Lactation Insights: Unveiling Milk Production and Composition Trends in Holstein-Friesian Crosses

Submitted by:

Nusrat Binte Amin

Roll: 18/101

Intern ID: 70

Registration No: 02069

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Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram-4225, Bangladesh

Lactation Insights: Unveiling Milk Production and Composition Trends in Holstein-Friesian Crosses

Approved by:

DR. Umme Salma Amin

Lecturer

Department of Dairy and Poultry Science

Faculty of Veterinary Medicine, CVASU

Faculty of Veterinary Medicine

Chattogram Veterinary and Animal Sciences University

Khulshi, Chattogram-4225, Bangladesh

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Abstract

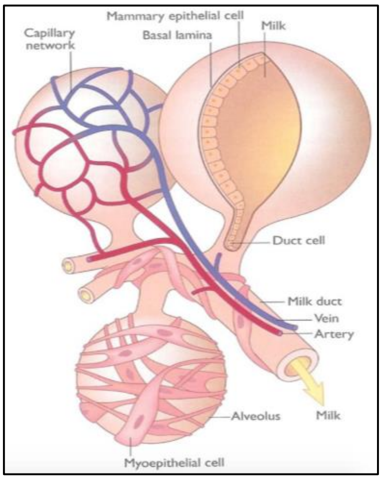
Dairy farming occupies a critical position in Bangladesh's agricultural system since it plays a vital role in employment, nutrition, and food security. Still, this sector faces a considerable challenge: there is a progressive gap in the supply of milk and its consumption which is crossing 45 lakh metric tons per annum. The present study aimed to investigate the impact of the lactation stages on milk production and its quality to improve the development of dairies positively. This study was conducted in Patiya upazila of Chattogram targeting 20 Holstein-Friesian crossbred cows that closely resemble the actual population. The collection of records was made very effective in different aspects across the three distinct phases of lactation. The research revealed that the amount of milk produced decreases with the progression of lactation as the average yield is 11.043 liters/day during early lactation. At the same time, the milk fat and lactose concentrations increased sharply during the late lactation stage, while SNF concentrations reached their maximum in mid-lactation. In addition, the research showed that the protein content in milk was slightly lower throughout the lactation period. The study thus reveals that the relationship between the lactation stage and milk composition is not simple. These differences also remind the stockholders about the necessity to implement the development of lactation management to not only preserve but also improve the quality and quantity of milk production. Knowledge of these lactation dynamics will thus enable dairy farmers to feed and manage their animals in ways that enhance yield, while at the same time also achieving the right components in milk at the correct proportion. This study provides a theoretical contribution to the existing literature in dairy science alongside practical implications to the policymakers as well as farmers in an attempt to enhance efficiency and sustainable dairy production in Bangladesh.

Keywords: Holstein-Friesian, Lactation stage, Milk Composition, Milk production

Chapter I

INTRODUCTION

The dairy sector of Bangladesh provides some form of employment and also helps in increasing the protein supply to people's meals thus helping in food security in addition to helping with Bangladesh's economic development. Dairy products take a central position in providing the human body with nutrients such as proteins, fat, carbohydrates, vitamins, and minerals in larger proportion compared to all foods, and is recommended that all ages of the population should consume it frequently (Hossain, 2022). According to (https://dls.portal.gov.bd), in Bangladesh, there are about 24.856 million cattle, 1.516 million buffaloes, 26.945 million goats, and 3.827 million sheep and the annual milk production (2022-2023) is 140.68 lakh metric ton. In the case of the contribution of livestock in GDP at a constant price, in 2022-2023(p) share of livestock in Agricultural GDP (%) was 16.52. The required requirement of milk production is 152.02 lakh metric tons but presently the supply of milk produced is 106.80 lakh metric tons. Hence, the production of milk should be scaled up to meet the consumer's expectations. In Bangladesh, cows are the most prominent source of milk (Datta, 2019). Therefore, for self-sufficiency in milk production, the Holstein Frisian (HF) cross can be a supportive one as given all the traits mentioned earlier, true crossbred cows surpassed indigenous cows in productivity (Ali, 2000).



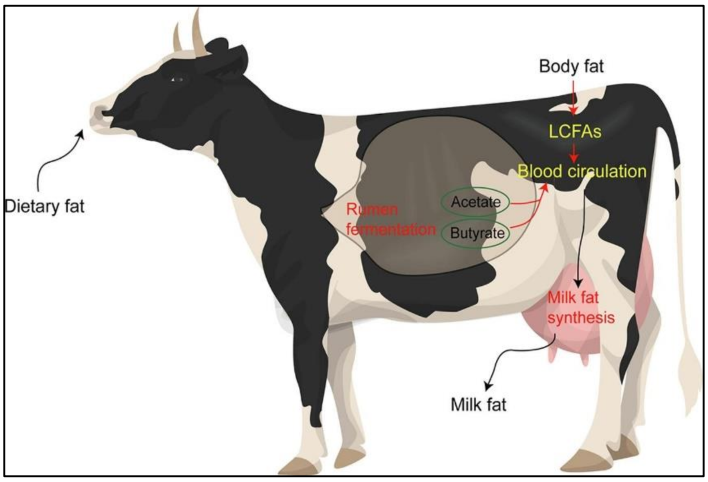
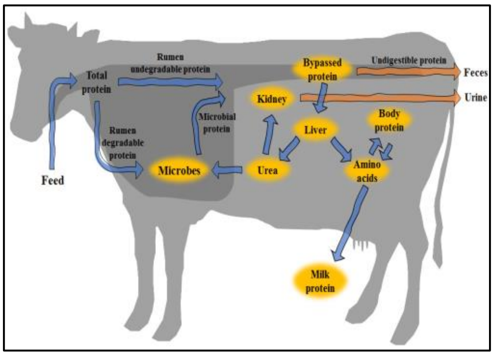


