COMPARATIVE DATA ANALYSIS OF REPRODUCTIVE AND MILK YIELD PERFORMANCE OF HOLSTEIN FRIESIAN AND SWEDISH RED CATTLE UNDER ORGANIC FARMING CONDITIONS IN TÜRKİYE

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ABSTRACT

In Türkiye, the cattle population has increased by 56% in the last quarter century. The number of cattle has risen from 10.7 million to 16.8 million. 70.4% of the annual red meat production and 93.6% of the milk production in the country originate from cattle. Almost all of this production comes from dairy breeds. As in other countries, the increasing demand for organic milk and dairy products in the country has led to the conversion of some dairy cattle to organic production. However, the search continues for the most suitable breeds for organic dairy farms operating under limited and restricted conditions, particularly regarding concentrate feed ratios. This study aims to identify the most suitable breed by comparing some reproductive and milk yield characteristics of Holstein Friesian and Swedish Red cattle raised organically in Türkiye. For this purpose, fertility and milk yield records of 1559 HF and 339 SR cows belonging to a private organic dairy farm operating in Kelkit district of Gümüşhane province in the Eastern Black Sea Region of Türkiye covering the years 2007-2012 were used. HF and SR heifers reached first calving age at 29.8 and 26.1 months, respectively, in other words, SR heifers reached first calving age 3.7 months earlier ($P<0.01$). Calving interval in HF and SR cows was determined as 406.1 and 380.8 days, respectively, and the difference was significant ($P<0.05$). HF cows had a longer service period (9.3 days) ($P<0.05$). The number of days milked was determined as 350.5 and 322.4 days in HF and SR cows, respectively, with a significant difference of 28.1 days in favor of HF ($P<0.01$). HF cows had a 305-day milk yield of 522 kg more, but this difference was not significant. While actual milk yield of HF cows was 1.074 kg higher ($P<0.05$). SR cows reached the peak point earlier (10.7 days) ($P<0.05$). In both breeds, positive and significant ($P<0.01$) relationships were determined between the first calving age and the number of days of milking between calving, and actual milk yield. In both breeds, a positive and significant relationship ($P<0.01$, $P<0.05$) was detected between calving interval and days in milk as well as actual milk yield. In other words, antagonistic relationships were determined between fertility and milk yield in both breeds. The findings of present study indicate that SR cows raised under organic conditions in Türkiye exhibit superior reproductive performance and maintain comparable milk yield characteristics. Overall, the findings reveal a breed-specific trade-off between reproductive robustness and lactation persistence under organic production constraints, indicating that SR cows may be better suited for organic systems that prioritize fertility, regular calving intervals, and long-term herd sustainability.

Keywords: Organic cattle farming, Reproductive performance, Milk yield, Holstein Friesian, Swedish Red, Phenotypic correlation

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INTRODUCTION

Organic agriculture emerged as a response to the adverse effects of industrial agriculture on the environment, human and animal health (Röss *et al*., 2018, Linehan *et al*., 2024). According to current data, organic farming is carried out on 98.9 million hectares of land in 188 countries, the organic product market volume has reached 136.4 billion euros, and the demand for these products has increased with the COVID-19 pandemic (Willer *et al*., 2025).

Organic dairy cattle farms differ from conventional farms in terms of prioritizing breeding practices for the health and welfare of cattle, being pasture-based, using limited amounts of concentrated feed in the ration, not using chemical fertilizers in feed, and not using antibiotics and hormones for growth and yield (Schwendel *et al*., 2015; Rodriguez-Bermüdez *et al*., 2019a; Bayram, 2021). Since consumers assume that these differences have a positive effect on the nutrient content and quality of milk (Bayram *et al*., 2013; Borawski *et al*., 2021), protect animal welfare to the maximum extent (Duval *et al*., 2020) and are a more environmentally friendly production model (Schwendel *et al*., 2015), there is a continuous increase in the demand for organic milk and products. As a result, in both EU countries and the USA, milk and its products are among the most demanded organic products after fruits and vegetables (Sorge *et al*., 2019; Nehring *et al*., 2021; Kumar *et al*., 2023; Carlson *et al*., 2023)

Milk yield of cattle raised under organic conditions has been reported to be 15% to 28% lower than those raised under conventional conditions (Hardeng and Edge, 2001; Sundberg *et al*., 2009; Brodziak *et al*., 2021; Hinken, 2022). The reason for the lower milk yield has been reported as the use of limited and lower amounts of concentrated feed in the ration and insufficient energy content in the roughage predominantly used in the ration (Sundberg *et al*., 2009; Brito *et al*., 2020; Brodziak *et al*., 2021). Lower profitability resulting from low milk yield appears to be a significant problem to the growth and sustainability of the organic dairy cattle sector worldwide (Sapbamrer and Thammachai, 2021). For the sustainability of the organic dairy cattle sector, the most important point that both researchers and breeders agree on is to increase milk yield in organic dairy cattle enterprises.

