



Impact of some Non-genetic Factors on the Economic Performance (Milk Production and Composition) of Crossbred Dairy Cows

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ABSTRACT

Mammary characteristics have a direct impact on dairy cow economic production. The current study was carried out at the University of Khartoum farm to examine the impact of non-genetic parameters such as parity order and lactation stages on milk production and composition in crossbred dairy cows. The study was conducted for 11 months from (January to November) 2022, during which the cows were in different production parity orders for milk (the second to the eighth season) at different age stages (3- 10 years), and physiological status. There was no discernible drop in the milk supply across all udder sections ($P \geq 0.05$) with advancing lactation from early to mid milking days, the highest decrease was in milking late (early 11.20, mid 10.02, and late 8.23 L), respectively. The difference in daily milk yield significance ($P \leq 0.05$) was for multiparous cows at 11.56 L and as much as 8.70 L for primiparous cows. The fat percentage was significantly affected by the lactation the stage ($P < 0.05$); the fat percentage in the milk was lower at the beginning of lactation, and then increased in the mid and late lactation (early 3.86%, mid 4.89%, and late 5.12%). In addition, milk composition percentages (protein, lactose, NFS, and density) did not differ significantly during the different stages of lactation: early, Mid, and late.

HIGHLIGHTS

- Advancing lactation from early to mid-milking days, the highest decrease was in milking late.
- The difference in daily milk yield significance ($P \leq 0.05$) was for multiparous cows and primiparous cows.
- The fat percentage in the milk was lower at the beginning of lactation, and then increased in the mid and late lactation.

Keywords: Milk yield, composition, udder quarters, parity order, stage lactation

Mammary characteristics have a direct impact on dairy cow economic production. The majority of milk cow selection is to increase milk yield. Dairy cows depend largely on their udders, measurements teat and udder differ between breeds and within the same herd, depending on parity order and lactation stage. Milk demand in developing countries is expected to increase by 25% by 2025 (FAO, 2018). Unfortunately, the dairy sector in Sudan faces low yields from native breeds and high production costs.

Udder morphological characteristics are prospective predictors of milk production in dairy cattle. According to (Bhuiyan *et al.*, 2004; Al-hayani *et al.*, 2023), the shape and size of the udder are important conformation

parameters to consider when choosing dairy animals for commercial milk production. Stankūnienė *et al.* (2008) discovered that milk production discrepancies of 10-15% between front and rear udders, additionally, variations in milking times of more than a minute negatively affect the health and output of udders. According to Kuczaj (2010), the productivity of the front and back quarters in cows that are best adapted to machine milking should account for

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42% and 58% of total milk output, respectively. Weiss *et al.* (2004) referenced earlier studies demonstrating that the rear udders produce 60.6% of the milk extracted from the cow's mammary gland, while the front quarters supply 39.4%.

The composition of milk concerns not only milk farmers but also processors and consumers. Milk content is influenced by a variety of hereditary and non-genetic characteristics. Knowing the impact of non-genetic factors such as parity order and lactation stage on milk supply and composition would help producers prepare to overcome the excessive volatility of their returns.

The current study was carried out at the University of Khartoum farm to look into the impact of non-genetic parameters such as parity order and lactation stages on milk production and composition in crossbred cows.

MATERIALS AND METHODS

Animals and management

The research was carried out on twenty-eight crossbred dairy cows in the University of Khartoum educational farm fields are under Unified administrative and nutritional conditions. The cows were in different production parity orders for milk (the second to the eighth season) at different age stages (3- 10 years), and physiological status. The cows were differently rated for calf sex (male or female) and stages of lactation. The study was conducted for 11 months from (January to November) 2022, during this period. The amount of milk produced by cows in each group was measured for early (after calving 15-105), mid (106-195 day), and late (196-290 days) lactation by hand milking twice a day (12:00 AM and 12:00 PM).

