Effects of non-genetic factors on milk yield and chemical composition of milk from Holstein-Friesian cows

Efectos de factores no genéticos en la composición química y producción de leche en vacas Holstein-Friesian

Efeitos de fatores não genéticos na composição química e na produção de leite em vacas da raça Holandesa-Frisia

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To cite this article:

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Received: November 12, 2022. Accepted: September 20, 2023
Abstract

Background: In order to accurately determine the performance of cows in terms of milk yield and milk components, it is necessary to determine the extent and direction of environmental factors. Although many studies have explored environmental factors affecting milk yield, there is not enough information about the effects and direction of environmental factors on the composition of milk. Objective: To determine the effects of non-genetic factors, such as calving season, lactation number, lactation stage, animal age, and herd size on milk yield, the chemical composition of raw milk, and Somatic Cell Count (SCC) in Holstein-Friesian cows.

Methods: Data were obtained from 15,354 raw milk samples of 5,118 Holstein-Friesian cows at 276 dairy farms in Türkiye. The data analysis was performed using the General Linear Model (GLM) feature of the SPSS statistics program. Results: Mean fat (F), protein (P), dry matter (DM), lactose (L), urea (U), and Log_{10}SCC values of cow milk were 3.74 ± 0.01, 3.19 ± 0.01, 11.36 ± 0.03, 4.32 ± 0.01%, 21.57 ± 0.28 mg/dL, and 5.244 ± 0.01 cells/mL, respectively. Peak milk yield (PMY), lactation milk yield (LMY), 305-day milk yield (305-d MY), and SCC values were found to be 33.7 ± 0.13, 8,538.33 ± 89.64 kg, 6,479.42 ± 168.96 kg, and 224,164.34 ± 4,402.79 cells/mL, respectively. Conclusion: It is recommended to take measures to improve the protein, dry matter, and urea component of milk in dairy farms in Türkiye and investigate in detail the relationship between raw milk urea component, subclinical mastitis, and reproductive features.

Keywords: cow; Holstein-Friesian; milk analyzer; milk composition; milk yield; non-genetic factors; phenotypic correlation; somatic cell count.

Resumen

Antecedentes: Para determinar con precisión el desempeño de las vacas en términos de producción de leche y componentes de la leche, es necesario conocer la cantidad y dirección de los factores ambientales. Aunque hay muchos estudios sobre los factores ambientales que afectan la producción de leche, no hay suficiente información sobre los efectos y la dirección de los factores ambientales en la composición de la leche. Objetivo: Determinar los efectos de factores no genéticos, tales como temporada de parto, orden de lactancia, etapa de lactancia, edad, tamaño del rebaño sobre la producción de leche, la composición química de la leche cruda y el recuento de células somáticas (SCC) en vacas Holstein-Friesian. Métodos: El material del estudio estuvo compuesto por 15.354 muestras de leche cruda de 5.118 vacas cabeza Holstein-Friesian en 276 granjas lecheras en Turquía. El análisis de datos se realizó utilizando la función de modelo lineal general (GLM) del programa estadístico SPSS. Resultados: Los valores...
medios de grasa (F), proteína (P), materia seca (DM), lactosa (L), urea (U), Log_{10}SCC de la leche de vaca se encontraron como 3,74 ± 0,01, 3,19 ± 0,01, 11,36 ± 0,03, 4,32 ± 0,01%, 21,57 ± 0,28 mg/dL, 5,244 ± 0,01 células/mL, respectivamente. La producción máxima de leche (PMY), la producción de leche de lactancia (LMY), la producción de leche a los 305 días (305-d MY) y los valores de SCC se determinaron como 33,7 ± 0,13, 8,538,33 ± 89,64, 6,479,42 ± 168,96 kg, 224,164,34 ± 4,402,79 células/mL, respectivamente. **Conclusiones:** Sobre la base de los resultados de este estudio, se recomienda tomar medidas para mejorar el contenido de proteína, materia seca y urea de la leche en las granjas lecheras de Turquía e investigar en detalle la relación entre el contenido de urea en la leche cruda y la mastitis subclínica y las características reproductivas.

**Palabras clave:** analizador de leche; composición de la leche; correlación fenotípica; factores no genéticos; Holstein-Friesian; producción de leche; recuento de células somáticas; vaca.

**Resumo**

**Antecedentes:** Para determinar com precisão o desempenho das vacas em termos de produção de leite e componentes do leite, é necessário conhecer a quantidade e a direção dos fatores ambientais. Embora existam muitos estudos sobre fatores ambientais que afetam a produção de leite, não há informações suficientes sobre os efeitos e a direção dos fatores ambientais na composição do leite. **Objetivo:** Determinar os efeitos de fatores não genéticos como estação de parto, ordem de lactação, estágio de lactação, idade, tamanho de la manada na produção de leite, composição química do leite cru e contagem de células somáticas (SCC) em vacas da raça Holandês-Frísia. **Métodos:** O material do estudo foi composto por 15.354 amostras de leite cru de 5.118 vacas da raça Holandesa-Frisia em 276 fazendas leiteiras na Turquia. A análise dos dados foi realizada utilizando o recurso General Linear Model (GLM) do programa estatístico SPSS. **Resultados:** Os valores médios de gordura (F), proteína (P), matéria seca (DM), lactose (L), uréia (U) e Log_{10}SCC do leite de vaca foram encontrados como 3,74 ± 0,01, 3,19 ± 0,01, 11,36 ± 0,03, 4,32 ± 0,01%, 21,57 ± 0,28 mg/dL e 5,244 ± 0,01 células/mL, respectivamente. Pico de produção de leite (PMY), produção de leite de lactação (LMY), produção de leite em 305 dias (305-d MY) e valores de SCC foram determinados como 33,7 ± 0,13, 8,538,33 ± 89,64, 6,479,42 ± 168,96 kg e 224,164,34 ± 4,402,79 células/mL, respectivamente. **Conclusões:** Recomenda-se tomar medidas para melhorar o teor de proteína, matéria seca e uréia do leite em fazendas leiteiras na Turquia e investigar em detalhes a relação entre o teor de uréia do leite cru, mastite subclínica e características reprodutivas.
Introduction