The organic farming regulation explicitly or implicitly recommends the use of local breeds with the statement that "their capacity to adapt to local conditions should be taken into account in the selection of breeds" (EC, 2007; MoAF, 2010). However, in many countries, especially in England, the Netherlands, Spain, France, Canada, Sweden and Türkiye, breeds with high genetic potential, especially the HF, are preferred as breeding material in organic dairy cattle enterprises, as in conventional production (Krieger *et al*., 2017; Bieber *et al*., 2019; Rodriguez-Bermüdez *et al*., 2020; Bayram, 2021; Hinken, 2022; Grodkowski *et al*., 2023). However, as a result of long-term selection studies conducted on the HF breed, it has been reported that it is not a suitable breed for organic farming due to negativities such as foot and hoof problems, udder health and low fertility (Grodkowski *et al*., 2023). In fact, in some countries where the breed is raised (Rodriguez-Bermüdez *et al*., 2019a; Manuelian *et al*., 2022), it has been reported that organic dairy cattle producers are not satisfied with the performance of the HF breed. In high-performance breeds such as HF, health, milk and fertility problems are experienced due to a high rate of negative energy balance, especially in the early period of lactation (Nauta, 2009, Ahlman *et al*., 2011; Bingölbali, 2019). For this reason, both producers and researchers are currently looking for an answer to the question of which breed is most suitable for organic dairy cattle farming. In other words, the search for a breed that can adapt to the region under limited conditions and maintain its productivity and health continues.

There is no cattle breed that gives the most suitable result by considering both yield and functional traits together in organic dairy cattle farms (Rodriguez-Bermüdez *et al*., 2019b). Studies and researches for this purpose are ongoing. There are some situations that limit the determination of the most suitable breed for organic dairy farming in different country conditions. The first and most important of these is that, according to the IFOAM standard, a maximum of 40% of the ration in organic dairy farms should consist of concentrate feeds on a dry matter basis (IFOAM, 2014). However, there are differences in the standards of countries in terms of the concentrate feed rates used in the ration. The said rates are 40%, 30% and 20% in Türkiye, Norway and Denmark, respectively (Nauta *et al*., 2006; Nauta, 2009; Bingölbali, 2019). These differences in concentrate feed rates at the country level can also cause differences in milk production levels (Bieber *et al*., 2019). Concentrate feed consumption per cow in organic dairy farms was reported as 2,373 kg/cow/year in Sweden, 1,500 kg in Spain, 1,200 kg in Germany and 616 kg in France (Krieger *et al*., 2017). The second important factor is that in some countries, cattle raised under organic conditions are required to go to pasture. In the USA, cattle older than 6 months are required to go to pasture for 120 days in organic dairy farms (Nehring *et al*., 2021). In Norway and Denmark, these periods are 2 and 6 months, respectively (Mogensen, 2012). According to the current organic farming regulation in Türkiye, there is a statement that "animals are provided with access to pastures at different times of the year" and there is no obligation to go to pasture (MoAF, 2010). Situations such as the time to reach pasture, the size and quality of pasture may cause differences in production levels.

Türkiye is extremely suitable for cattle breeding due to its natural resources and ecological conditions (Turan *et al*., 2017). Cattle population, which was 10.7 million head in 2000, increased by 56% reaching 16.8 million head in 2024. In 2024, 70.4% of the red meat and 93.6% of the milk produced in the country originated from cattle (Bayram *et al*., 2025). Almost all of these production values were obtained from dairy cows. As in the rest of the world, in order to meet the emerging demand for organic milk and dairy products in the country, some of the existing dairy farms are converting to organic production, and new organic dairy farms are being established. Significant changes have occurred in the organic milk sector in Türkiye in recent years, with production increasing by 410% in the last 20 years (2000-2020), from 7,640 tons to 31,234 tons. According to current data, 31,234 tons of organic milk are obtained from 8,140 cows in 44 organic dairy farms. However, it can be stated that the organic dairy sector in Türkiye has not reached its targeted level due to existing problems, primarily the inadequacy of organic concentrate feed (MoAF, 2024).

According to the current organic farming regulation in Türkiye, 60% of the total dry matter of the daily rations of lactating cows consists of roughage and 40% consists of concentrate. However, with the approval of the control and certification institution, the concentrate rate was increased to 50% for 3 months in newly born cows. The search continues for the most suitable breeds to adapt to dairy cattle farms operating under limited and restricted conditions, such as limited concentrate feed in the daily ration, the absence of chemical fertilizers in feed production, and the avoidance of hormones in reproduction and yield enhancement. This study aims to compare some milk and reproductive performance characteristics of Holstein Friesian and Swedish Red cattle raised organically together during the same period in farm conditions with a high altitude, continental climate, resulting in cold stress, and limited concentrate feed in the ration. We hypothesize that, under high altitude conditions characterized by cold stress and limited concentrate supplementation, Holstein Friesian cows, despite their high genetic potential for milk production, will exhibit poorer performance compared to Swedish Red cows. The present study aimed to (i) compare some milk yield and fertility performance traits of Holstein Friesian (HF) and Swedish Red (SR) cows reared during the same period under organic conditions of Türkiye, (ii) evaluate the suitability of the SR breed as an alternative to the HF breed, which is the dominant breed in organic dairy cattle farms in Türkiye but does not fully meet producers' expectations, and (iii) determine selected milk yield and fertility characteristics of the SR breed, which is a new breed in the dairy industry of Türkiye.