Milk yield and milk analysis

The evaluation of milking for the cows participating in the study begins 15 days after birth; the milk produced from each cow was weighed using the (liter) capacity standard for morning and evening milking, and the quantities of milk produced from each cow were recorded. Individual milk samples were collected daily in the morning and afternoon from January to November 2022, and the milk was stored in clean plastic tubes (50 ml) until it reached

the laboratory for analysis. Milk samples were tested using an ultrasound instrument (Milko Scan, Germany) in the dairy laboratory of the Department of Dairy Production at the College of Animal Production (Shambat). The milk sample (50 ml) was prepared at room temperature and homogenized before being placed into the device to prevent milk fat from accumulating on the sample's surface. He began reading the milk components digitally (analysis findings), which included the proportion of fat, protein, lactose, non-fat solids, and density.

STATISTICAL ANALYSIS

The GLM method for multivariate analysis of variance was used to statistically analyze the data. Using a program (SAS, 2012), the LSD test was utilized to identify significant differences between means. The linear model we employed was as follows:

$$\bar{X}_{ijk} = \mu + ai + bj + dk + \varepsilon_{ijk}$$

Where: μ = represents the general mean. ai = effects of parity order (primiparous or multiparous). bj = effects of stage lactation (after calving 15-105, 106-195, and 196-290 days). dk = effects of the udder quarters (LF, RF, LR, RR). ε_{ijk} = represents a random mistake.

Primiparous and multiparous cows' individual udder quarters, front, rear, and right and left quarters were compared in terms of daily milk production.

RESULTS AND DISCUSSION

Multiparous cows were found to be substantially more productive than primiparous cows when the daily milk supply of their mammary quarters was analyzed (Table 1). The rear quarters (RR and RL) of multiparous cows provided significantly more milk than primiparous cows, by 3.45 to 3.41 L and 2.43 to 2.49 L, respectively. At the same time, variations were noted, particularly in the front and rear quarters. Furthermore, primiparous cows produced 1.94–1.84 L of milk from their front quarters (FR and FL) compared to 2.33–2.37 L from multiparous cows (Table 1). For multiparous cows, the difference in daily milk yield was significant ($P \leq 0.05$) at 11.56 L, whereas for primiparous cows, it was as much as 8.70 L.

Table 1: Least squares means for Milk yield (L) all quarter, effect party order, and stage lactation in crossbred cows

Traits	N	Front Right	Rear Right	Front Left	Rear Left	Total
Party order						
Multiparous	15	2.33±0.05 ^a	3.45±0.04 ^a	2.37±0.05 ^a	3.41±0.05 ^a	11.56±0.13 ^a
Primiparous	13	1.94±0.03 ^b	2.43±0.04 ^b	1.84±0.02 ^b	2.49±0.05 ^b	8.70±0.12 ^b
Stage lactation						
Early	28	2.42±0.12 ^a	3.17±0.14 ^a	2.39±0.08 ^a	3.22±0.13 ^a	11.20±0.35 ^a
Midem		2.12±0.07 ^a	2.95±0.11 ^{ba}	2.00±0.07 ^b	2.95±0.12 ^b	10.02±0.31 ^b
Late		1.71±0.05 ^b	2.42±0.10 ^c	1.69±0.07 ^b	2.51±0.12 ^c	8.23±0.23 ^c

^{a,b,c} Meanings with the same superscript show a significant difference at ($p < 0.05$); Milking twice a 12:00AM and 12:00PM /day.