Milk is composed of water, proteins, amino acids, vitamins, lipids, fatty acids, and minerals. It is affected by factors such as breed or genetic group, milk production, stage of lactation, parity, feeding, and season of calving. Knowledge on the relative effects of genetic and environmental factors affecting milk components allows for changes in the composition of milk (Simões et al. 2014; Boro et al. 2016). Milk yield, milk chemical composition, and somatic cell count (SCC) can be affected by multiple genetic and non-genetic interrelated factors, such as parity, stage of lactation, calving season, herd, and calving year (Erdem et al., 2007; Atasever & Stadnik, 2015; Bertocchi et al., 2014; Sobczuk-Szul et al., 2015; Boujenane, 2021).

Practices that help breeders gain practical information about how to obtain quality raw milk and to improve the quality of different milk products (cheese, yogurt, cream, etc.) in different regions of Türkiye are also needed (Şahin & Yıldırım, 2012). The SCC in cow’s milk should be less than 200,000 cells/mL. If this number exceeds 200,000 cells/mL, then the udder lobe is most likely infected (Querengasser et al., 2002). In addition, the SCC in milk is an indicator of both the resistance and sensitivity of animals to mastitis, which can be used to monitor the level or formation of subclinical mastitis in herds or individual animals (Malik et al., 2018).

Milk Urea Nitrogen (MUN) is not in the protein structure and represents the total nitrogen in milk. Urea passes into the milk from the secretory cells of the mammary glands and is an indicator of the amount of degradable protein in the rumen. The MUN value is determined directly by the amount of urea in the milk. MUN values between 10 and 14 mg/dL are considered normal. Daily dry matter and protein consumption affect the MUN concentration in milk. While MUN values in milk below 10 mg/dL indicate insufficient dry matter and protein consumption, MUN values above 14 mg/dL indicate the opposite (Keser et al., 2019).

The purpose of this study was to determine the effects of non-genetic factors (calving season, lactation number, lactation stage, and animal age) on milk yield, the chemical composition of raw milk, and SCC in Holstein-Friesian cows.
Materials and Methods

Data were obtained from 15,354 raw milk samples of 5,118 Holstein-Friesian cows from 276 dairy cattle farms in Türkiye. An average of 3 raw milk samples per cow were used. Based on EU standards, raw milk samples were taken from each cow 3 times a year to determine the SCC (Anonymous, 2006). Raw milk samples were taken equally from the beginning to the end of the milking process using a special sampling tool (İzmirbirlik Süt Numune Alma Aparatı, İzmir, Türkiye). The raw milk sampler consists of two parts: a pipe system in a spiral structure that separates the samples from the milk output, and a 500 mL container for collecting milk samples (Figure 1).

Figure 1. Raw milk sampler (İzmirbirlik Süt Numune Alma Aparatı, İzmir, Türkiye)

SCC and chemical components (fat, protein, dry matter, lactose, and urea) of the collected raw milk were analyzed using the milk analyzer (Bentley Combi FTS, Maroeuil, France) (Figure 2). This analyzer was suitable and met the requirements of the International Committee for Animal Recording standards (ICAR, 2017).

The Bentley FTS, which represents the latest technology for automated milk analysis, can analyze 400 samples per hour. This piece of equipment was engineered in accordance with Bentley Instruments’ rigorous design principles and provides precise and accurate measurements. It uses a Fourier Transform Spectrometer (FTIR) to analyze the milk composition, including dry matter, fat, protein, lactose, urea, and SCC. After the first stirring, the milk is drawn from a sample vial and delivered to the measurement module. The sampling, sequencing, and identification of the sample vials are performed using the auto sampler. No chemicals are used in the analysis (Figure 2).
The Bentley FTS meets the standards set by the International Dairy Federation (IDF), International Committee of Animal Recording (ICAR), and Association of Official Agricultural Chemists (AOAC) (BENTLEY, 2023).

Figure 2. Bentley milk analyzer (Bentley Combi, FTS, Maroeuil, France).

For each animal where a milk sample was taken, the following data points were collected: fat, dry matter, lactose, protein, SCC, animal age, number of milking days, the highest daily milk yield, lactation milk yield, 305-day milk yield, season in which samples were taken, and lactation number. This information was obtained from the herdbook system of the Cattle Breeders’ Association of Türkiye.

Milk yield and milk components

In this study, the effects of calving season, lactation number, lactation stage, and animal age on fat (F), protein (P), dry matter (DM), lactose (L), urea (U), SCC, lactation milk yield (LMY), 305-day milk yield (305-d MY), and peak-day milk yield (PDMY) were investigated (Tables 1, 2 and 3).

Seasons were grouped into the following four classes: 1) Winter (December, January, February), 2) Spring (March, April, May), 3) Summer (June, July, August), and 4) Fall (September, October, November). For lactation number, cows were categorized as 1 through 7 and above. The animal age was classified in months as 24-36, 37-48, 49-60, 61-72, 73-84, 85-96, and 97 and above. Herd sizes were grouped into the following five classes: <51, 51-100, 101-500, 501-1000, and >1000 animals.
The lactation stage was studied by dividing it into six groups as follows: Lactation-I (<46 days), early Lactation-II (46-90 days), mid-Lactation (91-180 days), late lactation-I (181-270 days), and late Lactation-II (>270 days) (Table 4).

