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Cow Comfort Levels and Milk Production of Holstein Cows in Cool and Cold Seasons

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ABSTRACT

Cow comfort is a crucial factor for both milk quality and quantity, as well as the health of the animal. This study aimed to determine the variation of comfort indicators and milk production during cool and cold seasons in dairy cows, as there is still a lack of information on the change of comfort parameters during these seasons. A total of 167 Holstein cows raised in a private farm in Samsun province of Türkiye were evaluated by comfort parameters and milk production in the autumn and winter seasons. As hygiene parameters; rear legs hygiene scores (RLHS) and flank hygiene scores (FHS) were noted with a 1 to 4 scale (1= too clean and 4= too dirty). To obtain other parameters, 1 to 5 (1= very weak and 5= very fatty) and 1 to 4 (1= empty and 4= full rumen) scales were used for body condition score (BCS) and rumen fill score (RFS) values, respectively. Test day milk yield (TdMY) values were obtained from the farm records. The study analysed parameters in two seasons (autumn and winter), parity (1 to 3), and stage of lactation (SL; <100 d, 100-199 d and ≥200 d of lactation) groups. To calculate cow comfort level (CL_{100}), all comfort parameters were transferred to 100 points. While parity affected FHS ($P<0.01$) and RLHS ($P<0.01$), SL only affected RFS ($P<0.05$). All comfort parameters differed by the seasons and CL_{100} was found as higher ($P<0.01$) in autumn compared to winter value. TdMY was not affected by the season factor. The highest correlation (r=0.706) was found between CL_{100} and FHS_{100}. The values of CL_{100} and TdMY for the herd in both seasons indicate that it is necessary to review the herd management program to improve the welfare and productivity of the evaluated cows.

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SA planned and CA conducted the experiments. SA ensured statistical design. CA and SA prepared the manuscript.

Key words
Cattle, Dairy, Hygiene, Milk yield, Non-genetic factors, Welfare

INTRODUCTION

The dairy sector is primarily associated with dairy cattle in many countries. Cows do not only produce milk but also produce meat and thus, provide the main protein sources to humans. In recent years, consumers have demanded more quality animal foods, especially in developed countries. Therefore, achieving high quality milk and meat is seen one of the principal goals of dairy farm owners. As well known by animal scientists, supplying ideal environmental conditions to high producing cows is essential for gaining high milk yield. In other words, non-genetic factors such as climate, location, barn conditions, feeding regime, parity, or stage of lactation should be considered to increase productivity (Ledinek *et al*., 2012; Nyamushamba *et al*., 2014; Bayou *et al*., 2015).

In dairy farms, body condition score (BCS) of cows indicates out to the level of property of feeding management of any cow or whole herd (Atalay, 2019). Berry *et al*. (2003) estimated the genetic variance of the body condition status of dairy cows based on body weight, milk yield, and reproductive characteristics. Roche *et al*. (2007) investigated the association between BCS and milk yield in dairy cows. Ristevski *et al*. (2017) revealed that BCS is one of the risk factors for lameness in dairy cattle herds. Also, Roche *et al*. (2009) and Matthews *et al*. (2012) emphasized that BCS data reflect the animal welfare status.

In addition to BCS, Burfeind *et al*. (2010) developed an assessment system on the rumen filling degree that may be used as an indirect marker to decide whether feeding applications in the herd are proper or improper. Schneider *et al*. (2022) also used rumen fill scores (RFS) as an indicator for feed intake and animal welfare. Similarly, cow hygiene is commonly used as an indicator of animal comfort (Sadiq *et al*., 2017; Telezhenko *et al*., 2017). Celebi and Akdag (2022) found close relations between the hygienic status of cows with milk production level and some milk components. DeVries *et al*. (2012) reported that dairy cows produced poor quality milk if their bodies have dirt. Shortly, the investigation of welfare or comfort

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parameters is expected to present a useful guide to dairy farmers and also researchers. Many investigators have evaluated the comfort indicators and relations of those with milk yield and quality (Atasever and Erdem, 2009; DeVries *et al*., 2012; Sandrucci *et al*., 2014; Mendina *et al*., 2023), but there is still very little information on the change of comfort parameters in cool or cold seasons. In a preliminary study, Aksu and Atasever (2017) evaluated the effects of non-genetic factors on comfort parameters during the spring and summer seasons. Therefore, the change in cow comfort levels and milk yields of dairy cows in wet seasons will make significant contribution to the subject.

The main target of this study was to determine the cow comfort level and evaluate the distribution of milk yield in the cool and cold seasons.