There was no discernible drop in the milk supply across all udder sections ($P \geq 0.05$) with advancing lactation from early to mid milking days, the highest decrease was in milking late (early 11.20, Mid 10.02, and Late 8.23 L) respectively. Analysis of the right and left quarters separately showed that milk production was consistent and there was no significant difference ($p \geq 0.05$) in the stages of lactation (Table 1). Analysis of the front and rear quarters showed significance ($P \leq 0.05$), in the lactation of stage. The early stages of lactation, produced 4.81–6.39 L, and in the Mid of lactation were 4.12– 5.90 L, the late stage of lactation, 3.40 and 4.93 L of milk, respectively. With the rear quarters producing at a higher level. Additionally, multiparous cows produced much more hind quarters during the lactation stage than primiparous cows. In rear quarters multiparous produced 6.86 L and 4.92 L primiparous cows. Within front quarters, multiparous cows produced 4.70 L and 3.78 L primiparous cows. Advancing lactation of the stage (late). It was shown that the milk output decreased in every quarter (Table 1). The current results are consistent with the findings of (Bogucki, 2018), who discovered that in Polish Holstein-Friesian cows, the left and right front quarters produced significantly less milk than the right rear and left quarters in primiparous cows compared to multiparous. Šlyžius *et al.* (2013) found that in Lithuanian Black-and-White cattle, the left and right rear quarters generated 3.42 and 3.47 kg of milk, while the left and right front quarters produced 2.63 and 2.71 kg of milk.

Sitkowska *et al.* (2016) discovered in a related study that variations in milk production between the front and rear portions were caused by the lactation stage. Furthermore, (Bogucki, 2018) discovered that in Polish Holstein-Friesian

cows, milk yield decreased with the lactation stage. The lowest drop was in the left front quarters, while the biggest was in the right rear quarters. For primiparous cows, the front and rear quarters accounted for 45.8–54.2% of daily production; for multiparous cows, the contribution ranged from 41.8–58.2%. The daily milk production of the front and rear quarters differs more, particularly for multiparous cows, according to Stankūnienė *et al.* (2008).

A previous study demonstrates, however, that rear quarters produce much more milk than front quarters and are characterized by a longer milking time, a higher production peak, and a higher mean milk flow intensity (Tancin *et al.*, 2006). Milk yield is highest during the early stages of lactation and decreases as lactation progresses. (Ahmad *et al.*, 2011; Sahib *et al.*, 2019).

The productivity of older cows, multiparous 11.56 L, and primiparous 8.70 L, respectively, was considerably greater ($P \leq 0.05$) according to the least squares means of milk production in crossbred Friesian cows (Table 2). Breed variations in milk yield and the ability of cows to store milk between milkings (cisternal size) were likely the causes of the variations in milk yield falling rates. Milk composition was not significant ($P \geq 0.05$) between multiparous and primiparous cows, and the percentage of fat, protein, NSF, and Density was at multiparous 4.67, 3.52, 9.03, and 30.90%, and primiparous 4.43, 3.51, 8.94 and 30.98% respectively. But, see significant in multiparous was lactose 6.77 and primiparous 7.94% respectively (Table 2).

Milk yield was affected by the order of parity. Yoon *et al.* (2004) reported similar findings, noting that milk yield varied greatly with parity order. In addition, similar

this study, primiparous cows generally produce the least milk, while cows in their multiparous produce the most (Manzi *et al.*, 2020). This contrasted with the findings of (Gurmessa and Melaku, 2012; Pratap *et al.*, 2014; Sahib *et al.*, 2019), who found that parity order did not affect milk yield.

Table 2: Least squares means for milk yield and composition and effect Multiparous cows and Primiparous cows in crossbred cows

Traits	Multiparous	Primiparous
Milk production, (L/d)		
MY	11.56±0.13 ^a	8.70±0.12 ^b
Milk compositions (%)		
Fat	4.67±0.11	4.43±0.12
Protein	3.52±0.02	3.51±0.01
Lactose	6.77±0.03 ^b	7.94±0.02 ^a
SNF	9.03±0.04	8.94±0.04
Density	30.90±0.25	30.98±0.30

^{a,b} Means in same row and breed within a factor carrying different superscripts differ ($P < 0.05$); **SNF**: non-fat solids.

The parity order did not affect milk composition. Similarly, a study, by (Gurmessa and Melaku, 2012; Pratap *et al.*, 2014; Sahib *et al.*, 2019) found that parity did not affect the main milk components (fat, SNF, protein, and density). This contrasted with the findings of (Yoon *et al.*, 2004; Callero *et al.*, 2023), who found that milk fat and protein varied considerably with parity.