MATERIALS AND METHODS

Animals: The material of the study consisted of milk and reproductive records of HF and SR cows raised in a private organic dairy farm operating in the Kelkit district of Gümüşhane province in the Eastern Black Sea Region of Türkiye. This farm, which provided records of reproductive and milk yield characteristics, is the first organic dairy cattle farm established in Türkiye. Founded in 2003, the farm initially imported 1400 head of 3–6 month pregnant Holstein heifers from conventional, extensive production facilities in Wisconsin, USA. Swedish Red cattle were imported later, in 2006, with 350 head of 3–6 month pregnant heifers brought from conventional farms in Sweden. After a one-year transition period, organic production began. In other words, Swedish Red cattle were added to the herd after the Holstein. The cows selected for the study were those that were organically raised in both breeds simultaneously, had at least one lactation data point, and met the International Committee for Animal Recording (ICAR, 2018) criteria for the milk and reproductive yield characteristics examined. Due to this limitation, milk and reproductive performance records from 339 Swedish Red and 1559 Holstein Friesian cows covering the years 2007-2012 were used.

The region where the farm is located is approximately 1400 m above sea level, has a continental climate, and rainfall generally falls in spring and autumn. According to long-term data, the average temperature was 9.8 ^{0}C and the average annual precipitation was 465.9 mm. The average temperature values for the winter, spring, summer and autumn seasons were -1, 8.7, 18.9 and 10. 9 ^{0}C, respectively (TSMS, 2025).

Housing and Feeding: In this special farm where production is carried out under organic conditions, cattle are kept in completely closed barns with free stalls and sheds with roaming areas. According to the organic farming standard, 6 m^2/head area is allocated in the barn and 4.5 m^2/head area is allocated in the roaming areas. Basic farming practices such as care, nutrition, shelter and veterinary intervention in the farm are carried out in accordance with the regulation principles "on the principles and implementation of organic farming" issued by the Ministry of Agriculture and Forestry of the Republic of Türkiye in 2010 (MoAF, 2010).

In the organic dairy farm, the daily feed consumption of the cows on a dry matter basis is 21 kg, 8 kg (38%) of which is from concentrate and the remaining 13 kg (62%) is from roughage. The daily rations of the cows mainly consist of concentrated feeds such as corn, barley, vetch, lentil flour and concentrated milk feed produced under organic conditions, and roughage such as corn silage, alfalfa and meadow grass. In accordance with the organic farming regulation, feed additives were added to the daily ration and given as a complete ration (Total Mixed Ratio, TMR) *ad libitum* throughout the day.

Milking was done twice a day, morning and evening, and newly calved high-yielding cows were milked three times a day for three weeks. Daily milk yields were automatically recorded on the computer by means of transponders carried by each cow. Using this data set kept in the computer environment, yields such as real, 305-day milk yield, peak milk yield, time to peak and lactation period were calculated. The number of milking days was 305 days, and the actual milk yield was taken directly from the herd management program. Newborn calves were housed with their mothers for the first three days. Then they were taken to individual calf pens and weaned at the end of 90 days. Mating was done in the form of artificial insemination in all cows and heifers. No hormone and/or estrus regulator application was applied in the herd. Pregnant cows are dried off two months before calving.

Evaluated Traits: The following characteristics of HF and SR cows were determined in the dairy cattle farm produced under organic conditions. In determining these characteristics, the standards reported by the ICAR (2018) were taken into consideration. Table 1 shows the lowest and highest values of the variables examined as a result of classifications made according to the relevant standard.

Table 1. Minimum and maximum values for the characteristics examined.

Traits	The lowest	The highest
Age at first calving (months) (AFC)	20	36
Gestation period (days) (GP)	≥260	-
Calving interval (days) (CI)	310	650
Service period (days) (SP)	30	400
Number of inseminations per pregnancy (NIPP)	1	5 ≤

Statistical Analysis: Prior to the statistical analysis, the data were subjected to a normality test (Kolmogorov-Smirnov) using the SPSS package program. According to the test results, all variables showed a normal distribution. Multifactorial analysis of variance (ANOVA) was utilized to determine the effects of different factors on fertility (age at first calving, calving interval, number of inseminations, service period, gestation period) and milk yield traits (number of days milked, actual milk yield, 305-day milk yield, peak milk yield, time to reach peak).
Statistical model used is as follows:
Y_{ijklm}: $\mu + a_i + b_j + c_k + d_l + e_{ijklm}$
μ: General mean; a_i: Effect of calving year (i: 2007, …..2012); b_j: Effect of calving season (j: winter, spring, summer, autumn); c_k: Effect of birth order (k: 1, 2, 3, ≥4); d_l: Effect of breed (l: HF, SR); e: Random error. Along with analysis of variance, effect size (eta squared, η^2) was calculated to test the influence of independent variables on the dependent variable. According to the relevant study, eta squared indicates a small effect of 0.01, a medium effect of 0.06, and a large effect of 0.14 (Green and Salkind, 2008).
Correlations between some reproductive and milk yield characteristics of HF and SR cattle were determined, and a correlation heatmap was generated using the RStudio software (Version 2023.12.1; Posit team, Boston, MA, USA). Phenotypic correlation coefficients between fertility and milk production traits, along with their standard errors and levels of statistical significance, were calculated using the Pearson correlation method via IBM SPSS Statistics for Windows (Version 29.0; IBM Corp., Armonk, NY, USA). Since all data were obtained from an existing computerized database and were collected from retrospective records, ethics committee approval was not required.