Figure 1: Synthesis of Milk **Figure 2:** Synthesis of Milk Fat (Tian, 2022)



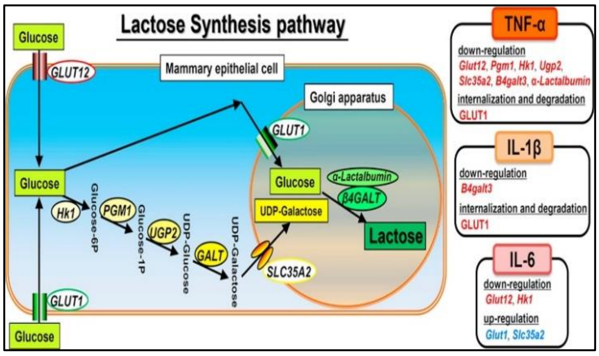


Figure 3: Synthesis of Milk Protein (Kim & Lee, 2021)

Figure 4: Synthesis of Milk Lactose (Kobayashi, 2016)

Recently there have been a lot of efforts to maintain market share given the deep competition from non-dairy products. Functional foods which include probiotic milks, yogurts, and fermented dairy drinks are another way through which the investors can tap into increasing consumer knowledge on the dairy components and their contribution to health and energy. There has also been fast advancement in technology regarding the processing of dairy products **(Figure 5)**.

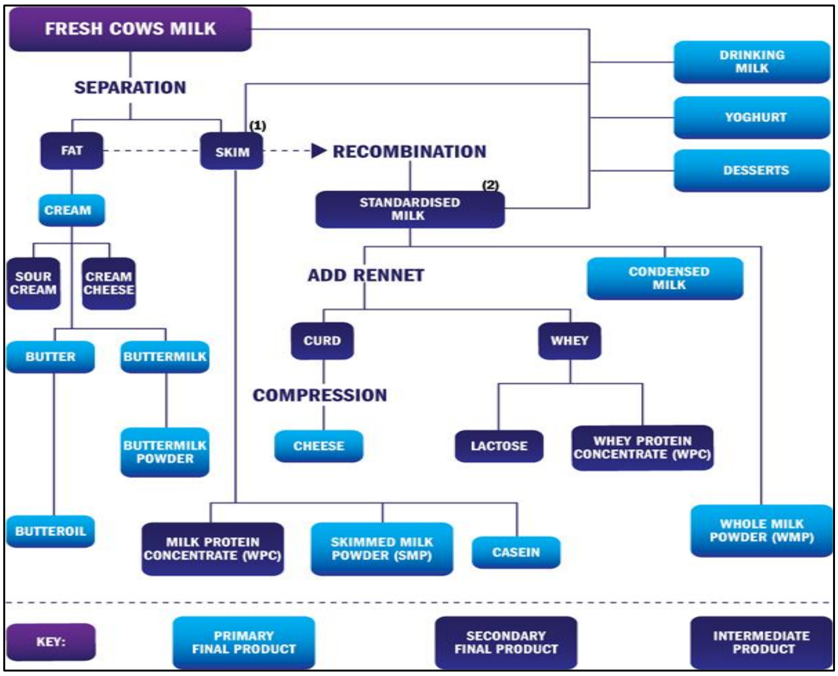


Figure 5: The conversion of milk, by a range of processes, into a variety of dairy products and food ingredients. (1) Skim milk is comprised of protein, other solids (lactose, minerals) and water; (2) Standardized milk, with a fat content adjusted by the addition of skim or cream) (More, 2009)

Thus, it can be concluded that different types of dairy products are not similar to each other and are based on the different components of milk. Milk is averagely composed of 87% water, 4-5% lactose, 3% protein, 3-4% fat, 0.8% 62 minerals and 0.1% vitamins (Pereira, 2014). However, the composition and properties of fresh milk have no fixed values and it becomes a difficult task for manufacturers of the milk products. Such variability is prompted by several factors which include the following. The main factors are (i) genetic factors (e.g. breed and individual), (ii) stage of lactation, (iii) health status of the animal, and (iv) environmental factors (e.g. climate, feed, method of milking) (Cheung & Mehta, 2015). During the early period of lactation and toward the very end, the secretion and composition of milk greatly transform. Considering the essence of milk production and composition as key determinants in the milk industry influencing the economic returns and quality of milk products, this research focuses on the quality aspect by determining the impacts of the lactation stages (early, mid, and late lactation) on milk yield and composition of HF crossbred cows. The findings of this research may have applications for dairy farmers and the dairy industry. Furthermore, knowledge of the yield and composition of milk and their changes across the various stages of lactation allows for proper practices in management. By presenting specific changes in terms of milk yield and quality that reflect the stage of lactation, this work was intended to help dairy farmers and researchers improve decision-making about their herds' health, milk quality, and the dairy industry as a whole. Thus, this study aimed to meet the following primary objectives-

- To investigate whether the lactation stage (early, mid, and late) has a statistically significant impact on milk yield and composition in HF crossbred cows.
- To estimate the magnitude of the differences in milk production and composition between lactation stages.

