Influence of Diet and Lactation Duration on the Physicochemical Composition of Sheep Milk in El Oued (Algeria) Region

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Abstract

This study evaluated the composition of colostrum and milk in ewes from two farms in the El Oued (Algeria) region, with a focus on fat, protein, and dry matter contents during different stages of lactation. Results from colostrum analysis revealed similar fat and protein levels between the two farms, while Farm I exhibited a higher dry matter content. During lactation, fat and protein concentrations were higher in Farm I compared to Farm II on days 10 and 30, but equalized by day 70. In contrast, dry matter content was comparable between the two farms on days 10 and 70, with Farm II surpassing Farm I on day 30. Correlation analysis demonstrated a significant negative association between milk composition (fat, protein, and dry matter) and lactation time, indicating a progressive decline of these parameters throughout the lactation period. These findings highlight farm-related variations and the temporal decline in sheep milk quality, which may be critical for optimizing nutritional management and dairy production.

Keywords: Sheep milk, Colostrum composition, Lactation stage, Milk quality, El Oued region

1. Introduction

Nutrition constitutes one of the most crucial elements of management that sheep breeders need to prioritize [1]. Ewes that are fed well-balanced rations are not only more fertile, but they are also easier to milk, and they wean a greater number of lambs that experience more rapid growth rates. As a result, optimal nutrition plays a vital role in enhancing the overall productivity and efficiency of sheep farming operations [2]. Adequate nutrition plays a critical role in determining the productivity and health of ewes. Those that are well-fed and properly nourished are more likely to produce a larger number of healthy lambs, exhibit improved reproductive performance, and enjoy enhanced resistance to disease and infection [3]. Therefore, prioritizing nutritional management is essential for sheep breeders seeking to optimize the efficiency and profitability of their operations [4]. Milk is a nutrient-rich food that is particularly beneficial for infants and children, supporting their growth and development [5]. Sheep milk production is a vital component of the agricultural economy in the El Oued region, where the quality and composition of milk are crucial for the production of traditional dairy products. The El Oued region is known for its unique climate and geography, which can impact the nutritional value and physico-chemical composition of ewe's milk [6]. The quality of ewe's milk is essential for the production of high-quality dairy products, such as cheese and yogurt, which are highly valued for their nutritional and sensory properties, the dietary regimen and lactation duration are critical factors that influence the physico-chemical composition of ewe's milk, and understanding their impact is essential for optimizing milk production and quality [7]. Despite the importance of sheep milk production in the El Oued region, there is limited research on the impact of dietary regimen and lactation duration on the physico-chemical composition of ewe's milk, highlighting the need for further investigation. This study is conducted under local breeding conditions, comparing indoor and outdoor rearing systems. We will evaluate the milk production performance of the females and analyze the physico-chemical properties of their milk, including fat, protein, and dry matter content, to determine the quality of the milk and inform future breeding and management practices.

2. Materials and Methods

2.1. Materials and Samples

Thirty milk samples from 30 ewes were collected fresh in the morning (during the first milking). These samples were packaged in sterile, labeled, and capped plastic bottles to which approximately 15 µg of potassium dichromate ($K_2Cr_2O_7$) was added to ensure milk preservation and prevent deterioration of its chemical components. The samples were immediately stored in a cooler (4°-6°C) and then refrigerated. Milk samples were analyzed several times, from October 2020 to the end of November 2021. Milk collected from the farms targeted by our study was analyzed for certain physicochemical characteristics (related to lamb growth) at the laboratory of the National Institute of Vocational Training in El-Oued. When collecting samples, certain rules must be observed, including: Wash the ewe's hands and udder (teats) before milking; Wear sterile gloves during milking; Discard the first few drops from each quarter, and transport the samples in bottles previously sterilized by heating.

2.2. Methods

2.2.1.Fat Content

The Gerber Acid-Butyrometric method has been recommended for the separation and measurement of fat. The principle of the technique consists of dissolving the milk components, except for the fat, with sulfuric acid under the influence of centrifugal force. With the addition of a small amount of isoamyl alcohol (1 mL), the fat separates into a clear, transparent layer.