RESULTS

Reproductive Characteristics: The fertility traits examined in HF and SR cows are given in Table 2. SR cows reached AFC 3.7 months earlier than HF, this difference between two breeds was statistically significant (P<0.01). Although the GP was 2.9 days longer in HF, the difference was not significant. The CI was 25.3 days longer in HF compared to SR cows (P<0.01). The SP was 120.1 and 110.8 days in HF and SR cows, respectively, the difference of 9.3 days between the two breeds was significant (P<0.01). Although the NIPP was lower in SR the difference was not significant. When the eta-squared (η^2) value of fertility is examined, it is revealed that the breed's influence on the relevant characteristics is quite low.

Table 2. Some fertility traits of Holstein Friesian and Swedish Red cows.

Traits	N	Holstein Friesian	N	Swedish Red	P	η²
		Mean ± SE[1]		Mean ±SE[1]		
Age at first calving (months)	387	29.8 ± 0.154	165	26.1 ± 0.187	0.001	0.022
Gestation period (days)	401	279.0 ± 0.615	198	276.1 ± 0.539	0.249	0.02
Calving interval (days)	1404	406.1 ± 3.87	201	380.8 ± 8.10	0.0001	0.008
Service period (days)	658	120.1 ± 3.09	332	110.8 ± 6.49	0.002	0.011
Number of inseminations per pregnancy	1329	2.27 ± 0.060	194	1.96 ± 0.147	0.649	0.022

SE: Standard Error, η^2: Eta-square

Milk Yield Characteristics: The milk yields traits examined in HF and SR cows are given in Table 3. HF cows were milked 28.1 days longer than SRs, the difference observed between the two breeds was statistically significant (P<0.01). HF cows had 1074 and 522 kg higher average milk yield in terms of actual and 305-day milk yield, respectively. The difference observed in actual milk yield between the two breeds was statistically significant (P<0.05). HF cows reached peak milk yield 10.7 days earlier than SRs cows (*P*<0.05), and the milk yields at peak point were close to each other in two breeds. When the eta-squared value indicating effect size was examined, the effect of breed on milk yield traits was found to be quite low (Table 3).

Table 3. Some milk yield traits of Holstein and Swedish Red cows.

Traits	N	Holstein Friesian	N	Swedish Red	P	η²
		Mean ± SE[1]		Mean ± SE[1]		
Number of days in milk	1498	350.5 ± 3.08	284	322.4 ± 7.60	0.001	0.006
305 days milk yield	885	6980 ± 70.5	151	6458 ± 219.5	0.958	0.001
Actual milk yield	620	8136 ± 107.0	167	7062 ± 215.3	0.041	0.002
Days to peak yield	886	69.1 ± 2.26	282	79.8 ± 5.61	0.039	0.001
Peak milk yield	882	35.0 ± 0.26	279	32.4 ± 0.66	0.397	0.001

SE: Standard Error, ***η²***: Eta-square

The lactation curve for 305-day milk yield of Holstein Friesian and Swedish Red cattle is given in Figure 1. Examining the figure, it can be seen that the lowest milk yield in both breeds was obtained in the first lactation. This is because the cows did not fully develop and grow during the first lactation, resulting in low milk yield. In both breeds, there was a continuous increase in milk yield in subsequent lactations, reaching the highest milk yield in the fourth lactation. However, as seen in Figure 1, the magnitude of this increase was greater in Holstein Friesian cows (Figure 1).

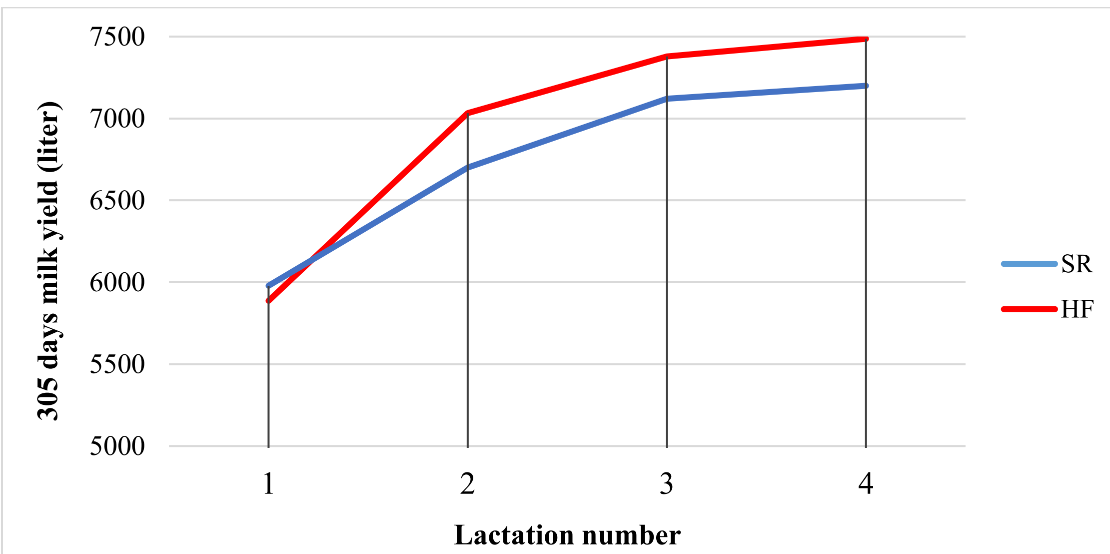

Figure 1. Comparison of 305-day milk yield across parities (SR vs HF)

Other factors examined for their effects on milk yield and the levels of interaction between these factors: The effects of year and season on the number of milking days are significant (*P<0.01*). As the years progressed in the farm, the number of milking days decreased. The lowest number of milking days was recorded in 2012 (295 days), and the highest number of milking days was recorded in 2007 (378 days). This result can be interpreted as the cows being forced to leave lactation early because the daily ration did not fully meet their nutritional needs, mainly due to the limited use of concentrate feed (40%) and cold stress. This result can be interpreted as problems in the adaptation of the cattle to the farm. The effect of season on the number of milking days is significant (*P<0.01*). According to the results, cows milked in winter had the longest number of milking days (372.2 days), while those milked in spring had the shortest (345.2 days). Significant interactions (*P<0.01, P<0.05*) were found between season x year and season x lactation in terms of milking days.