Chapter II

MATERIALS AND METHODS

2.1 Study area and population

The study was conducted in Patiya upazila located at 22.3000°N 91.9833°E of Chattogram district, Bangladesh. There are 280 numbers of dairy farms and the number of cross-breed cattle is 21754 (www.dls.patiya.chittagong.govt.bd). This type of study was not conducted before in the area and that's why the area was selected for this study. In the selected farm, the number of total cows, lactating cows, and dry cows are 178, 34, and 23 respectively, and on average, daily milk production is 400-450 liters. The selected farm followed the measures of quarantine before putting new animals in the farm, had a separate shed for the sick animals, and used to get the animals vaccinated and dewormed regularly if necessary. It also possessed cultivable land of its own.

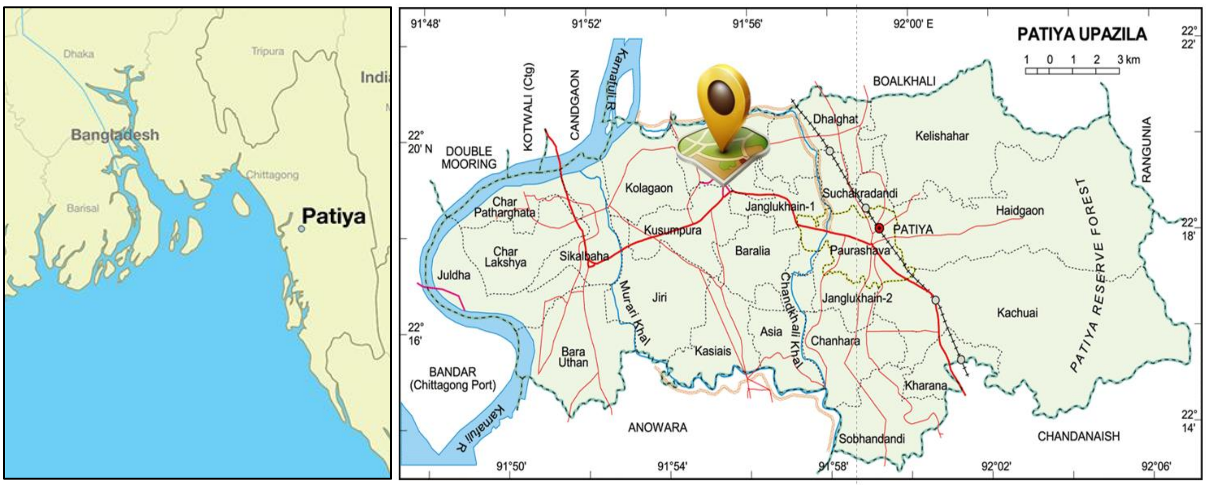


Figure 6: Geographical location of Patiya Upazila

2.2 Study population and design

2.2.1 Animals

A total 20 number of HF cross breed cows were studied from a dairy farm. All cows were healthy, disease-free, and managed under standard farm practices, including feeding, housing, and milking protocols.

2.2.2 Lactation Stages

The lactation period was divided into three stages: early (1 to 100) days in milk (DIM), mid (100 to 200 DIM), and late (>200 DIM). These timeframes were chosen based on established knowledge of typical lactation curves in dairy cows (Sahib, 2019).

2.2.3 Management

Throughout the study, all cows received a balanced diet formulated to meet their nutritional requirements according to their production level (**Table 1**). Animals were individually fed on the roughage and concentrate at a ratio of 32:8 per day for two times. They were supplied fresh drinking water from a deep tube well ad libitum. Animals are milked twice a day by a milking machine at (10-12) hours intervals.

Table 1: The proportion of ingredients used in dairy cow ration

Component	**Analyzed Value (%)**
Green Grass	
Dry Matter	27.67
Protein (CP) [Dry Matter Basis]	5.25
Crude Fiber (CF) [Dry Matter Basis]	52.14
Granular Feed Mixture	
Moisture	8.80
Protein (CP)	17.33
Crude Fiber (CF)	14.25
Crude Fat (EE)	5.54
Ash	11.96
Calcium (Ca)	3.50

2.3 Data collection

The data of Milk production was collected from their record book (level of milk production). The total daily milk yield was calculated for each cow within each lactation stage based on the collected data.