MATERIALS AND METHODS

Study design and animal selection

The study was conducted in a private dairy farm in Samsun province of Türkiye during cool (autumn; September, October, and November) and cold (winter; December, January, and February) seasons. A total of 167 Holstein cows were evaluated by flank hygiene scores (FHS), rear legs hygiene scores (RLHS), body condition score (BCS) and rumen fill score (RFS). Only clinically healthy cows were included in this study.The cows were managed in similar management conditions and fed with a total mixed ration (TMR) throughout the study period.

Scoring processes

For hygiene assessment, a scale chart 1 to 4 (1= very clean and 4= very dirty) was utilized. The scale chart 1 to 5 (1= very weak and 5= very fatty) and 1 to 4 (1= empty and 4= full rumen) were used for obtaining BCS and RFS, respectively (Aksu and Atasever, 2017). Half or quarter points (for example: 2.5 or 2.75) were used for BCS when necessary. All scoring was performed during evening milking time once a month.

Milk yield assessment

The cows evaluated in this study were milked twice a day and production values were recorded automatically by a computer. To evaluate milk production, test day milk yield (TdMY) values were referred to average values of three days including prior, control and next day milk yields.

Statistical work

Cows were separated to three parity (cows with parity 3 were evaluated within parity 3) and stage of lactation subgroups (SL 1= 1-99 d; SL=2: 100-199 d and SL 3= ≥200 d of lactation). While independent t-test was performed to reveal the effects of seasons on the comfort parameters and TdMY, Duncan's multiple range test was applied to groups with ≥3. The following mathematic model was utilized to determine the effects of parity and SL on the comfort parameters:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + e_{ijk}$$

where Y_{ijk} = dependent variable, μ = overall mean, α_i= parity effect (i=1 to 3), β_j = stage of lactation (j=1 to 3) and e_{ijk}= random residual effect.

Besides, all values obtained from comfort parameters were transferred to 100 points to determine total comfort levels (CL_{100}) of the cows. For this, cleanliness was accepted as comfortability level, and scores for FHS and RLHS were designed as: 1=100, 2= 75; 3= 50 and 4= 25 p. For RFS; scores were designed as; 1=25; 2=50, 3=75 and 4=100 p. In BCS evaluation in 100 points scale; BCS=3.25 and 3.50 scores were assumed as optimum (Atalay, 2019; Muiño *et al*., 2021) and transferred to 100 p. The other BCS values were equalled to 100 p as: 1 and 5= 0; 1.25, 1.50 and 4.25= 25 p; 2, 2.25, 2.50 and 4= 50 p; and 2.75, 3 and 3.75= 75 p. To reveal the total cow comfort level (CL_{100}) per animal, an index with weight percentages of four parameters was designed. The index formula was:

$$CL_{100}=25\%FHS_{100}+25\%RLS_{100}+25\%BCS_{100}+ 25\% RFS_{100}$$

To estimate associations of the parameters, Kendall's tau-b correlation coefficients were calculated. The statistical assessments were performed by SPSS 17 at the 0.05 level of significance.

RESULTS

Table I shows descriptive values of all parameters investigated in the present study. As can beseen, the lowest and highest values were similar for FHS and RLHS. However, FHS had a higher mean by dirtiness.

Table I. Descriptives of the evaluated parameters.

Trait	n	Min	Max	Mean (±SE)
FHS	167	1	4	2.52±0.08
RLHS	167	1	4	2.40±0.07
BCS	167	1.50	3.50	2.54±0.03
RFS	167	1	3	2.15±0.04
TdMY	167	10.80	31.65	24.94±0.22

FHS, flank hygiene scores; RLHS, rear legs hygiene scores; BCS, body condition score; RFS, rumen fill score; TdMY, test day milk yield.

BCS values were distributed from 1.50 p to 3.50 p, and the mean was found to be 2.54±0.03 p (Table I). The lowest and highest RFS values were noted as 1 p and 3 p, and the mean (2.15±0.04) was found within the moderate class. The mean of TdMY was determined as 24.94±0.22 kg and approximately 21 kg difference between the lowest and highest values was attractive (Table I).

Effects of parity and SL on the comfort parameters are presented in Table II. Accordingly, both parity and SL were effective on two hygiene traits (P<0.01). For BCS and RFS, no statistical difference was found among the parity groups. Similarly, the effects of SL on FHS, RLHS, and BCS were not different (Table II). However, cows in the first days in the milk (DIM) group had higher RFS when compared to the other ones.

