for interpreting the production performance observed in the present study.

All animals were maintained under uniform management practices with *ad libitum* access to fresh and clean drinking water. Cows were machine milked twice daily at 04:00 h and 16:00 h. Individual milk yield was recorded daily using a milking machine recording unit across the monsoon, winter and summer seasons. Milk samples were collected at weekly intervals for compositional analysis. Milk fat, solids-not-fat (SNF), protein and lactose contents were determined using a milk analyzer. Energy-corrected milk (ECM) yield was calculated as:

ECM=0.327 x Milk yield (kg) +12.95 x Fat yield (kg)+7.65 x Protein yield (kg)

Feed efficiency was calculated as: (Energy corrected milk yield (kg))/(Dry matter intake (kg))

In addition to production parameters, economic efficiency was evaluated by calculating return over feed cost. Gross return was estimated based on daily milk yield and the prevailing selling price of milk at the cooperative dairy, while feed cost was computed from the daily intake of individual feed ingredients and their respective purchase prices at the Livestock Research Station. Return over feed cost was obtained by subtracting feed cost from gross return. Since non-genetic factors such as parity and season are known to influence feed intake, milk yield, production efficiency and return over feed cost serve as an important economic indicator to assess how these factors affect not only biological performance but also the profitability of dairy production systems. Thus, inclusion of return over feed cost provides a comprehensive understanding of the combined effect of non-genetic factors on both production and economic returns in lactating cows. The overall feed cost was estimated by combining the costs of concentrate, dry fodder and green fodder at 25, 10 and 3.5 (Rs/kg), respectively. The cow's milk selling price was based on the selling price, which was Rs. 40/kg over the experimental period. Feeding costs were calculated based on unit milk output as well as return on feed cost for lactating cows.

Statistical Analysis

Data were analyzed using the appropriate statistical packages. Descriptive statistics and one-way ANOVA procedure were used to analyze the dry matter intake, average milk yield, milk composition, ECM and feed efficiency (FE).

The statistical model used was: $y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$, where, μ is the overall mean, α_i = *i*-th variable, β_j = *j*-th random effects and e_{ij} = random error. The differences between means were separated according to Duncan's multiple range tests. Probability values of $p<0.05$ and $p<0.01$ were used to define statistically significant results.

Results and Discussion

Impact of Season on Milk Yield, Milk Composition, Feed Efficiency and ROFC

The effect of season on milk yield, milk composition, feed efficiency and return over feed cost (ROFC) in Kankrej cows is

Table 1: Proximate analysis of feeds and fodder (on % DM basis) fed to Kankrej cows

Name of sample	Moisture	Crude protein	Crude fibre	Crude fat	NFE	Total ash
Pellet feed	4.45	18.59	6.58	2.43	64.15	8.25
Green maize fodder	84.40	5.37	32.53	1.42	51.11	9.57
Green bajra fodder	78.30	7.80	28.50	5.70	48.20	9.80
Lucerne fodder	80.10	18.70	22.60	2.90	44.90	10.90
Jowar hay	10.20	4.20	32.30	1.40	53.30	8.80

presented in Table 2. No significant (p>0.05) differences in milk yield were observed among seasons. This might be attributed to the availability of sufficient green fodder across seasons and the adaptability of the breed to the local environment. Earlier studies, however, reported significant seasonal effects on milk yield in Ongole (Kumar *et al.,* 2003), Khillar (Dhaware *et al.,* 2008), and Deoni cows (Basak and Das, 2018). Similarly, Nantapo and Muchenje (2013) observed higher milk yield during the hot-dry spring compared to winter in Holstein-Friesian and Jersey cows, while Dodzi and Muchenje (2012) associated increased lying activity in summer with enhanced rumination activity, which could have improved rumen fermentation and thereby influenced milk composition.

Dry matter intake (kg/d) was significantly (p<0.01) higher in winter compared with monsoon and summer. This may be attributed to the availability of better quality green fodder during winter. In addition, the favourable climatic conditions and lower environmental stress during winter likely improved animal comfort and appetite, resulting in greater feed intake. Feed efficiency was significantly (p<0.05) affected by season, being better during summer, followed by winter and monsoon. Improved feed efficiency during summer may be attributed to better quality and digestibility of roughages, as also reported by Britt *et al.* (2003).

Season also had a significant (p<0.05) effect on milk composition (Table 2). Percentages of fat, solids-not-fat, protein and lactose were higher in summer compared to winter and monsoon. Similar findings were reported by Marcondes *et al.* (2014) and Ivanov *et al*. (2017). Fluctuations in milk solids are primarily due to variations in fat and protein (Chen *et al.,* 2014). In this study, milk fat percentage differed significantly (p<0.05) among seasons, with a higher value observed during summer compared to monsoon and winter. This increase may be attributed to the higher feeding of dry jowar hay during summer, which promotes greater ruminal fermentation of structural carbohydrates and production of acetate volatile fatty acids. Acetate produced during ruminal fermentation serves as a major precursor for de novo milk fat synthesis in dairy animals (Bauman and Griinari, 2003). Increased acetate production may have contributed to the higher milk fat percentage observed during summer. Bansal *et al.* (2009) also reported higher fat and protein contents in summer, whereas Cziszter *et al.* (2012) observed lower fat percentage in summer than in winter.