Statistical analysis

Data analysis was performed using the SPSS statistics program (SPSS 25.0; 2021). In the analysis of the data, analysis of variance (ANOVA) was used. A statistical model was assumed for evaluating the effects of calving season, lactation number, animal age, and herd size on milk yield, milk components, and SCC. Since repeated milk samples from animals were taken randomly on different lactation days, the effect of repeated measurements was included in the error variance. The following statistical model was used:

\[ Y_{ijkl} = \mu + a_i + b_j + c_k + d_l + e_{ijkl} \]

Where:

- \( \mu \) = Overall Mean.
- \( a_i \) = Effect of \( i^{th} \) season at calving (1-4).
- \( b_j \) = Effect of \( j^{th} \) lactation number (1-7).
- \( c_k \) = Effect of \( k^{th} \) animal age (1-7).
- \( d_l \) = Effect of \( l^{th} \) herd size (1-5).
- \( e_{ijkl} \) = Random error.

Duncan’s multiple range test (p<0.05) was used to compare the mean values of groups. Correlations among the milk yield and milk components were also calculated by the SPSS program (SPSS 25.0, 2021).

Results

The mean standard deviation and median results of F, P, DM, L, U, SCC, PDMY, LMY, and 305-d MY are provided in Table 1.

Table 1. Descriptive statistics for milk yield, raw milk components, and SCC.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>N</th>
<th>X ± SE</th>
<th>SD</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>%</td>
<td>1,490</td>
<td>3.74 ± 0.01</td>
<td>0.56</td>
<td>3.68</td>
</tr>
<tr>
<td>P</td>
<td>%</td>
<td>1,490</td>
<td>3.19 ± 0.01</td>
<td>0.31</td>
<td>3.16</td>
</tr>
<tr>
<td>DM</td>
<td>%</td>
<td>1,490</td>
<td>11.36 ± 0.03</td>
<td>1.02</td>
<td>11.33</td>
</tr>
</tbody>
</table>
In the study, although the effect of calving season on P and DM was not statistically significant (p>0.05), the effect of calving season on L (p<0.05), F (p<0.01), and SCC (p<0.01) was significant. The effect of lactation number on F (p>0.05) was not significant, while its effect on P, DM, L, and SCC was statistically significant (p<0.01) (Table 2). The effect of animal age and herd size on F, P, DM, L, and SCC was found to be statistically significant (p<0.01) (Table 2).

The effect of calving season and herd size on LMY, 305-d MY, Urea, and PDMY was found to be statistically significant (p<0.01). Although the effect of lactation number on LMY and 305-d MY was not significant (p>0.05), the effects on U (p<0.05) and PDMY (p<0.01) were significant. In addition, the effect of animal age on 305-d MY (p<0.05), LMY, U, and PDMY (p<0.01) were significant (Table 3).
### Table 2. Least squares means of raw milk components according to factors.

<table>
<thead>
<tr>
<th>Factors</th>
<th>N</th>
<th>X ± SE</th>
<th>X ± SE</th>
<th>X ± SE</th>
<th>X ± SE</th>
<th>X ± SE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Herd size (head)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;51</td>
<td>473</td>
<td>3.60 ± 0.02&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.13 ± 0.01&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.20 ± 0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.25 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>249,611.07 ± 6,940.80&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>51-100</td>
<td>254</td>
<td>3.69 ± 0.03&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>3.23 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.25 ± 0.06&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.26 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>275,973.03 ± 9,937.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>101-500</td>
<td>380</td>
<td>3.76 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.23 ± 0.01&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.75 ± 0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.43 ± 0.18&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>225,614.92 ± 8,632.51&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>501-1000</td>
<td>187</td>
<td>3.56 ± 0.05&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.40 ± 0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>11.91 ± 0.07&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.51 ± 0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>162,564.17 ± 18,677.82&lt;sup&gt;bc&lt;/sup&gt;</td>
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<tr>
<td>&gt;1000</td>
<td>196</td>
<td>4.29 ± 0.03&lt;sup&gt;d&lt;/sup&gt;</td>
<td>2.98 ± 0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>10.64 ± 0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.21 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>151,573.98 ± 2,748.76&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Calving season</strong></td>
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<td></td>
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<td></td>
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<tr>
<td>Winter</td>
<td>286</td>
<td>3.76 ± 0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.16 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.32 ± 0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.29 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>239,304.23 ± 9,162.12&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>Spring</td>
<td>233</td>
<td>3.58 ± 0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.20 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.48 ± 0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.36 ± 0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>216,238.24 ± 11,072.04&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Summer</td>
<td>463</td>
<td>3.64 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.19 ± 0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.33 ± 0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.31 ± 0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>245,631.99 ± 9,167.40&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Autumn</td>
<td>508</td>
<td>3.89 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.19 ± 0.01&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.37 ± 0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.33 ± 0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>199,711.00 ± 6,518.58&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Lactation number</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>279</td>
<td>3.72 ± 0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.31 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>11.78 ± 0.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.51 ± 0.02&lt;sup&gt;d&lt;/sup&gt;</td>
<td>185,468.32 ± 13,235.68&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>2</td>
<td>367</td>
<td>3.79 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.18 ± 0.02&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.39 ± 0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.35 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>210,707.06 ± 7,898.99&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
<tr>
<td>3</td>
<td>400</td>
<td>3.80 ± 0.03&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.17 ± 0.01&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.30 ± 0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.28 ± 0.02&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>226,615.05 ± 7,546.44&lt;sup&gt;abc&lt;/sup&gt;</td>
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<tr>
<td>4</td>
<td>213</td>
<td>3.70 ± 0.04&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.10 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.04 ± 0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.20 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>250,654.18 ± 10,716.77&lt;sup&gt;bcd&lt;/sup&gt;</td>
</tr>
<tr>
<td>5</td>
<td>133</td>
<td>3.74 ± 0.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.13 ± 0.03&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.15 ± 0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.24 ± 0.03&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>278,076.54 ± 15,401.94&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
<td>3.88 ± 0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.16 ± 0.04&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>11.36 ± 0.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.30 ± 0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>228,090.91 ± 14,978.54&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
<tr>
<td>7+</td>
<td>43</td>
<td>3.77 ± 0.09&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.22 ± 0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.29 ± 0.15&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.24 ± 0.05&lt;sup&gt;c&lt;/sup&gt;</td>
<td>264,302.33 ± 21,308.18&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Animal age (months)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>24-36</td>
<td>31</td>
<td>3.76 ± 0.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.43 ± 0.06&lt;sup&gt;c&lt;/sup&gt;</td>
<td>12.20 ± 0.17&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.64 ± 0.07&lt;sup&gt;d&lt;/sup&gt;</td>
<td>274,451.61 ± 55,247.65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>37-48</td>
<td>277</td>
<td>3.60 ± 0.03&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.31 ± 0.02&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.71 ± 0.06&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.49 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>176,780.36 ± 13,119.01&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>49-60</td>
<td>229</td>
<td>3.70 ± 0.03&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.17 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.49 ± 0.06&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.37 ± 0.02&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>214,898.38 ± 8,934.86&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>61-72</td>
<td>365</td>
<td>3.84 ± 0.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.16 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.30 ± 0.06&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.29 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>216,177.26 ± 75,59.11&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>73-84</td>
<td>236</td>
<td>3.73 ± 0.03&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.14 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.14 ± 0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.22 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>249,793.81 ± 10,483.25&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>85-96</td>
<td>163</td>
<td>3.73 ± 0.05&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.11 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.10 ± 0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.21 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>247,588.22 ± 11,371.27&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td>97≤</td>
<td>189</td>
<td>3.79 ± 0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.16 ± 0.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.20 ± 0.07&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.24 ± 0.02&lt;sup&gt;c&lt;/sup&gt;</td>
<td>260,049.77 ± 4,400.63&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