The effect of lactation number on 305-day milk yield was significant (*P<0.01*), while the effects of other factors examined (year and season) were insignificant. Milk yield was lowest in the first lactation and highest in the fourth lactation. 305-day milk yields for lactations 1-4 were 5909, 7123, 7380, and 7485 kg/year, respectively. No significant interaction was found between the factors examined in relation to 305-day milk yield.

The effect of lactation number on actual milk yield was significant (*P<0.01*), while the effects of other factors examined and the interactions detected between factors were insignificant. The lowest actual milk yield was reached in the 1st lactation, and the highest in the 4th lactation. In the farm in question, the actual milk yields for lactations 1-4 were 6623, 7244, 7878, 8057, and 7138 kg/year, respectively.

The effect of years on some fertility traits: As a measure of the adaptation of cattle to the farm, the changes in reproductive performance on a yearly basis are shown in Figures 2 and 3. Based on the examination of the relevant figures 2 and 3 Swedish Red cows exhibited better performance in the fertility traits considered compared to Holstein Friesian cows. With respect to age at first calving, a clear increasing trend over the years was observed in both breeds. Although year-to-year variations were evident for service period and calving interval, no systematic increasing or decreasing trend was detected.

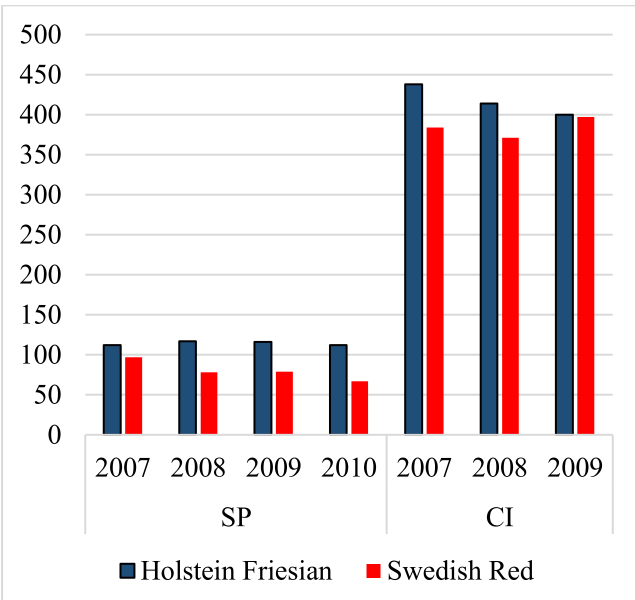

Figure 2. Comparison of Service Period and Calving Intervals (days) of Holstein Friesian and Swedish Red cows over some years

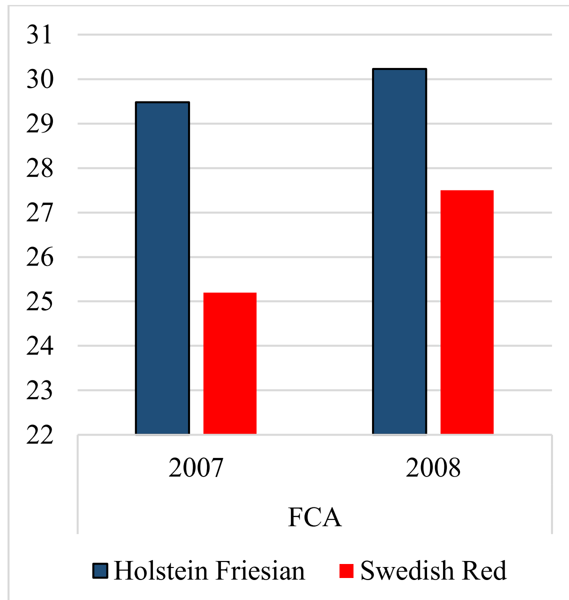

Figure 3. Comparison of Fist Calving Age (months) of Holstein Friesian and Swedish Red cows over some years

CI: Calving Interval, SP: Service Period, FCA: First Calving Age

Phenotypic correlations between fertility and milk yield traits: A heat correlation map was created using some reproductive and milk yield characteristics of HF and SR cattle. The results are given in Figures 4 and 5. In both breeds, positive and significant (P<0.01) relationships were found between FCA, CI, DIM and actual milk yield. The corresponding phenotypic correlation coefficients were 0.939**±0.006 and 0.920**±0.008 in Holstein Friesian cows, whereas the respective values in Swedish Red cows were 0.989**±0.026 and 0.852**±0.027. Similarly, positive and significant (P<0.01) relationships were found between CI and days in milk, and actual milk yield in both breeds.