First, the sulfuric acid (10%) is diluted in a proportion of 9 mL of sulfuric acid to 1 mL of distilled water. With the butyrometers installed on their stands, first add 10 mL of sulfuric acid, 11 mL of milk drawn from the sample to be analyzed are added to the sulfuric acid, then 1 mL of isoamyl alcohol is added. With each butyrometer kept closed, they are shaken until a homogeneous mixture is obtained, the butyrometers are then centrifuged. Centrifugation takes place at a rotation speed of 1100 rpm for 4 minutes. Once this operation is complete, the tubes are then removed to take the reading. During the reading, the butyrometer must be kept in a perfectly vertical position, bringing the lower level of the lipid phase, while holding the cap, until it is exactly within the graduated scale.

The fat content of milk, expressed in grams per liter, is equal to:

$$[Fat\ content]\ (g/L) = n' - n$$

n': the value reached by the upper level of the fat column.
n: The value reached by the lower level of the fat column.

2.2.2.Protein content

The raw milk protein assay was performed using the Bradford method. This is a simple process for determining the protein concentration of different types of food. The collected fractions are treated with a solution of Coomassie blue and orthophosphoric acid, which bind specifically to proteins. The technique involves diluting the milk samples and then reading them with a spectrophotometer set at 595 nanometers.

To perform a 1:50 dilution, 10 µL of milk is taken from each sample using a micropipette and made up to 500 µL with distilled water. Duplicate samples are prepared by taking 50 µL to which 2.5 ml of Bradford solution is added. Stir for 10 minutes. Samples and standards were measured at 595 nm against the reagent blank between 2 minutes and 1 hour after mixing. BSA was used to establish the calibration curve.

The protein content of milk, expressed in grams per liter, is equal to:

$$[Protein\ content](g/L) = A * D$$

A: Absorbance (read directly on the spectrophotometer screen).
D: Dilution volume.

2.2.3. Dry Matter Content

Dry matter is the product resulting from the drying by evaporation of a volume of milk.

10 mL of milk are added to a crucible or dry dish, weighed and tared, using a pipette. The crucibles are then placed in an oven at 103°C for 5 hours. The dishes are then removed from the oven and weighed after cooling.

The dry matter is then determined according to the following formula:

$$[Dry\ matter\ content](g/L) = \left(\frac{m1 - m2}{V}\right) * 1000$$

m1: Mass in grams of the dish and residue after drying and cooling.
m2: Mass in grams of the empty dish.
V: Volume in ml of the test sample.

2.3. Statistical Analysis

The results obtained were expressed by the average for each group, and to better visualize the results by graphical representation and histograms, using EXCEL. MINITAB software is used for comparisons of means. Significant differences between means are determined by the STUDENT t-test including; NS: Non-significant difference (P>0.05), S: Significant difference (P <0.05).

3. Results

3.1. Composition of Sheep's Colostrum

In histogram 01, we observe that the fat content of farm I is equal to that of farm II, and the protein content of farm I is equal to that of farm II. On the other hand, we note that the dry matter content of farm I is higher than that of farm II.

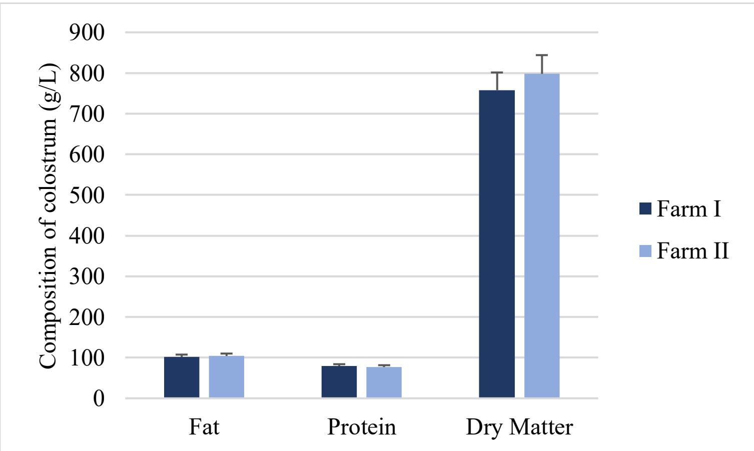

Figure 1. Colostrum composition of ewes from farm I and II.