2.4 Sample collection and analysis

Milk samples were taken in the morning from 20 individual cows with variations in the stage of lactation. The samples were obtained in an aseptic manner with no influence from the researcher due to anonymity. After milking of individual cows, milk was thoroughly mixed by pouring into the bucket from the udder and after that, approximately 50 ml of milk samples were aseptically collected from each cow in a dry clean falcon tube. After that, samples were appropriately aliquoted and transported to the laboratory for testing not more than 2 hours after being kept in an ice box. Milk samples were analyzed for fat content (%), solids-not-fat (SNF) content (%), protein content (%), and lactose content (%) using the Lactoscan SL30 Ultrasonic Milk Analyzer. The stage of lactation was recorded and grouped into early, mid, and late lactations. The analyzer was regularly calibrated and maintained according to the manufacturer's specifications. Its accuracy levels are as follows: Fat: ±0.06%; SNF: ±0.15%; Protein: ±0.15%; Lactose: ±0.2%; Added water: ±3.0%; Density: ±0.3 g/L; Salts: ±0.05%; pH: ±0.05%.

Figure 7: Lactoscan SL30 Ultrasonic Milk Analyzer

2.5 Data analysis

2.5.1 Data Preparation

The data of daily milk yield and milk composition were compiled into a Microsoft Excel spreadsheet. Data cleaning and formatting were performed in R (4.4.0) to ensure accuracy and suitability for analysis.

2.5.2 Statistical Analysis

R (4.4.0) was used to perform a one-way ANOVA analysis to assess the impact of lactation stage (early, mid, and late) on milk yield and each milk composition (fat%, SNF%, protein%, lactose%). The assumptions of normality and homogeneity of variance were tested before performing the ANOVA analysis. Tukey's Honest Significance test (Tukey's HSD test) was conducted to identify significant pairwise differences in milk production and composition among lactation stages. The level of significance was set at $\alpha = 0.05$ for all statistical tests.

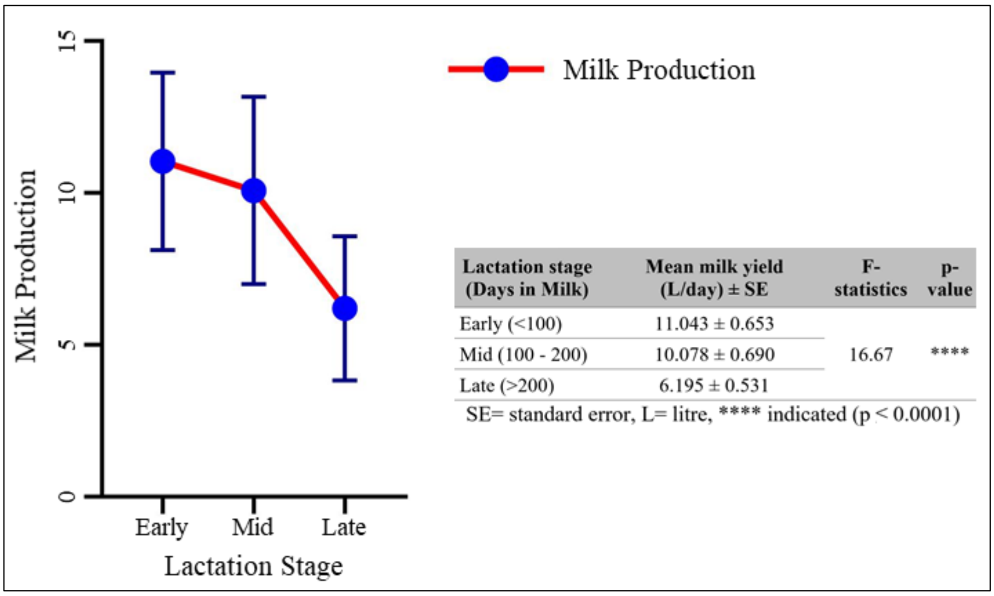
Chapter III

RESULTS

3.1 Impact of Lactation Stage on Milk Production

Milk production in HF crossbred cows exhibited a pronounced decline across lactation stages (**Figure 8**). The early lactation stage was characterized by peak milk yield, averaging (11.043 ± 2.921 L/day). A substantial reduction of approximately 8.74% in milk yield was observed during mid-lactation (10.078 ± 3.086 L/day), followed by a more dramatic decrease of approximately 43.90% to (6.195 ± 2.376 L/day) in late lactation. The observed pattern of milk yield decline aligns with the established physiological changes occurring in dairy cows post-partum. It appears to be linear, with a relatively consistent decrease between stages. The ANOVA results confirmed a highly significant difference in milk yield among the three lactation stages ($p<0.0001$).

The coefficient of variation (CV) for milk yield was 26.45% in early lactation, 30.62% in mid-lactation, and 38.35% in late lactation, respectively. The progressive increase in CV from early to late lactation indicates a growing variability in milk production among cows. This trend suggests that factors influencing milk yield become increasingly diverse as lactation progresses.