Feed represents the most significant expense in livestock production, constituting 60% - 70% of the overall cost. Reducing feeding costs relies on enhancing the conversion of feed into milk nutrients (Linn, 2006). Return over feed cost (ROFC) varied across seasons, reflecting the combined influence of milk yield, feed intake and feeding cost on economic efficiency. Higher ROFC observed during summer and winter may be attributed to improved feed efficiency and relatively higher milk yield, which enhanced gross returns despite variations in dry matter intake. In contrast, lower ROFC during monsoon could be associated with comparatively reduced milk yield and moderate feed utilization efficiency. Although winter exhibited the highest milk yield, the increased feeding cost partially offset the economic advantage. These results indicate that seasonal variation affects not only productive performance but also profitability, and ROFC serves as a reliable economic indicator to evaluate the impact of non-genetic factors such as season on dairy production systems. Similar observations have been reported by Britt *et al*. (2003), who highlighted the influence of seasonal feed quality on efficiency and economic returns, whereas Marcondes *et al*. (2014) reported seasonal variation in milk production and composition affecting overall profitability. Furthermore, Nantapo and Muchenje (2013) and, Dodzi and Muchenje (2012) also documented that seasonal changes in feeding conditions and animal

Table 2: Least-Square Means (±SE) for the impact of season on average milk yield, milk composition, feed efficiency and return over feed cost in lactating Kankrej cows

Details	Monsoon	Winter	Summer	Overall mean	Significance
No. of observations	**17**	**16**	**16**	**49**	
Milk yield (l/d)	11.65 ± 0.53	13.03 ± 0.69	12.73 ± 0.55	12.45 ± 0.35	NS
DM intake (kg/d)	9.53^{a} ± 0.09	10.22^{b} ± 0.14	9.39^{a} ± 0.11	9.71 ± 0.08	**
Feed efficiency	1.31^{a} ± 0.05	1.38^{ab} ± 0.08	1.54^{b} ± 0.09	1.48 ±0.05	*
Milk fat (%)	3.93^{a}± 0.06	3.91^{a} ± 0.09	4.21^{b} ± 0.22	4.01 ± 0.09	*
SNF (%)	8.15^{a} ± 0.08	7.93^{a} ± 0.13	8.65^{b} ± 0.13	8.24 ± 0.08	**
Milk lactose (%)	4.32^{a} ± 0.04	4.26^{a} ± 0.08	4.60^{b} ± 0.07	4.39 ± 0.04	**
Milk protein (%)	3.28^{a} ± 0.02	3.25^{a} ± 0.04	3.49^{b} ± 0.05	3.34 ± 0.03	**
ECM yield (kg/d)	12.56^{a}±0.57	14.10^{ab}±0.75	14.52^{b}±0.64	13.72±0.39	**
Total feeding cost (Rs.)/ animal/day	203.09^{a}	218.69^{b}	200.93^{a}	207.78	**
Market value of cow milk/ animal/ day (@ Rs.40/kg)	502.40^{a}±22.80	564.00^{ab}±30.00	580.90^{b}±25.60	552.80±15.60	**
Return over feed cost (₹/d)	299.31^{a}±23.00	345.31^{ab}±30.50	379.97^{b}±26.00	345.02±16.00	**

Means with different superscripts (a,b) within the treatment groups differ significantly (*p<0.05; **p<0.01; NS: Not-significant) responses significantly influence milk yield and economic outcomes in dairy cattle

Impact of Parity on Milk Yield, Milk Composition, Feed Efficiency and ROFC

The effect of parity on milk yield, milk composition, feed efficiency and return over feed cost (ROFC) is presented in Table 3. The overall mean milk yield was 12.45±0.35 kg/d, and was significantly ($p<0.01$) influenced by parity. Yields were highest in the third and fourth parities, followed by second, and lowest in the first parity. Similar observations were made in Ongole (Kumar *et al.,* 2003) and Deoni cows (Basak and Das, 2018). Other studies also reported increasing milk yield with parity, peaking at fourth lactation (Mellado *et al.,* 2011), which may be attributed to increased udder size (Davis and Hughson, 1988), higher number of secretory cells (Sorensen *et al.,* 2006), improved nutrient partitioning (Wathes *et al.,* 2007), and higher feed intake in multiparous cows (Dado and Allen, 1994). Parity had no significant effect on dry matter intake, but feed efficiency increased linearly ($p<0.05$) from first to fourth lactation, reflecting higher milk production with similar dry matter intake. Hurley *et al.* (2018) also reported variation in feed efficiency with parity in dairy cows.