NS: Not significant (p>0.05). *, **: Significant at the level of p<0.05, **: Significant at the level of p<0.01.

Different superscript letters (a, b, c, d) within the same column indicate significant difference between means.

N: Sample size, SD: Standard deviation, X: Least square mean, SE: Standard error, F: Fat (%), P: Protein (%), DM: Dry matter (%), L: Lactose (%), U: Urea (mg/dL), SCC: Somatic cell count (cells/mL).
Table 3. Least squares means for milk yield characteristics and urea according to factors.

<table>
<thead>
<tr>
<th>Factors</th>
<th>LMY</th>
<th>305-d MY</th>
<th>U</th>
<th>PDMY</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>X ± SE</td>
<td>X ± SE</td>
<td>N</td>
<td>X ± SE</td>
</tr>
<tr>
<td>Herd size (head)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;51</td>
<td>974</td>
<td>7,025.08 ± 189.91b</td>
<td>6,409.88 ± 400.80a</td>
<td>387</td>
</tr>
<tr>
<td>51-100</td>
<td>121</td>
<td>6,835.49 ± 256.47b</td>
<td>5,550.38 ± 507.32a</td>
<td>206</td>
</tr>
<tr>
<td>101-500</td>
<td>65</td>
<td>8,856.00 ± 179.54b</td>
<td>6,895.01 ± 330.04b</td>
<td>260</td>
</tr>
<tr>
<td>501-1000</td>
<td>233</td>
<td>10,025.80 ± 207.28c</td>
<td>8,646.33 ± 372.05c</td>
<td>86</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>303</td>
<td>8,099.88 ± 123.28a</td>
<td>6,694.55 ± 278.94b</td>
<td>194</td>
</tr>
<tr>
<td>Calving Seasons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>974</td>
<td>**</td>
<td>**</td>
<td>1,133</td>
<td>**</td>
</tr>
<tr>
<td>Winter</td>
<td>169</td>
<td>7,897.63 ± 238.71a</td>
<td>8,099.88 ± 123.28a</td>
<td>225</td>
</tr>
<tr>
<td>Spring</td>
<td>89</td>
<td>7,958.00 ± 297.82a</td>
<td>7,805.09 ± 645.36c</td>
<td>169</td>
</tr>
<tr>
<td>Summer</td>
<td>258</td>
<td>8,288.53 ± 157.59a</td>
<td>7,051.88 ± 330.45c</td>
<td>351</td>
</tr>
<tr>
<td>Autumn</td>
<td>458</td>
<td>9,028.22 ± 128.01b</td>
<td>6,367.45 ± 243.22b</td>
<td>388</td>
</tr>
<tr>
<td>Lactation Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>974</td>
<td>NS</td>
<td>NS</td>
<td>1,133</td>
<td>**</td>
</tr>
<tr>
<td>1</td>
<td>399</td>
<td>8,616.64 ± 116.57a</td>
<td>6,818.04 ± 258.74a</td>
<td>180</td>
</tr>
<tr>
<td>2</td>
<td>212</td>
<td>8,372.86 ± 200.14b</td>
<td>6,437.45 ± 367.64a</td>
<td>259</td>
</tr>
<tr>
<td>3</td>
<td>229</td>
<td>7,978.81 ± 225.71a</td>
<td>6,221.88 ± 372.27a</td>
<td>322</td>
</tr>
<tr>
<td>4</td>
<td>84</td>
<td>8,346.35 ± 331.50b</td>
<td>6,361.38 ± 541.44a</td>
<td>175</td>
</tr>
<tr>
<td>5</td>
<td>29</td>
<td>7,756.93 ± 323.61a</td>
<td>5,278.45 ± 840.34c</td>
<td>112</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>8,567.55 ± 759.31a</td>
<td>5,964.36 ± 1,440.28a</td>
<td>45</td>
</tr>
<tr>
<td>7 ≤</td>
<td>10</td>
<td>6,802.88 ± 412.61a</td>
<td>4,796.90 ± 1,336.07a</td>
<td>40</td>
</tr>
<tr>
<td>Animal Age (months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>974</td>
<td>**</td>
<td>**</td>
<td>1,133</td>
<td>**</td>
</tr>
<tr>
<td>24-36</td>
<td>54</td>
<td>8,653.34 ± 402.36b</td>
<td>6,534.51 ± 597.89b</td>
<td>14</td>
</tr>
<tr>
<td>37-48</td>
<td>312</td>
<td>8,578.20 ± 124.36b</td>
<td>6,905.61 ± 389.71b</td>
<td>151</td>
</tr>
<tr>
<td>49-60</td>
<td>165</td>
<td>8,625.95 ± 237.12b</td>
<td>6,874.28 ± 439.37b</td>
<td>177</td>
</tr>
<tr>
<td>61-72</td>
<td>212</td>
<td>9,007.64 ± 212.01b</td>
<td>6,574.12 ± 431.80b</td>
<td>283</td>
</tr>
<tr>
<td>73-84</td>
<td>120</td>
<td>8,599.79 ± 297.49b</td>
<td>6,220.31 ± 523.49b</td>
<td>199</td>
</tr>
<tr>
<td>85-96</td>
<td>60</td>
<td>7,065.30 ± 380.29a</td>
<td>3,823.65 ± 552.25a</td>
<td>143</td>
</tr>
<tr>
<td>97 ≤</td>
<td>51</td>
<td>7,497.41 ± 218.68a</td>
<td>6,054.20 ± 615.96b</td>
<td>166</td>
</tr>
</tbody>
</table>