Lactation stage (Days in Milk)	Mean milk yield (L/day) ± SE	F-statistics	p-value
Early (<100)	11.043 ± 0.653	16.67	****
Mid (100 - 200)	10.078 ± 0.690		
Late (>200)	6.195 ± 0.531		

SE= standard error, L= litre, **** indicated ($p < 0.0001$)

Figure 8: Milk Production at Different Stages of Lactations

Furthermore, Tukey's HSD test revealed that milk production in the early lactation stage was significantly higher than in the late lactation stage ($p<0.0001$). Similarly, milk production in the mid-lactation stage was significantly higher than in the late-lactation stage ($p<0.001$). However, no significant difference was observed between milk production in the early and mid-lactation stages ($p > 0.05$) **(Table 2)**.

Table 2: Comparison of Milk Production at Different Lactation Stages

Trait	Comparison	Mean Difference	p-value
Milk Production	Early vs. Mid	-0.964	NS
	Early vs. Late	-4.848	****
	Mid vs. Late	3.884	***

*** indicated ($p <0.001$), **** indicated ($p <0.0001$), NS Indicated ($p >0.05$)

These results can therefore not be doubted as showing a very significant decline in milk production as HF crossbred cows continue through their lactation period. The early lactation stage provides the highest yield coupled with a decline in the middle and later stages of lactation. This decline can be explained by several factors including; low nutrient intake because the cow is pulling out energy from stored nutrients, hormonal changes, and changing structure of the udder tissue.

3.2 Impact of Lactation Stage on Milk Composition

A total of 20 samples were analyzed. Samples were grouped based on the stage of lactation as early-lactation (<100 DIM), mid-lactation (100-200 DIM), and late-lactation (>200 DIM). The percentage of cow milk samples under different stages of lactation is given in the **Figure 9**.

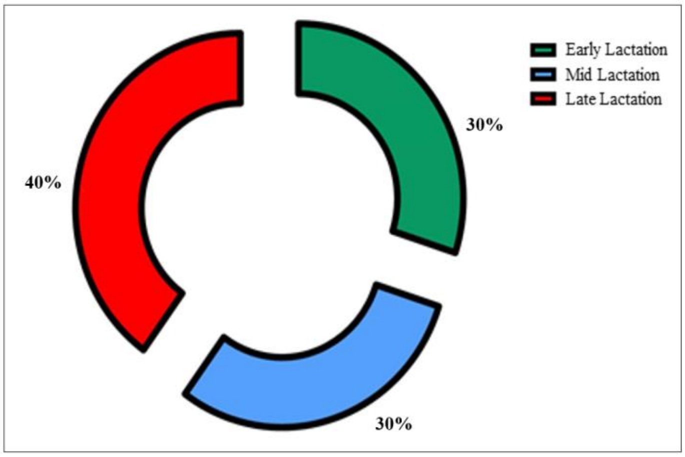


Figure 9: Percentage of Milk Samples at Different Lactation Stages

All the milk samples were subjected to estimation of fat, SNF, protein, and lactose content. The overall mean value for each milk component is given in **Table 3**.

Table 3: Overall Mean of the Different Milk Components (%)

Sl. No	Milk Components (%)	Mean ± SE
1	Fat	3.53 ± 0.132
2	SNF	8.29 ± 0.071
3	Lactose	4.53 ± 0.078
4	Protein	2.81 ± 0.244

To assess the influence of the lactation stage on milk composition, a one-way ANOVA was conducted on fat, SNF, protein, and lactose percentages (**Figure 10**).