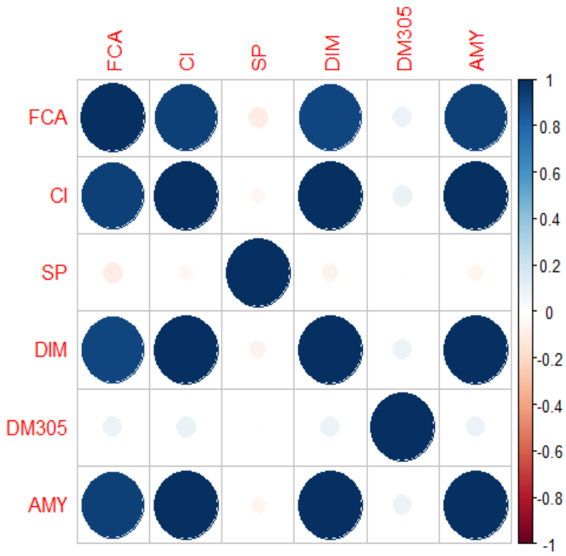

Figure 4. Phenotypic correlations in reproductive and milk yield performance of Holstein cows.

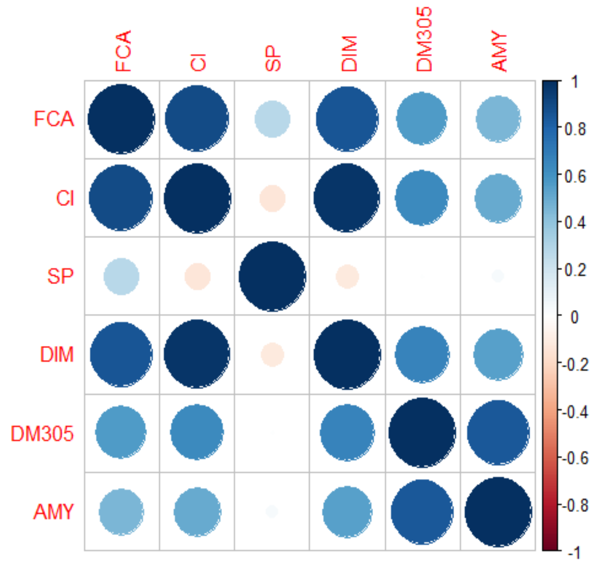

Figure 5. Phenotypic correlations in reproductive and milk yield performance of Swedish Red cows.

FCA: First Calving Age, GL: Gestation Length, CI: Calving Interval, SP: Service Period, DIM: Days in Milk, 305 MY: 305 Days Milk Yield, AMY: Actual Milk Yield, DPY: Days to Peak Yield, PMY: Peak Milk Yield

The phenotypic correlations between calving interval and days in milk as well as actual milk yield were 0.993**±0.001 and 0.996**±0.00 in Holstein Friesian cows, and 0.970**±0.04 and 0.508*±0.089 in Swedish Red cows, respectively.

DISCUSSION

In cattle farms, the duration during which animals are unproductive yet incur high costs should be minimized, while heifers should reach their first calving at the optimal age to enhance the profitability and sustainability of the enterprises. In this current study, HF and SR heifers reached the AFC at 29.8 and 26.1 months, respectively. SR heifers reached the AFC at a significantly ($P < 0.01$) earlier than HFs. In Spain and Sweden, the AFC in HF heifers raised under organic conditions was reported as 27.2 in and 27.8 months, respectively (Rodriquez-Bermüdez *et al.*, 2020; Sundberg *et al.*, 2009). In Sweden, the average age at first calving for Holstein Friesian and Swedish Red heifers raised under conventional conditions were reported as 28.1 and 28.2 months, respectively (Liedgren *et al.*, 2024). In two farms where organic production is carried out in Türkiye, the AFC in HF heifers was reported as 29.1 and 27.4 months (Alapala and Ünal, 2016; Baycan, 2022). The AFC determined for SR cattle in this study (26.1 months) is lower than the values (27.9-28.2) reported by Sundberg *et al.* (2009) and Liedgren *et al.* (2024) for the same breed. In some studies, conducted on HF cattle raised under conventional conditions in Türkiye in the last 20 years, the first calving age was reported between 27.2 and 28.7 months (Şahin, 2009; Alapala and Ünal, 2016; Güngör, 2019). The reason for the later AFC of HFs in this study compared to SRs and conventionally reared HFs could be explained by two factors. Firstly, the high altitude and continental climate of the region where the farm is located means that the cattle suffer from cold stress, while at the same time it is difficult to provide protein-rich organic feed due to the inadequate conditions. The second reason is that the limited use of concentrates in the ration could adversely affect the growth and development of breeds with high genetic potential, such as HF, as well as yield.

In terms of NIPP, SRs had a better performance, but the observed difference of 0.31 units was not significant. In studies comparing the two breeds under organic conditions (Bieber *et al.*, 2019; Bieber *et al.*, 2020), SR cattle (1.85, 1.90) had a better performance than HFs (1.96, 2.0). Swedish Reds also performed better under conventional breeding conditions (1.96, 2.02) (Liedgren *et al.*, 2024). Although the NIPP in both breeds was 2 or less in the relevant studies, the NIPP in HFs was observed to be 2.27 in this study. This result shows that HFs are more affected by cold stress in cows and energy deficiency resulting from the use of limited concentrates in the ration. As stated in the study's hypothesis, it was reported that Holstein Friesian cows would be more affected by limited amounts of concentrate feed, in other words, they would experience a greater degree of negative energy status. Due to problems in follicular formation during negative energy status, there was an increase in the number of NIPPs.