NS: Not significant (p>0.05). *: Significant at the level of p<0.05. **: Significant at the level of p<0.01.

Different superscript letters (a, b, c, d) within the same column indicate significant difference between means.

N: Sample size, X: Least square mean, SE: Standard error, LMY: Lactation milk yield (kg), 305-d MY: 305-day milk yield (kg), PDMY: Peak-day milk yield (kg), U: Urea (mg/dL).
Although the F component presented the highest value in the mid-lactation stage (91-180 days), it showed the lowest in the second late lactation stage (270 days ≥). The difference between lactation stages in terms of the F component was found to be statistically significant (p<0.01). However, while the P component presented the highest value within the first late lactation stage (181-270 days), it showed the lowest value in the middle lactation stage (91-180 days). The difference between lactation stages in terms of P component was observed to be statistically significant (p<0.05) (Table 4).

For the DM and L components, the highest values were detected within the first stages of late lactation (181-270 days) and the first stages of early lactation (<45 days), respectively. However, the lowest values were determined in the second early lactation (46-90 days) and middle lactation (91-180 days) stages for the DM component as well as in the second late lactation stage for the L component. The differences between lactation stages were found to be not statistically significant for the DM (p=0.065) nor the L components (p=0.111) (Table 4).

The U component had the highest value in the middle stage of lactation (91-180 days) although the lowest value was seen in Log10SCC within the same stage. However, during the first late lactation stage (181-270 days), Log10SCC had the highest value, while the U component had the lowest value. The differences between lactation stages for Log10SCC and U components were statistically significant (p<0.01) (Table 4).

### Table 4. Least squares means of raw milk components according to lactation stages.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>N</th>
<th>F</th>
<th>P</th>
<th>DM</th>
<th>L</th>
<th>Log10SCC</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage</td>
<td></td>
<td>F ± SE</td>
<td>P ± SE</td>
<td>DM ± SE</td>
<td>L ± SE</td>
<td>Log10SCC ± SE</td>
<td>U ± SE</td>
</tr>
<tr>
<td>1st Early (≤ 45)</td>
<td>91</td>
<td>3.67 ± 0.06&lt;sup&gt;b&lt;/sup&gt; ab</td>
<td>3.20 ± 0.03&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>11.49 ± 0.11&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>4.37 ± 0.04&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>5.22 ± 0.04&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>21.43 ± 1.32&lt;sup&gt;a&lt;/sup&gt; a</td>
</tr>
<tr>
<td>2nd Early (46-90)</td>
<td>188</td>
<td>3.76 ± 0.04&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>3.17 ± 0.02&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>11.29 ± 0.07&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>4.34 ± 0.03&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>5.24 ± 0.02&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>23.72 ± 0.82&lt;sup&gt;b&lt;/sup&gt; b</td>
</tr>
<tr>
<td>Middle (91-180)</td>
<td>346</td>
<td>3.93 ± 0.03&lt;sup&gt;c&lt;/sup&gt; c</td>
<td>3.13 ± 0.02&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>11.29 ± 0.06&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>4.32 ± 0.02&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>5.18 ± 0.02&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>25.31 ± 0.62&lt;sup&gt;b&lt;/sup&gt; b</td>
</tr>
<tr>
<td>1st Late (181-270)</td>
<td>285</td>
<td>3.78 ± 0.03&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>3.22 ± 0.02&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>11.50 ± 0.06&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>4.36 ± 0.02&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>5.28 ± 0.02&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>19.27 ± 0.57&lt;sup&gt;a&lt;/sup&gt; a</td>
</tr>
<tr>
<td>2nd Late (270≥)</td>
<td>580</td>
<td>3.62 ± 0.02&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>3.20 ± 0.01&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>11.35 ± 0.04&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>4.30 ± 0.01&lt;sup&gt;a&lt;/sup&gt; a</td>
<td>5.27 ± 0.01&lt;sup&gt;b&lt;/sup&gt; b</td>
<td>19.67 ± 0.39&lt;sup&gt;a&lt;/sup&gt; a</td>
</tr>
<tr>
<td>Overall</td>
<td>1,490</td>
<td>3.74 ± 0.01</td>
<td>3.19 ± 0.01</td>
<td>11.36 ± 0.03</td>
<td>4.32 ± 0.01</td>
<td>5.24 ± 0.01</td>
<td>21.57 ± 0.28</td>
</tr>
</tbody>
</table>

NS: Not significant (p>0.05), *: Significant at the level of p<0.05, **: Significant at the level of p<0.01.