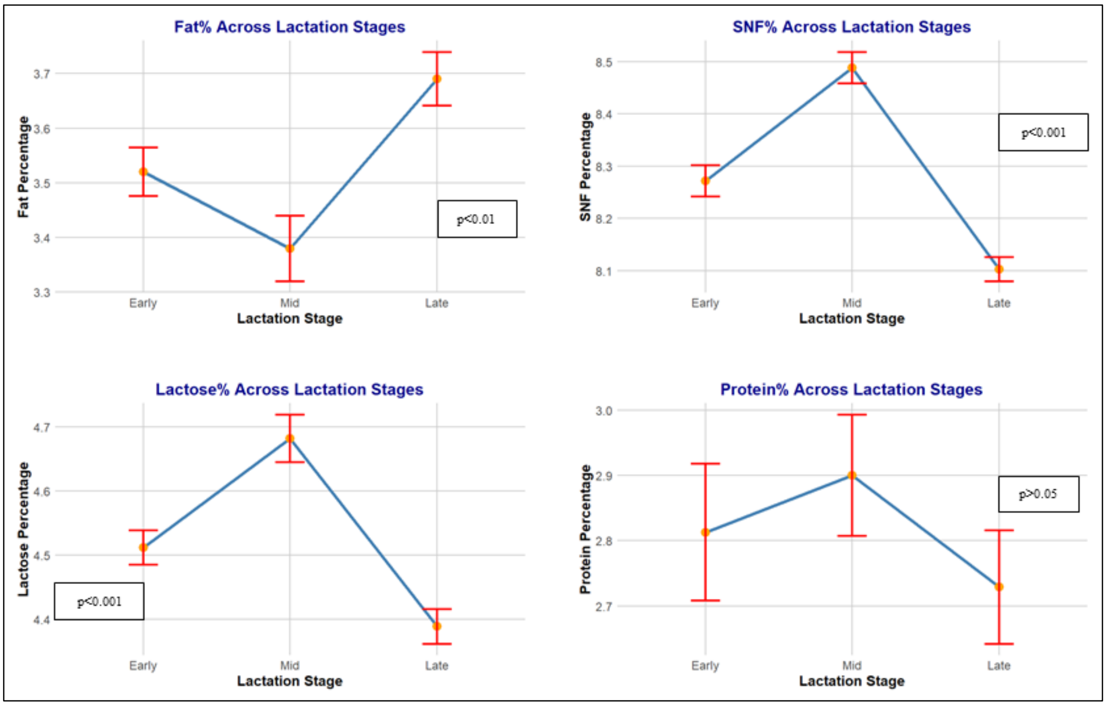


Figure 10: Chemical Composition of Milk at Different Stages of Lactation

To further explore the differences in fat, SNF, and lactose percentages across lactation stages, Tukey's HSD tests were conducted.

Table 4: Comparison of Milk Composition between Lactation Stages

Milk Composition (%)	Comparison	Mean Difference	p-value
Fat	Early vs. Mid	-0.140	NS
	Early vs. Late	0.175	NS
	Mid vs. Late	-0.315	**
SNF	Early vs. Mid	0.217	***
	Early vs. Late	-0.169	***
	Mid vs. Late	0.386	***
Lactose	Early vs. Mid	0.170	**
	Early vs. Late	-0.123	*
	Mid vs. Late	0.293	****
Protein	Early vs. Mid	0.087	NS
	Early vs. Late	-0.085	NS
	Mid vs. Late	0.171	NS

* indicated ($p < 0.05$), **indicated ($p < 0.01$), ***indicated ($p < 0.001$), ****indicated ($p < 0.0001$), NS indicated ($p > 0.05$)

3.3 Milk Composition at Different Lactation Stages

The composition of milk demonstrated notable differences throughout the different stages of lactation-

3.3.1 Fat Percentage

A gradual increase in fat percentage was observed from early to late lactation. Mean fat content was 3.52 ± 0.11% in early lactation, decreasing by approximately 4.52% (3.38 ± 0.147%) in mid-lactation, and further increasing by 9.44% (3.70 ± 0.14%) in late lactation. This represents an overall increase of 5.06% in fat content from early to late lactation **(Figure 9)**. While a general upward trend was evident, statistical analysis using Tukey's HSD test revealed a significant difference only between mid and late lactation stages ($p<0.01$) **(Table 4)**.

3.3.2 SNF Percentage

SNF percentage displayed a distinct unimodal pattern, peaking in mid-lactation at 8.49 ± 0.073%. A subsequent decline of 1.94% occurred from mid to early lactation (8.27 ± 0.074%), and a further decrease of 4.60% was observed from mid to late lactation (8.10 ± 0.064%) **(Figure 9)**. Statistical analysis confirmed significant differences among all lactation stage pairs ($p < 0.001$) **(Table 4)**.

3.3.3 Lactose Percentage

Similar to fat percentage, lactose content exhibited a gradual increase throughout lactation. Mean lactose content was 4.51 ± 0.066% in early lactation, rising by 3.99% (4.68 ± 0.091%) in mid-lactation, and subsequently decreasing by 6.19% (4.39 ± 0.077%) in late lactation **(Figure 9)**. Significant differences were observed among all lactation stages based on Tukey's HSD test **(Table 4)**.

3.3.4 Protein Percentage

Protein content remained relatively stable across lactation stages, with mean values of 2.81 ± 0.258%, 2.90 ± 0.228%, and 2.73 ± 0.246% for early, mid, and late lactation, respectively **(Figure 9)**. Statistical analysis did not reveal significant differences among the lactation stages ($p >0.05$) **(Table 4)**.

The combined results from the ANOVA and Tukey's HSD tests provide a clear picture of how the lactation stage impacts milk composition in HF crossbred cows:

- The lactation stage significantly affects fat, SNF, and lactose content in the milk.
- Fat content is highest in late lactation, followed by early and then mid-lactation.
- SNF content is highest in mid-lactation, followed by early and then late lactation.
- Lactose content follows a similar pattern to fat, with the highest value in late lactation and the lowest in mid-lactation.
- Protein content displays minimal variation across lactation stages.

Therefore, it can be concluded that lactation stage should be taken into account if the quality of the milk is to be assessed, or new products should be introduced to the market by the dairy industry. A comparison of cow milk composition reveals that the values may significantly change during lactation and such changes affect the adaptability of milk for certain uses.

Chapter IV

DISCUSSION

The purpose of the present study was to identify the impact of the stage of lactation on milk production and its content in HF crossbred cows. This study identified huge variations in milk yield and fat, SNF, and lactose percentages depending on the stage of lactation and the more stable content of protein. This information proves to be useful in understanding and predicting the fluctuations in milk productivity and its quality during the period of lactation.