3.2. Fat in Sheep's Milk

In histogram 02, we observe that the fat content for farm I is higher than that of farm II on the 10th day and the 30th day. On the other hand, on the 70th day, the fat content of farm I is equal to that of farm II.

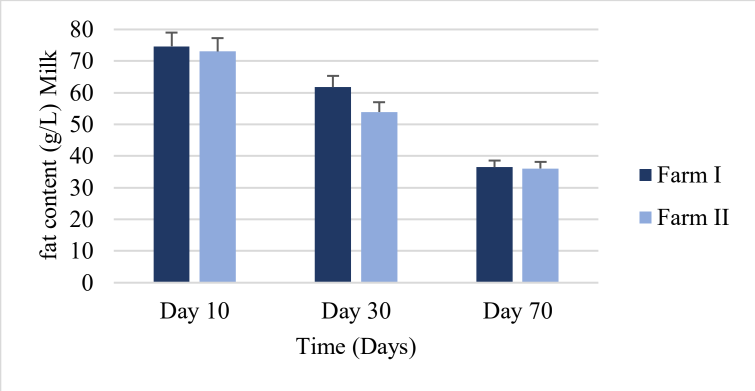

Figure 2. Fat content in the milk of ewes from farm I and II according to lactation duration.

3.3. Protein in Sheep's Milk

In histogram 03, we observe that the protein content of farm I is higher than that of farm II for the 10th day and the 30th day. On the other hand, for the 70th day, the protein content of farm I is equal to that of farm II.

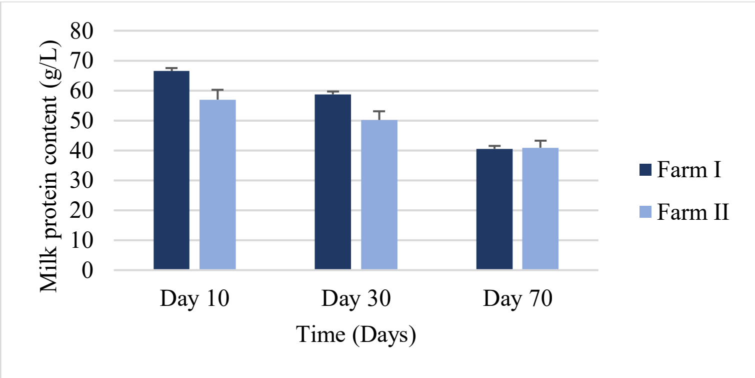

Figure 3. Protein content in the milk of ewes from farm I and II according to lactation duration.

3.4. Dry Matter in Sheep's Milk

In histogram 04, we observe that the dry matter rate of farm I is equal to that of the dry matter of farm II for the 10th day and the 70th day. On the other hand, for the 30th day, the dry matter rate of farm I is lower than that of the dry matter of farm II.

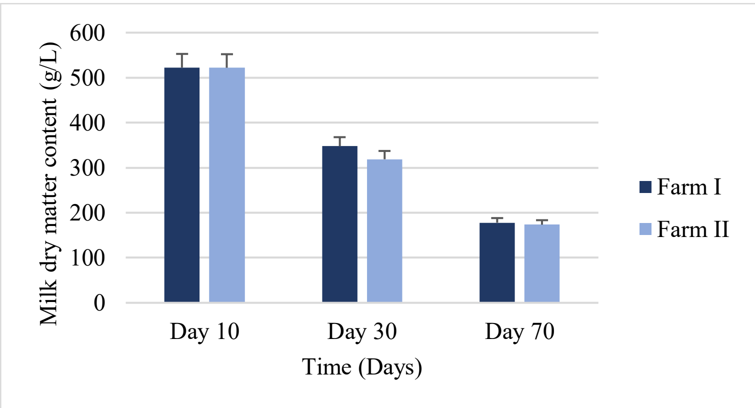

Figure 4. Dry matter content in the milk of ewes from farm I and II according to lactation duration.