The SP of HF cows was approximately 10 days longer than SRs (P<0.01). Consistent with the results obtained in this study, longer SP of HF cows (104.1 and 173.4 days) has been reported in studies comparing this breed with SRs (HF 121 and 121.8 days; SRs 107 and 111.4 days) (Bieber *et al.*, 2019; Bieber *et al.*, 2020) and in other studies conducted in Türkiye (Alapala and Ünal, 2016; Baycan, 2022). Considering that the ideal SP in dairy cattle farms is recommended to be approximately 85 days, the service period observed in both breeds in this study appears to be considerably high, particularly in HF cows. Nauta *et al.* (2006) reported that in cows raised under organic conditions, the risk of negative energy status in the early lactation period is higher than in the conventional system, as a result of the energy supplied by the diet being less than the energy required due to the limited use of concentrated feed in the ration. It has been reported that in cattle with high genetic potential in terms of milk yield, such as HF, some functions, especially reproduction, will be negatively affected since most of the energy supplied is used for yield (Sundberg *et al.*, 2009). In dairy cows, although milk yield reaches its highest level during the first 8-10 weeks of lactation, feed intake is not at its peak. Since the nutrients consumed during this period do not meet all needs, a negative energy state occurs. This problem is expected to be more pronounced in cattle with high genetic potential, such as Holstein Friesian. The severity and duration of the negative energy state negatively impact follicle formation and hormone secretion, resulting in adverse reproductive performance. In this study, the difference between HF and SR may have resulted from this situation. Due to these problems, in countries such as Canada, Denmark and the USA, crossbreeds are preferred over purebred dairy cattle in organic dairy cattle farms (Hinken, 2022). However, in countries such as England, France, Spain and Sweden, HF breeds continue to be used predominantly in organic dairy cattle farms due to the high demand for organic milk (Bieber *et al.*, 2020).

The GL was 279.0 and 276.1 days in HF and SR cattle, respectively, and the difference in favor of HF (2.9 days) was insignificant. These results are consistent with the results reported for HF (276.3, 277.5) (Alapala and Ünal, 2016; Baycan, 2022) and SR cows (275.4 days) (Aksakal *et al.*, 2010). Furthermore, the CI was determined to be 25.3 days longer in HF cows than in SR cows (P<0.01). This difference may be due to the longer SP in HF cows. Similar studies investigating CIs in HF (404.5-446 days) and SR (395.0-397.5 days) cows reared under organic conditions reported a longer calving interval in HF cows, consistent with the results of this study (Sundberg *et al.*, 2009; Bieber *et al.*, 2019; Rodrigez-Bermüdez *et al.*, 2019a; Bieber *et al.*, 2020; Rodrigez-Bermüdez *et al.*, 2020; Baycan, 2022). Similarly, in Sweden, the calving interval of Holstein Friesian cattle raised under conventional conditions was longer than that of Swedish Reds, both at the first and second calving. The first and second calving intervals were reported as 412 and 410 days for Holstein Friesian cattle, and 405 and 392 days for Swedish Reds (Liedgren *et al.*, 2024). Although breeding efforts aimed at increasing productivity have nearly doubled milk yield in various dairy cattle breeds, none have yet surpassed the HF breed in terms of milk production (Rodriguez-Bermüdez *et al.*, 2019b). Nevertheless, the increasingly pronounced negative correlation between milk yield and fertility has become a major concern (Berry *et al.*, 2014; Rodriguez-Bermudez *et al.*, 2020, Baycan, 2022). For the sustainability of dairy enterprises, it is crucial that each cow produces a healthy calf approximately every 360–380 days, ideally once per year. Swedish Red cows are found to have better reproductive performance characteristics than Holstein Friesian cows, due to reaching first calving age earlier, having a shorter service period and calving interval. Based on this result, Swedish Red cows are recommended as breeding cattle for organic dairy farms in Türkiye, considering their reproductive performance characteristics. In Holstein Friesian cows, the limited use of concentrate feed in the ration can be interpreted as insufficient fulfillment of nutrient needs and greater susceptibility to cold stress.

Although the 305-day milk yield of HF cows is approximately 522 kg higher than that of SRs, this difference was not significant. In other studies comparing these two breeds (Sundberg *et al.*, 2009; Bieber *et al.*, 2020), HF cows had approximately 1-ton higher milk yield. Large variations (5809-9209 kg) have been reported in the results of studies investigating the milk yield of HF cows reared under organic conditions (Sundberg *et al.*, 2019; Bieber *et al.*, 2020; Rodriguez-Bermüdez, *et al.*, 2018; Horn *et al.*, 2013; Rodriguez-Bermüdez *et al.*, 2020; Hinken, 2022; Alapala and Ünal, 2016; Baycan, 2022). The reasons for these variations are probably; (1) the result of differences in organic farming standards at the country level, (2) differences in the amount of concentrate feed allowed to be used in the ration, (3) whether the cattle have access to pasture or not. The findings of present study are significant as HF and SR cows were compared under identical management and environmental conditions. Pasture-based production is of great importance for the sustainability of organic animal farms. According to the current organic farming regulation in Türkiye, it is stated that "animals are provided with access to pastures at different times of the year (MoAF, 2010), meaning that there is no obligation to put cattle out to pasture, however it was observed that organic farms in Türkiye do not allow cattle to graze on pasture. Nevertheless, in countries such as the USA, Norway and Denmark, cattle older than 6 months are required to go to pasture (Mogensen, 2012). In organic farms, greater attention should be paid to breed selection when pasture access is possible. Because it has been reported that in pasture-based feeding, the daily feed intake of cattle decreases by 20%, preventing them from achieving milk yields aligned with their genetic potential (Bieber *et al.*, 2020). In other words, high genetic potential breeds such as HF are not suitable for limited concentration in the ratio and pasture-based feeding. The 305-day milk yield obtained for both breeds in this study is lower than the milk yield reported in studies where pasture-based production was not carried out (Bieber *et al.*, 2020; Sundberg *et al.*, 2009). This result may be attributed to the continental climatic conditions of the farm and the low energy content of the roughage, resulting from insufficient and irregular rainfall, as well as to the adverse effects of cold stress, which can increase maintenance energy requirements and negatively affect animal performance.