4.1 Impact of Lactation Stage on Milk Production

The lactation stage had a highly significant influence on milk production, decreasing steadily from the early to the later stage of lactation. This distinct reduction in milk production from early to late stages of lactation is typical of the lactation curve in dairy cows; mainly due to the withdrawal of lactogens and the increasing energy required for milk production and overall metabolism, reduced dry matter intake and processes of involution (Hart, 1979). Again, the variation in milk production across lactation stages between the cows might be due to differences in genetic potential, feeding regimen, and reproductive status of the animals (Kirkland & Gordon, 2001). The results point to the significance of considering the lactation stage when implementing strategies for operating dairy herds and forecasting milk yields.

4.2 Impact of Lactation Stage on Milk Composition

This study showed that fat, SNF, and lactose contents differed considerably between lactation stages, although not for the protein component. All observed changes in milk composition are the result of the interconnection between hormonal, metabolic, and mammary gland factors. The increase in fat and rise of lactose percentages from early through to mid-lactation is supported by published data on the lipid metabolism related to lactation and the synthesis of lactose (Contreras & Sordillo, 2011). Another notable fact is the identified higher SNF content in mid-lactation, which is chosen to be explained in more detail. The variation of the regularity can be attributed to differences in dietary habits, metabolic rates, and genetics. One of the things that have been noted is that there is little variation in the protein content regardless of the stage of lactation which is somewhat unusual seeing that protein is a major component of milk. However, the stabilization of protein content is inconsistent with many earlier studies (Sudhakar, 2013).

These outcomes confirm preceding investigations about the cyclical changes in milk production and nutrient contents. According to (Collier, 1984), (Walsh, 1980) changes in milk production and composition are mainly due to hormonal changes in the three phases of lactation. It was noted that milk yield declined as the days in milk progressed and at the same time, the milk fat percent improved gradually. Similar results were reported by (Yoon, 2004). This was contrary to the results of (Gurmessa, 2012) who reported the occurrence of the peak milk yield at the mid-lactation. The milk yield was significantly ($p<0.05$) lower and the fat percent was significantly higher in the lactation stage above 200 days when compared to the lactation stage below 100 days (Sahib, 2019). Similar results were reported by (Gurmessa, 2012) and (Shuiep, 2016). The increase in milk fat percentage in late lactation may be due to reduced milk yield during this period as reported by (Auldist, 1998). Again, according to (Davies, 1983), (Schmidt, 1971), (Mepham, 1983) in a normal lactation of the dairy cow, the parameters of milk yield begin at high levels and reach their maximal value after 3 to 6 weeks after calving, and then decrease toward the end of lactation. These two factors are therefore normally inversely related to the milk yield, for instance, while the fat content of milk is a percentage figure, it is found to have an inverse relationship to both the protein percentage and the yield of milk. Compared to the other groups, the percentage composition begins at a medium level, drops to the minimum during the period of intensive lactation, and then rises by the end of lactation. (Schmidt, 1971), (Mepham, 1983), (Tucker, 1963). However (Sudhakar, 2013) reported that milk constituents and milk yield were not influenced by the stage of lactation. Again, according to (Mukherjee, 2017) the stage of lactation affected the fat%, as well as total solids content in the cows' milk. The fat% of the cow milk was comparatively lesser in the early stage of lactation than in the later stage. The late stage of lactation also recorded a higher percentage of lactose as compared to the early stage of lactation. Whereas (Sarkar, 2006) reported that the lactation stage was not statistically significant on the fat content of cow's milk, but it impacted the protein, SNF, and lactose content significantly. A significant impact of this factor has also been reported by (Suman, 2009).

IMPLICATIONS

Consequently, the outcomes of the current study will make a considerable contribution to the research and practice in the dairy industry. A decline in milk yield that was observed in this study in the later stages of lactation shows that there is a need to incorporate efficient management practices to cope with the losses. The differences in the composition of milk during various stages of lactation give the potential for diversification of the milk products and their quality. For example, the difference in fat and lactose content known to be high in milk of late lactation can be a strategic weapon for the production of cheese, butter, and other quality dairy products. On the other hand, the higher SNF content of mid-lactation milk may be beneficial to products that are produced for consumers who need more protein content such as protein-enriched beverages and infant formula. Knowledge of the compositional changes can also help in feeding regimes and milking practices to get better quality and more quantity of milk. So, we can say that this knowledge can be directly applied within the dairy sector to:

- Planning of milking periods and feeding programs concerning the changes in production and composition of milk during different lactations.
- Predictability of the production and the composition of milk can easily be enhanced for the dairy farms making the resource allocation easier and better planned.
- Yielding important information concerning the actions taken by the management to enhance the body growth of HF crossbred cows in the lactation period.
- On this note, the project would contribute to the formulation of breed-specific management practices for HF crossbred cows in the dairy sector.

LIMITATIONS AND FURTHER RESEARCH

Some of the limitations of this study include the fact that the subjects of the study were HF crossbred cows only, and thus might not reflect the same results if applied to other breeds of cows or even different populations of HF crossbred cows. Further large sample sizes and varieties of genetic background studies are needed to employ the findings of the current study and to investigate the cellular and molecular processes involved. Moreover, to enhance the general understanding of this phenomenon, research on the impacts of dietary factors, environmental conditions, and other factors of management on milk yield and composition at the various stages of lactation is recommended.