3.5. Correlation Between Milk Composition and Time

Figure 05 presented the correlation between milk composition and time reared within the El Oued region. The findings illustrated in this figure indicated that there was statistically negative significant correlation between fat, protein and dry matter with time in sheep milk. This indicated that the amount of fat, protein and dry matter in sheep milk decreased over time during lactation.

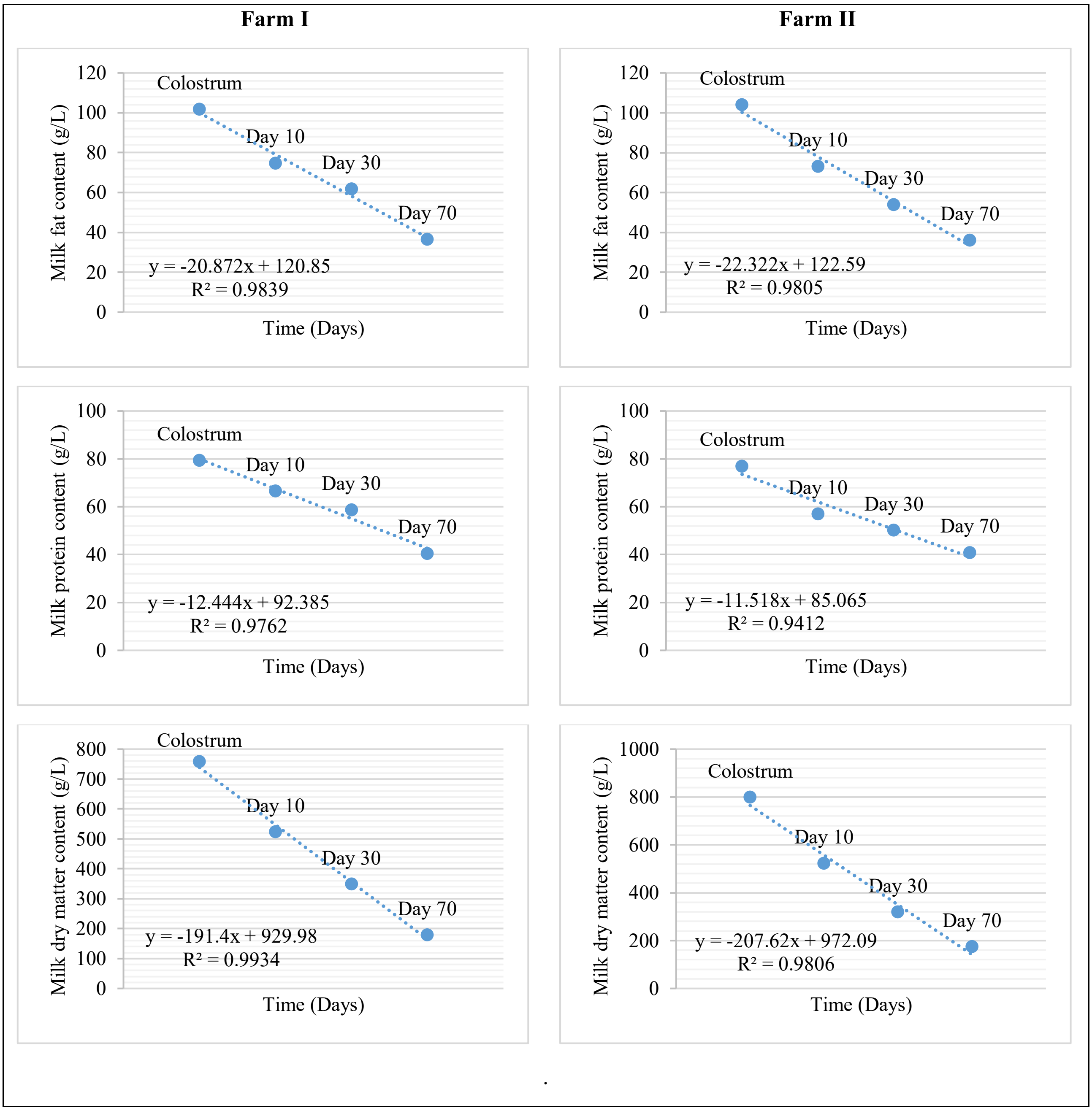

Figure 5. Correlation between milk composition and time

4. Discussion

The composition of milk from various animal species exhibits significant variability not only between different species but also within the same species, and even among different breeds or types within a single species [8]. This variability can be attributed to a range of factors, including nutritional intake, stage of lactation, age of the animal, time of year, and milk production levels [9]. The composition of colostrum is distinctly different from

that of mature milk [10]. Notably, colostrum has a higher dry matter content, which can be attributed to its significantly higher protein content, [11]. This unique composition plays a critical role in the development and health of newborn animals, highlighting the importance of colostrum in early life nutrition. According to various studies, the composition of colostrum includes a fat content of approximately 100 g/l, a protein content of around 150 g/l, and a dry matter content of about 180 g/l [12,13]. The results showed that the fat content varied between 104.11 g/L in Farm I and 101.73 g/L in Farm II. The protein content was between 77.02 g/L in Farm I and 79.38 g/L in Farm II, while the dry matter content ranged from 797.83 g/L in Farm I to 757.63 g/L in Farm II. The results of our study indicate that the feeding regimen did not have a significant impact on the composition of colostrum, including fat, protein, and dry matter content, between the extensive (Farm I) and intensive (Farm II) farming systems, suggesting that the feeding practices employed in each system did not substantially affect the nutritional content of the colostrum. Notably, our findings are consistent with those of other research investigations [12,13].