Different superscript letters (a, b, c, d) within the same column indicate significant difference between means.

N: Sample size, X: Least square mean, SE: Standard error, F: Fat (%), P: Protein (%), DM: Dry matter (%), L: Lactose (%), U: Urea (mg/dL), Log10SCC: Value based on log10 for somatic cell count.
A positive, significant (p<0.01) and strong relationship between DM and L content was determined in the present study. Additionally, there was a positive, significant (p<0.01) and moderate relationship between the contents of P and L, between 305-d-MY and PDMY, and between the contents of DM and P. However, significant and negative correlations were found out between the SCC and all the traits, except with the component P. The direction of the relationship between SCC and P was positive, whereas it was negative with the other traits (PDMY, F, DM, L, U) (Table 5).

**Table 5.** Phenotypic correlations between milk yield, milk components, and SCC.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>PDMY</th>
<th>F</th>
<th>P</th>
<th>DM</th>
<th>L</th>
<th>U</th>
<th>SCC</th>
<th>LMY</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDMY</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>0.078**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.191**</td>
<td>0.051*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>0.232**</td>
<td>0.379**</td>
<td>0.678**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>0.301**</td>
<td>0.182**</td>
<td>0.585**</td>
<td>0.841**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>0.131**</td>
<td>0.256**</td>
<td>0.094**</td>
<td>-0.147**</td>
<td>-0.136**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCC</td>
<td>-0.207**</td>
<td>-0.127**</td>
<td>0.096**</td>
<td>-0.064*</td>
<td>-0.143**</td>
<td>-0.104**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>LMY</td>
<td>0.340**</td>
<td>-0.063</td>
<td>0.110</td>
<td>0.084</td>
<td>0.149**</td>
<td>0.050</td>
<td>0.046</td>
<td>1</td>
</tr>
<tr>
<td>305-d MY</td>
<td>0.648**</td>
<td>0.046</td>
<td>0.218**</td>
<td>0.247**</td>
<td>0.289**</td>
<td>0.153**</td>
<td>-0.043</td>
<td>0.443**</td>
</tr>
</tbody>
</table>

*: Significant at the level of p<0.05. **: Significant at the level of p<0.01.


r<0.3 none or very weak, 0.3<r<0.5 weak, 0.5<r<0.7 moderate, and 0.7 < r strong correlations.

**Discussion**

In this study, the mean F component was 3.74 ± 0.01% (Table 1). In previous studies, Hanus et al. (2010), Czajkowska et al. (2014), Suárez et al. (2016), and Kul et al. (2019) found the mean F component to be 4.06, 3.73, 4.17, and 3.39, respectively. Önal et al. (2021) reported that the lowest F component of milk by season was 3.44 ± 0.058% in autumn and 3.72 ± 0.048% in summer. Visentin et al. (2018) found that the milk yield averaged 22.74 kg/d and the mean F component was 4.03 ± 0.61%. On the other hand, El-Tarabany et al. (2018) reported that the F component was 3.44% for Holstein-Friesian cows, while Boujenane (2021) reported that the average F component was 3.54 ± 0.76%. Marshall et al. (2020) also found that in the early and late lactation periods, the F component in milk was 5.12 and 6.52%, respectively. In addition,
while the F component in raw milk was affected by herd size, calving season, and animal age, it was not affected by the lactation number. The F component in raw milk increased for <51, 51-100, and 101-500 herd sizes (3.60 ± 0.02, 3.69 ± 0.03, 3.76 ± 0.03, respectively). A decrease in the F component was observed for herd sizes of 501-1,000 head (3.56 ± 0.05%). The highest F component was obtained for herd size greater than 1,000 heads (4.29 ± 0.03%).

In this study, the lowest F component occurred during the spring season (3.58 ± 0.03%) and increased during the summer, autumn, and winter months (3.64 ± 0.02, 3.89 ± 0.03, and 3.76 ± 0.03%, respectively). This difference is likely related to the adequacy of the roughage stocks of the farms. The values obtained in this study for the summer and autumn seasons are different from the results (3.72 ± 0.06, and 3.44 ± 0.06%, respectively) obtained by Önal et al. (2021).

In this study, the P component was determined to be 3.19 ± 0.01% (Table 1). In a similar study conducted on this subject, it was determined that the mean P component in milk was 3.28% with a range of 3.19 to 3.33% (Aydin et al., 2010). In other studies, the P component to shown to be 3.43, 3.53, 3.66, and 3.37% by Suárez et al. (2016), Visentin et al. (2018), El-Tarabany et al. (2018), and Czajkowska et al. (2014), respectively. In addition, Marshall et al. (2020) and Boujenane (2021) reported that the mean P component was 3.02 ± 0.34%. Sarialioğlu and Laçin (2021) reported that the P component in family dairy farms and modern dairy farms was 3.49 ± 0.07 and 3.45 ± 0.01%, respectively. Önal et al. (2021) reported that the highest P component ratio for the winter season was 3.46 ± 0.031.

This study found that the P component in raw milk increased as herd size increased to 1,000. For herd sizes greater than 1,000, the P level in milk decreased. Accordingly, it can be said that the P component fluctuated depending on the lactation number and animal age, rather than a steady increase or decrease.