CONCLUSIONS

The present study explains the relationship between the lactation stage and the yield and composition of milk in HF crossbred cows. Milk production showed a steep reduction from the early to peak lactation period while the percentage composition of the skim milk also changed significantly. Protein, fat, and lactose content were almost similar to each other, gradually and continually rising throughout the period while SNF was at the highest level during the mid-lactation period. Protein content proved to be quite constant. These emphasize the dynamic nature of the process of lactation and make it easy to understand why successful milk production requires attention to the stage of lactation and why the burgeoning dairy industries should consider the stage of lactation. Thus, more research is needed to get a better understanding of the fundamental processes that lie behind these changes. Exploring the possible ways of genetic and physiological relations, and correlation with the nutrient input and output is vital for finding useful ways to improve the quality and quantity of milk. Hence, to close these knowledge gaps, the dairy industry will be able to use the available resources effectively to provide the required improvement on the products and bring them in line with the market demands of consumers.

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BIOGRAPHY

I am Nusrat Binte Amin, the daughter of Md. Fazal Amin Chowdhury and Kulsuma Khatun. I graduated with a CGPA of 5.00 in both SSC (2015) from Bakolia Govt. High School and HSC (2017) from Govt. Hazi Mohammad Mohsin College. Currently, I am an Intern Veterinarian at Chattogram Veterinary and Animal Sciences University. My goal is to become a skilled veterinary surgeon specializing in pet animal medicine, and I am eager to advance my knowledge and engage in various research activities in this particular field.

APPENDIX

A questionnaire to investigate the impact of lactation stage on milk yield and composition

Section 1: Farm and Herd Information

1. Name of the farm:

2. Location of the farm (Village/Upazila):

3. How many years have you been involved in dairy farming?

4. What is the total number of cows you have on your farm?

5. What breed of cows do you primarily keep on your farm?

6. What time of the year do your cows typically calve?

7. How long does the dry period (non-lactating period) usually last for your cows?

Section 2: Milk Production and Lactation Management

8. Do you keep records of milk production for individual cows?

9. During which lactation stage do your cows produce the highest amount of milk?

10. On average, how much milk (in liters) does a cow produce daily in each lactation stage?

11. Have you noticed any seasonal variation in milk yield or quality across lactation stages?

12. Do you monitor the health condition of your cows more frequently during any particular lactation stage?

13. Do you conduct regular tests for milk quality (fat, protein, lactose, SNF)?

14. If yes, what changes have you observed in milk composition during different stages of lactation?

15. Have you noticed any impact of lactation stage on milk color or consistency (e.g., creaminess)?

Section 3: Feeding Practices and Health Management

16. How do you adjust the feeding practices during different lactation stages?

17. What type of feed do you provide during different stages of lactation?

18. How often do you change or adjust the ration of feed according to the lactation stage?

19. Does the quality of the feed provided affect the fat and protein content of milk during different lactation stages?

20. Have you received any guidance or advice from veterinary professionals or consultants on adjusting feed according to lactation stages?

21. What strategies do you employ to prevent or reduce mastitis and udder infections?

22. Have you faced any issues related to mastitis or other udder infections that affected milk yield or quality during lactation?

23. Do you have access to sufficient veterinary services for managing health issues during the lactation stages?

Section 4: Challenges and Feedback

24. What challenges do you face in maintaining milk production and quality across lactation stages?

25. Have you faced difficulties in accessing proper feed or nutritional supplements during different lactation stages?

26. What support do you think would help improve milk production and quality in your farm?

27. How satisfied are you with the overall milk yield and quality from your cows?

28. Would you be interested in receiving training or additional resources to improve lactation management on your farm?

Interviewee	**Interviewer**
Owner/Manager/Employee	**Nusrat Binte Amin**

Statistical analysis with R (V 4.4.0)

ANOVA test in R

```
> anova1 = aov(milk_yield~ preg*lacts)
> summary(anova1)
            Df Sum Sq Mean Sq F value Pr(>F)
preg         1   2.02   2.016   0.107  0.748
lacts        2   4.43   2.216   0.118  0.890
Residuals   16 300.91  18.807
> anova1
Call:
   aov(formula = milk_yield ~ preg * lacts)

Terms:
                    preg     lacts Residuals
Sum of Squares   2.01612   4.43163 300.91342
Deg. of Freedom        1         2        16

Residual standard error: 4.336714
2 out of 6 effects not estimable
Estimated effects may be unbalanced
> summary(anova1)
            Df Sum Sq Mean Sq F value Pr(>F)
preg         1   2.02   2.016   0.107  0.748
lacts        2   4.43   2.216   0.118  0.890
Residuals   16 300.91  18.807
```

Shapiro test in R

```
> View(prdata)
> shapiro.test(milk_yield)

       Shapiro-Wilk normality test

data:  milk_yield
W = 0.98431, p-value = 0.977
```