Dry matter in milk represents the nutrient-rich portion left after water removal, consisting of fat, protein, lactose, and minerals [14]. The 140 g/l dry matter value could be an average or specific to a particular type of milk, as different dairy species have different milk compositions [15]. Total solids content of 42% is exceptionally high and likely represents a highly concentrated milk, possibly due to specific feeding conditions or often increasing as milk yield decreases towards the end of the lactation period [16]. The fat content in milk typically ranges from more than 40 g/l, often varying depending on factors such as the breed of the animal, stage of lactation, nutrition, and farming practices [9,17]. Our study's results are consistent with previous research, which confirms our finding that the average values for fat content were 68.23 g/l in Farm I and 63.47 g/l in Farm II, highlighting the variation in milk composition between the two farms. Our findings are consistent with previous research, which showed that the average protein content of sheep's milk is significantly higher, typically ranging from around 47 g/l upwards, with our study recording values of 62.60 g/l in Farm I and 53.53 g/l in Farm II [18]. According to prior study, the variation in milk production within and between breeds is significant and depends on the effect of pre-partum and post-partum supplementation [19,20]. Our results corroborate these findings, showing that milk production at Farm II, which practices pre-partum and post-partum supplementation, is higher than at Farm I, where no supplementation is used. Sheep feeding is undoubtedly a key factor in successful sheep farming [21].
According to our results, the effects of feeding on the composition of colostrum and milk (fat, protein, and dry matter) between the two farms are statistically non-significant, as the percentage values of fat, protein, and dry matter do not differ significantly between the two farming systems (Farm I: extensive, Farm II: intensive). These findings confirm those of previous studies, which reported that nutrition affects the quantity of colostrum and milk but not their quality. However, other factor such as parity, colostrum yield, season, and collection timing after calving, were found to impact colostrum composition. By managing these factors, dairy farmers can improve colostrum quality and ultimately calf health [21].

5. Conclusion

This study confirms that colostrum and milk composition (fat, protein, and dry matter) show minimal variation between extensive and intensive farming systems. Feeding practices did not significantly impact the nutritional quality of colostrum or milk. However, other factors—such as parity, season, lactation stage, and timing of collection—play a more influential role. Consistency with previous research strengthens these findings. Managing non-nutritional factors may be key to improving colostrum quality and neonatal health.

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