Önal et al. (2021) reported that the highest DM component (13.50% ± 0.103) in milk was observed in the spring. Suárez et al. (2016), El-Tarabany et al. (2018), and Czajkowska et al. (2014) found the DM component to be 13.16, 12.80, and 12.61%, respectively. In contrast, Boujenane (2021) reported that the mean DM component in milk was 8.72 ± 0.36%. Another study found the mean DM component in milk from family dairy farms and modern dairy farms to be 9.64 ± 0.21 and 9.52 ± 0.05%, respectively (Sarialioğlu and Laçin, 2021). Changes in the DM component in terms of herd size, lactation number, and animal age was consistent with changes in protein rates. Therefore, fluctuations in the DM component may have been due to differences in the feeding levels of the farms, which is similar to the protein rate.
In this study, the mean L component of milk was 4.32 ± 0.01% (Table 1). Ayaşan et al. (2011) previously found that the L component in milk was between 4.15 ± 0.06 and 4.34 ± 0.06%. Flipejova and Kovacik (2009) reported that milk L component ranged from 4.02 to 4.99 with a mean value of 4.59, and El-Tarabany et al. (2018) found the mean L component in milk to be 4.94%. In addition, Czajkowska et al. (2014) found this rate to be 4.89 ± 0.21%, and Boujenane (2021) reported that the mean L component was 4.89 ± 0.24%. Moreover, Marshall et al. (2020) found the L component in milk in the early and late lactation periods to be 5.04 and 4.81%, respectively. It is known that the L component of milk is not markedly affected by feeding. In terms of herd size, the trend of the L component was similar to that of the P and DM components. The L component of milk decreased as animal age increased. In terms of seasons, the lowest (4.29 ± 0.02%) and highest (4.36 ± 0.02%) L component percentages were observed in winter and spring, respectively.

In this study, the mean SCC value (224,164.32 ± 4,401.80 cells/mL) was found to be lower than the ones reported by Flipejova and Kovacik (2009) and Suárez et al. (2016) (1,525,400 and 523,207 cells/mL, respectively), but was in line with the SCC value obtained by Gürbulak et al. (2009) (226,800 ± 4,200 cells/mL). Eyduran et al. (2005) reported that lactation number and months had an effect on SCC in the milk from Holstein-Friesian cows and the mean SCC for August and November were 1,311,761 ± 239,631 and 732,810 ± 146,264 cells/mL, respectively. Böcekli (2015) assessed the effect of SCC on milk yield and found that <200,000, 201,000-500,000, and >501,000 cells/mL had a significant effect on milk yield with 28.75, 27.48, and 26.78 kg being generated, respectively.

In a similar study, it was reported that the highest SCC values occurred during the summer months (Aytekin and Boztepe, 2014). In a study conducted by Önal et al. (2021), it was shown that lactation number and seasons affected SCC. The authors found that milk with the highest SCC occurred during the 4th lactation (928.30 ± 117.93 x10^3 cell/mL) and milk with the lowest SCC was obtained during the 1st lactation (356.47 ± 50.55 x10^3 cell/mL). They also showed that from winter, spring, autumn, and summer, the SCC values descended from 1,003.88 ± 83.53, 877.63 ± 97.43, 575.81 ± 63.97, and 212.36 ± 17.94 x10^3 cell/mL, respectively (Önal et al., 2021). Sarialioğlu and Laçin (2021) also reported that the mean SCC values in milk samples were 4.23±0.19 and 3.79±0.16 Log_{10} for family dairy farms and modern dairy farms, respectively.
SCC decreased with increasing herd size. This result is thought to be due to the investment made for modernization and automation. The highest seasonal SCC values were observed in summer and winter seasons, respectively. It is thought that this result is caused by high temperature in summer and high humidity in winter and unfavorable barn conditions.

When examining the herd records and feed profile of a dairy farm, the nitrogen value of milk (U) is used as the standard method, since it provides a practical approach for measurement and evaluation (Roy et al., 2011). In this study, the U value was found to be 21.57±0.28 mg/dL. In addition, the U value was significantly affected by lactation stage (Table 4), calving season, and lactation number (p<0.01), but was not significantly affected by animal age (Table 3).

The urea nitrogen value of normal milk varies depending on many factors. It has been shown that if the protein level in milk is 3.0 and 3.2%, then the value of milk urea nitrogen varies between 12 and 16 mg/dL; as the percentage of P in milk increases, the urea nitrogen value in milk decreases. The reason for this is that more nitrogen consumption is used as milk protein (Abdouli et al. 2008).

Although Depatie (2000) reported that SCC did not affect the milk urea nitrogen value, Kwai-Hang et al. (1985) stated that an increase in SCC increased milk urea nitrogen. In contrast, other studies have reported that the milk urea nitrogen value is low in milk that has an excess of SCC. In those studies, the milk urea concentration was reported to have a positive relationship with milk yield and a negative relationship with milk F levels (Faust et al., 1997).

Abdouli et al. (2008) reported that the milk urea nitrogen value of cows bred under Mediterranean conditions was 30.39 mg/dL, while this value was 20.43-32.49, 11.15, 12.7-13.9, 20.64, and 11.75 mg/dL by Frank and Swensson (2002), Arunvipas et al. (2008), Meeske et al. (2009), Czajkowska et al. (2014), and Zhang et al. (2018), respectively. Marshall et al. (2020) also found that the U component in milk during the early and late lactation periods was 18.60 and 16.10 mg/dL, respectively. In contrast, Boujenane (2021) found the mean U component to be 17.6 ± 8.17 mg/dL.