Milk fat percentage was significantly ($p<0.05$) lowest in first lactation and highest in fourth lactation. Yang *et al.* (2013) observed similar trends in Chinese Holstein cows. Heifers require more nutrients for growth (Oltner *et al.,* 1985), which may partly explain lower milk fat in early parities. Other milk constituents such as protein, lactose and solids-not-fat were not significantly ($p>0.05$) influenced by parity. In contrast, Yang *et al.* (2013) reported parity effects on milk protein and total solids in Holstein cows.

Return over feed cost (ROFC) varied significantly across parities, reflecting the combined influence of milk yield, feed intake and feeding cost on economic efficiency. ROFC was significantly higher in fourth and third parities, followed by second and first, which may be attributed to higher milk yield and improved feed efficiency in later parities, leading to increased gross returns without a proportionate rise in feeding cost. In contrast, lower ROFC in the first parity could be associated with reduced milk production and diversion of nutrients towards growth rather than milk synthesis. Although feed intake did not differ significantly among parities, the increased productive performance in later parities resulted in better economic returns. These findings indicate that parity influences not only productive performance but also profitability and ROFC serves as a reliable economic indicator to evaluate the impact of non-genetic factors such as parity on dairy production systems. Similar observations have been reported by Kumar *et al.* (2003), Mellado *et al.* (2011) and Hurley *et al.* (2018), who also noted improved production efficiency and economic returns with advancing parity in dairy cattle.

Conclusion

The present investigation demonstrated that season exerted a significant effect on feed intake, feed efficiency, milk composition and return over feed cost, whereas milk yield remained unaffected in Kankrej cows. Parity significantly influenced milk yield, milk fat percentage, feed efficiency and return over feed cost, while dry matter intake and other milk composition did not vary significantly across parities. Return over feed cost (ROFC) was significantly affected by both season and parity, reflecting their combined influence on economic efficiency. Notably, ROFC was highest during the summer season, particularly in advanced parities (third and fourth), which may be attributed to improved feed efficiency and relatively higher milk yield, resulting in enhanced gross returns without a proportional increase in feeding cost.

Table 3: Least-Square Means (±SE) for the impact of parity on average milk yield, milk composition, feed efficiency and return over feed cost in lactating Kankrej cows

Details	First parity	Second parity	Third parity	Fourth parity	Overall mean	Significance
No. of observations	**14**	**14**	**14**	**7**	**49**	
Milk yield (l/d)	10.33^{a}±0.34	12.31^{b}±0.55	14.07^{c}±0.64	13.74^{c}±0.67	12.45±0.35	**
DM intake (kg/d)	9.51±0.18	9.71±0.15	9.95±0.15	9.62±0.14	9.71±0.08	NS
Feed efficiency	1.15^{a}±0.05	1.39^{b}±0.05	1.59^{bc}±0.09	1.67^{c}±0.13	1.42±0.05	**
Milk fat (%)	3.76^{a}±0.14	4.00^{a}±0.11	4.22^{ab}±0.14	4.56^{b}±0.35	4.08±0.09	**
SNF (%)	8.24±0.18	8.28±0.14	8.21±0.10	8.24±0.24	8.24±0.08	NS
Milk lactose (%)	4.37±0.10	4.39±0.08	4.40±0.05	4.41±0.13	4.39±0.04	NS
Milk protein (%)	3.33±0.05	3.34±0.05	3.33±0.04	3.35±0.09	3.34±0.03	NS
ECM Yield (kg/d)	$11.03±0.36^{a}$	$13.54±0.59^{b}$	$15.87±0.68^{c}$	$16.12±0.72^{c}$	13.82±0.37	**
Total feeding cost (Rs.)/ animal/day	205.79	207.78	212.91	205.85	207.78	NS
Market value of cow milk/ animal/day (@ Rs.40/kg)	441.20^{a} ±14.40	541.60^{b} ±23.60	634.80^{c} ±27.20	644.80^{c} ±28.80	552.80 ±14.80	**
Return over feed cost (₹/d)	235.41^{a} ±15.00	333.82^{b} ±24.00	421.89^{c} ±28.00	438.95^{c} ±29.00	345.02 ±16.00	**

Means with different superscripts (a,b,c) within the treatment groups differ significantly (**P<0.01; NS: Not-significant)

The superior economic performance of Kankrej cattle during summer further highlights their inherent thermo-tolerance and adaptability to high ambient temperatures, particularly under semi-arid conditions. This breed's ability to sustain productive efficiency under heat stress underscores its physiological resilience and efficient nutrient utilization. In the context of rising global temperatures and increasing climatic variability, such traits assume critical importance for ensuring sustainability and profitability in dairy production systems. Therefore, the findings of the present study emphasize that both season and parity should be carefully considered while formulating feeding and management strategies and they also establish Kankrej cattle as a climate-resilient and economically viable genetic resource for dairy farming in heat-prone regions.

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