Table II. Comfort parameters (Means±SEM) by parity and SL subgroups.

	n	FHS	RLHS	BCS	RFS
Parity		P<0.01	P<0.01	ns	ns
1	37	2.95±0.16[b]	2.98±0.15[b]	2.50±0.08	2.25±0.08
2	70	2.47±0.11[a]	2.38±0.11[a]	2.57±0.06	2.14±0.06
3	60	2.30±0.12[a]	2.06±0.11[a]	2.54±0.05	2.11±0.07
SL		ns	ns	ns	P < 0.05
100d <	29	2.48±0.18	2.46±0.17	2.67±0.08	2.39±0.08[b]
100-199d	65	2.55±0.13	2.44±0.13	2.53±0.06	2.09±0.08[a]
≥ 200d	73	2.50±0.12	2.34±0.11	2.50±0.05	2.12±0.05[a]
Overall	167	2.52±0.08	2.40±0.07	2.54±0.03	2.15±0.04

Different superscript letters ([a,b]) within the same column indicate significant difference. ns, not significant; SL, stage of lactation; FHS, falnk hygiene scores; RLHS, rear legs hygiene scores; BCS, body condition score; RFS, rumen fill score.

Table III shows the effect of season on all parameters. Hygiene parameters had higher scores in the winter season (P<0.01). Also, cows had higher BCS (P<0.01) and RFS (P<0.01) values in the winter.

Table III. Comfort parameters (Means±SEM) during two seasons.

Season	n	FHS	RLHS	BCS	RFS
Autumn	92	2.14±0.09[a]	2.02±0.08[a]	2.45±0.05[a]	2.04±0.05[a]
Winter	75	2.98±0.12[b]	2.87±0.11[b]	2.65±0.05[b]	2.29±0.06[b]
Overall	167	2.52±0.08	2.40±0.07	2.54±0.03	2.15±0.04

For details of traits, see Table I.
For statistical details, see Table II.

The change of TdMY and CL_{100} according to two different seasons is presented in Figure 1. The mean of CL_{100} in the autumn season was higher (P<0.01) than the mean calculated for the winter.

The correlations between the evaluated traits are given in Table IV. The highest correlation (r = 0.776) was obtained between two hygiene parameters. Also, significant correlations of FHS_{100} and $RLHS_{100}$ were estimated between CL_{100}.

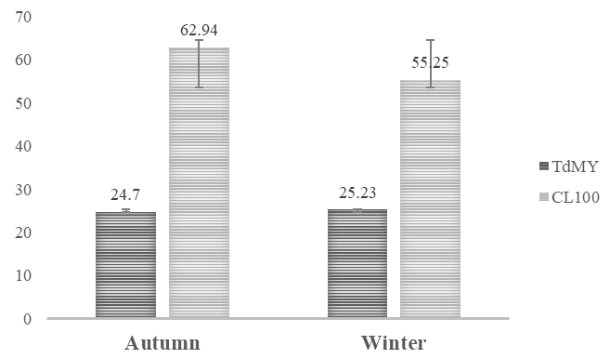

Fig. 1. Changes in TdMY (test day milk yield) and CL_{100} (cow comfort level by 100 p scale) during autumn and winter seasons.

Table IV. Kendall's tau-b correlation coefficients among the comfort parameters.

Traits	$RLHS_{100}$	BCS_{100}	RFS_{100}	CL_{100}
FHS_{100}	0.776	-0.060	-0.043	0.706
$RLHS_{100}$		-0.074	-0.102	0.677
BCS_{100}			0.435	0.285
RFS_{100}				0.196

For details of traits, see Table I. CL, cow comfort level. parameters were evaluated by 100 p scale.

The relationship of CL_{100} with TdMY is presented in Figure 2. As seen, the values of CL_{100} intensed around 45-70 p interval and TdMY was extensive around 25 kg.

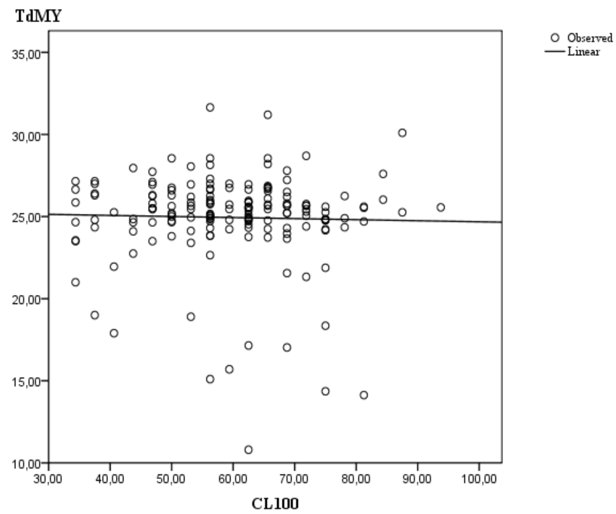

Fig. 2. Relations of TdMY (test day milk yield) with CL_{100} (cow comfort level by 100 p scale) values.