In this study, HF cows were determined to be milked 28.1 days longer than SRs (P<0.01). Consistent with the results obtained in this study, Hinken (2022) found the number of days milked in HF cows as 350 days. In two studies conducted in Türkiye (Alapala and Ünal, 2016; Baycan, 2022), the number of days milked in HF cows was stated as 308.3 and 372.5 days, respectively. In a previous study conducted in the same farm (Aksakal *et al*., 2010), the number of days milked for SRs was reported as 302.5 days, which is lower than this study. In order to obtain one calf per year, which has a significant effect on the continuity of the herd and the profitability of the farm in cattle farming enterprises, the number of days milked and the number of days dry should be adjusted very well at the farm level. Considering that the recommended lactation length for dairy cattle in Türkiye is between 300–320 days, and dry period is around 60 days (Özbeyaz, 2011), SR cows appears to show better performance in Organic conditions. As a result of the longer number of days milked, HFs had approximately 1.074 kg more actual milk yield than SRs, this difference was found to be significant (P < 0.05). As a result of years of breeding efforts in Holstein Friesian cattle, under good care and feeding conditions, this breed has the highest milk yield. Therefore, the difference observed in this study, both in terms of 305 days and actual milk yield, is an expected result. However, in dairy cattle farms, fertility and milk yield are complementary elements and need to be balanced. Although milk yield is high, some problems in fertility make it difficult to choose which breed to use in Türkiye. To clarify this situation, it is necessary to determine the losses resulting from fertility failure and the gains obtained from excess milk production, and to conduct economic analysis studies.

HF cows reached peak milk yield earlier (10.7 days) than SR cows (P<0.01). The difference in milk yields for this period was not significant. In some dairy breeds, especially HF, the time to reach peak point was reported as 62.2-63.8 days and milk yields for this point were reported as 33.2-35.7 kg (Markusfeld *et al.*, 1997; Reesch *et al.*, 2007; Berry *et al.*, 2007). According to these results, HF and SR cows reared under organic conditions had a slightly longer time to reach peak point, but their milk yields were similar. The delayed arrival of peak milk yield in both breeds under organic conditions may be attributed to an energy deficiency during early lactation and cold stress.

Due to its ease of interpretation and tracking, heat correlation maps are more frequently used to determine the relationship (correlation) between multiple characteristics. In both breeds, positive and significant phenotypic correlations were observed between AFC and CI with both the number of days in milk and actual milk yield. In other words, as demonstrated in previous studies (Berry *et al.*, 2014; Pritchard *et al.*, 2013; Sewalem *et al.*, 2010; Bayram *et al.*, 2012), the fertility traits are negatively affected with the increase in milk yield. Another important relationship is that as the number of days in milk increases, the calving interval increases in both breeds. This outcome leads to a reduction in the total number of calves a cow can produce over its lifetime on the farm. According to the heat correlation map, in both races delayed AFC age caused an increase in both the number of milking days and actual milk yield. Delayed first calving also extends the period when cattle are unproductive and costly. As a result of long-term breeding studies carried out to increase milk yield in some dairy breeds, especially HF, despite the significant increase in milk yield, serious problems have emerged in health and productivity periods, especially in fertility. Insufficient energy status for these functions has been shown to be the reason for this situation. Due to the limited use of concentrated feed in organic dairy cattle farms, these issues have become more pronounced. In fact, low fertility is one of the most important reasons for culling in organic dairy cattle farms (Rozzi *et al.*, 2007; Ahlman *et al.*, 2011; Ahlman *et al.*, 2014; Bingölbali, 2019).

Conclusion: In the present study which compared certain fertility and milk yield characteristics of different breeds raised under organic conditions in Türkiye, SR heifers reached the AFC earlier than HF heifers, and also exhibited shorter CI and SP. As stated in the study hypothesis, the negative energy state observed in Holstein Friesians as a result of limited concentrate feed use and cold stress caused by the continental climate negatively affected reproductive performance. The fertility performance of SR cattle was better. However, HF cows had better milk yield performance because they had longer milking days and actual milk yield. To recommend the best breed for organic dairy cattle farms in Türkiye, economic analysis studies are needed to reveal the economic losses due to reduced reproductive performance in Holstein Friesian cattle and the gains resulting from higher milk yields.

Data availability: The datasets generated are available from the corresponding author on request.

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