Milk production and the percentage of fat was significantly by the lactation of stage ($P < 0.05$), the fat percentage in the milk was lower at the beginning of lactation, and then increased in the mid and late lactation (early 3.86%, mid 4.89%, and late 5.12%). This effect can partly be explained by a “dilution effect” which is the inverse relationship between milk yield and milk fat in milk animals. In addition, milk composition percentages (protein, lactose, NFS, and density) did not differ significantly during the different stages of lactation: early, Mid, and late (Table 3).

The mean milk production during the lactation stage (10.76, 9.62 and 7.83 L/day) was higher than that reported by Sahib *et al.* (2019) in crossbred dairy cattle. It was also greater than by Pratap *et al.* (2014) findings in crossbred Holstein-Friesian cows. The lactation stage significantly

affected milk production and milk fat ($P < 0.05$), but not other milk components. Milk production dropped with each stage of lactation, whereas milk fat percentage increased. The rise in milk fat percentage in late lactation could be ascribed to lower milk production during this time. Similar findings were reported by (Yoon *et al.*, 2004; Gurmessa and Melaku, 2012; Sahib *et al.*, 2019).

Table 3: Effect stage lactation in milk yield (L) and milk composition of experimental crossbred cows

Traits	Early	Midem	Late
Milk production, (L/d)			
MY	10.76±0.35 ^a	9.62±0.25 ^a	7.83±0.23 ^b
Milk compositions (%)			
Fat	3.86±0.20 ^b	4.89±0.17 ^b	5.12±0.15 ^a
Protein	3.47±0.03	3.50±0.04	3.57±0.03
Lactose	4.77±0.04	4.74±0.05	4.72±0.05
SNF	8.93±0.07	8.94±0.09	9.17±0.06
Density	31.50±0.26	30.46±0.48	30.84±0.29

^{a,b} Means in same row and breed within a factor carrying different superscripts differ ($P < 0.05$); MY: Milk yield production in a 24h-period by hand milking twice a 12:00 AM and 12:00 PM /day. **SNF**: non-fat solids. Milking twice a 12:00 AM and 12:00 PM /day.

Our findings on milk components differed from those published by (Mukherjee *et al.*, 2017; Sarkar *et al.*, 2006) in crossbred and KF cows. The percentages of protein, lactose, and SNF differed significantly, whereas the percentage of milk fat did not differ across the stages of lactation. Furthermore, Sudhakar *et al.* (2013) found that the lactation stage did not affect milk components or production. However, some research found that the lactation stage had no significant impact on milk composition percentages (Ibeawuchi and Dangut 1996).

CONCLUSION

Multiparous cows generally outperform primiparous cows regarding milk yield and milk component concentrations. The difference in daily milk yield significance ($P \leq 0.05$) was for multiparous cows at 11.56 L and as much as 8.70 L for primiparous cows. The milk yield of all udder quarters was found to not decrease significantly ($P \geq 0.05$) with advancing lactation from early to mid-milking days, the highest decrease was in milking late (early 11.20, mid 10.02 and late 8.23 L), respectively. Milk composition was not

significant ($p \geq 0.05$) between multiparous and primiparous cows. The percentages of fat, protein, NSF, and density were at multiparous 4.67, 3.52, 9.03, and 30.90%, and primiparous 4.43, 3.51, 8.94, and 30.98%, respectively. However, what was significant in multiparous was lactose 6.77 and primiparous 7.94%, respectively. The percentage of fat was significantly affected by the lactation stage ($p < 0.05$), the fat percentage in the milk was lower at the beginning of lactation, then increased in the mid and late lactation (early 3.86%, mid 4.89%, and late 5.12%). In addition, milk composition percentages (protein, lactose, NFS, and density) did not differ significantly during the different stages of lactation: early, Mid, and late.

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