The overall mean value (21.57 ± 0.28 mg/dL) obtained was above the accepted upper limit for milk urea nitrogen (14 mg/dL). In this study, the mean U values were high for herds with 501-1,000 and >1,000 heads (23.26 ± 1.60 and 30.97 ± 0.42 mg/dL, respectively). This is hypothesized to be due to the use of high protein mixed feeds for obtaining a higher milk yield per cow.
The mean PDMY, LMY, and 305-day MY values in this study were $33.70 \pm 0.14$, $8,538.33 \pm 89.64$, and $6,479.42 \pm 168.96$ kg, respectively. The effects of calving season on PDMY, LMY, and 305-day MY were statistically significant ($p<0.01$) (Table 3). The effect of lactation number on PDMY was not significant, while the effect of it on LMY and 305-day MY was statistically significant ($p<0.01$) (Table 3). The effects of cows’ age on PDMY and LMY ($p<0.01$) were also statistically significant (Table 3).

In this study, the LMY was found to be $8,538.33 \pm 89.64$ kg. In some studies, the LMY value was $5,929 \pm 23$, $7,700.02 \pm 99.17$, $4,716.1 \pm 243$, $3,032.41 \pm 66.78$, $5,720.00 \pm 43.6$, and $4,726.12$ kg by Bakır and Kaygısız (2013), Yıldırım et al. (2018), Gamaniel et al. (2019), Kidane et al. (2019), McClean et al. (2020), and Sanad et al. (2021), respectively. However, this study found that the LMY value was higher than all of the mentioned studies.

In this study, the 305-day MY value was $6,479.42 \pm 168.96$ kg. In similar studies conducted in Holstein-Friesian cows, this value was found to be $5,523 \pm 27$, $8,246 \pm 1,194.6$, $9,435 \pm 156.12$, $7,923.28 \pm 80.92$, $6,197.88 \pm 1,681.35$, and $8,369.72$ kg by Bakir and Kaygısız (2013), Van Eetvelde et al. (2017), Duru (2018), Yıldırım et al. (2018), Tutkun and Yener (2018), and Habib et al. (2020), respectively. Although the LMY value obtained in this study was higher than the values found by Bakır and Kaygısız (2013) and Tutkun and Yener (2018), it was found to be lower than the values found by Van Eetvelde et al. (2017), Duru (2018) and Yıldırım et al. (2018). Since the mean of lactation period is different for each herd, the 305-day MY is used instead of LMY to compare the herds with each other in terms of milk yield. Accordingly, the differences observed for the 305-day MY are thought to be due to the genetics of herds, the environment in which they were raised, and the different feeding plans.

In this study, the mean PDMY value ($33.70 \pm 0.14$ kg in Holstein-Friesian cows) was lower than the ones found by Sönmez et al. (2018; $35.00 \pm 0.50$) and Castaño et al. (2020; $39.77$), but it was higher than the values obtained by Serkan et al. (2013; $30.81 \pm 0.83$), Yılmaz and Kaygısız (2000; $21.5 \pm 0.60$), Abosaq et al. (2017; $22.79$) and Ghavi and Zadeh (2019; $31.31$). In terms of milk yield, the 305-d MY was used as a basis for comparison of milk yield, since the lactation period of the cows showed variation. Accordingly, it was found that the milk yield in herds with sizes between 101 and 1,000 heads was higher than in herds with sizes below 100 heads and above 1,000 heads. In terms of seasons, the lowest 305-d MY was found throughout autumn, and the highest during winter. This situation is associated with the increase in calving in winter and spring and the increase in roughage and concentrate feed production based on the
climate in Türkiye. Although there were fluctuations in the 305-d MY values of the lactation number and animal age groups, there was a decreasing trend in the 305-d MY due to the increase in lactation number and age.

While F and U ratios increased during the early lactation period (1-90 days), the P ratio decreased. During the middle lactation period (days 91-180), F and U ratios reached their highest values, while the P ratio saw its lowest levels. For the late lactation period (>181 days), the F and U ratios decreased, while the P ratio increased. Due to the use of body fat reserves throughout the early lactation period and the increase in the amount of feed according to the increase in milk yield, the fat rate increased until the end of the middle lactation period.

Unlike fat, protein component is not markedly affected by feeding, but has a negative relationship with milk quantity. For this reason, the protein level is at the lowest level during the middle lactation stage when milk yield is at the highest. However, the protein component in the early and late lactation stages is higher than in the course of the mid-lactation period.

Although the SCC decreased during the middle lactation period, it increased in the early and late lactation periods. It is thought that this situation results from the increase in epithelial cell loss of the mammary gland with the progression of the lactation period and the mastitis problem in the dry period before the early lactation period.

The U component in milk was at the highest level in the mid-lactation period. However, it was found at a lower level during the early and late lactation periods. This is due to the increase in the amount of concentrated feed due to the amount of milk, as well as the change in the protein and energy contents of the feed ration. Considering that the accepted U component in raw milk is 10-14 mg/dL, the U levels were found to be very high during all lactation stages.

In conclusion, the results of this study revealed that the effect of the calving season on 305-day MY, LMY, PD MY, U, L, F, and SCC, the effect of lactation number on PD MY, P, DM, L, and SCC, and the effect of animal age and herd size on LMY, 305-day-old MY, PD MY, and all milk components were statistically significant.

Although the dairy farms examined in the study are conscious of the level of milk yield per animal and the quality of it, they nevertheless need to take some measures to improve the P, DM, and U components of milk. In addition, based on the results of this study, it is recommended that detailed research be conducted on subclinical mastitis, as well as on the relationship between MUN and reproduction in dairy farms in Türkiye.
Declarations

Acknowledgement

The use of this study data was authorized by “the Cattle Breeders’ Association of Türkiye (CBAT)” on 21.08.2019 by the decision of the Board of Directors No. 2019/10. Thus, I would like to thank CBAT.

Funding

This study was conducted with the contributions of the Cattle Breeders’ Association of Turkey (CBAT).

Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

Author contributions

The design of the study, the literature review, the analysis of the data, and the writing of the article were all conducted by OŞ.

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