DISCUSSION

According to Table I, both hygiene parameters had moderate scores according to hygiene thresholds. Sant'anna and Paranhos da Costa (2011) emphasized that the corporal hygiene of dairy cows refers to animal welfare and climatic or environmental conditions and behavioral factors play an important role in this case. Ariza *et al.* (2020) informed that foot dirtiness is one of the major causes of lameness that is referred to an important reflector of animal health and welfare status. As a general comment, taking radical precautions to decrease hygiene scores has to be seen a profitable approach in the evaluated dairy farm.

In this study, while no BCS was noted as higher than 3.50 p (Table I), this case might be regarded as the low obesity risks for the evaluated cows. However, the calculated relatively low mean of BCS points out to important problems with the feeding management program of the herd. Roche *et al.* (2009) point out to close relationship between BCS and cow productivity, wealth, and health. Green *et al.* (2014) have reported the negative associations between low BCS and foot diseases, cow welfare, and farm's economy. The calculated BCS mean in this study was lower than the values of some studies conducted on the Holstein breed (Aksu and Atasever, 2017; Stadnik and Atasever, 2017; Aksoy *et al*., 2022; Kul *et al*., 2022).

The descriptives of RFS refer to important deficiencies in the feeding regime and similar comments those mentioned for BCS might be expressed. In other words, redesigning the herd feeding program of the cows is seen as an imperative process.

In Table I, the determined mean of TdMY was found to be higher than the study result of Aksu and Atasever (2017) that was conducted during spring and summer seasons, but lower than some study results were carried out on Holstein cows in Türkiye conditions in different seasons (Duru, 2018; Önal *et al*., 2021; Kul *et al*., 2022). While these differences might most likely be caused by different herd management applications, locations, seasons, or other environmental factors, boosting this amount to higher levels would be beneficial to the sustainability of the farm.

While FHS and RLHS values reached to dirty class in the first calved cows, no statistical difference was found between parity 2 and parity 3 groups (Table II). The relatively higher scores in the first group may be caused by the inexperience of cows in keeping their bodies from the muddy and wet conditions around their barns after calving.

Despite no statistical difference, the relatively higher BCS of cows in this group was note worthy (Table II). Roche *et al*. (2009) emphasized the close relations of BCS with a level of feeding and diet type. This study on BCS points out the proper feeding management of the herd during the early lactation period and shows that cows may enter the negative energy balance due to peak milk yield and elevated energy requirements (Fenwick *et al*., 2008; Roche *et al*., 2009). Despite this, obtained high means for two parameters related to nutrition of cows might be assumed as a favorable finding.

Our Table III shows that the hygiene parameters of cows had elevated scores in the winter when compared with that of the autumn season. Samsun city where the present study was conducted had more rainy days in the winter season when compared to autumn. Therefore, the cows might be exposed to more humid or muddy floors in this season. Neave *et al*. (2022) reported that keeping dairy cows in muddy areas is a potential animal welfare theme. High dirtiness during winter may cause intramammary infections due to bacterial invasion. Fávero *et al*. (2015) found a negative association between the density of wet bedding and dairy cow cleanliness and mastitis. This case may be threat to the raw milk quality and animal health (Cardozo *et al*., 2015). Therefore, it is suggested that dairy owners take utmost precautions to maintain cow hygiene, especially during the winter months.

Similarly, BCS and RFS had higher values in the winter (Table III) and this case may be commented on the keeping cows indoors during the wet or cold weather and feeding them, especially concentrated feeds. However, cows spend much time on the pasture during autumn and consume considerable forages with low energy content during this time compared to the winter season.

Despite no statistical difference between the seasons (Fig. 1), approximately 0.5 kg more milk was produced per milking cow in the winter. This case might be explained by feeding cows with more concentrated feeds in cold weather conditions when the cows are kept indoors. This concept supports the comments performed for BCS and FHS values of cows in Table III.

CL_{100} mean of the autumn season was more favorable than the mean of the winter (Fig. 1). This finding has clearly shown the adverse effects of coldweathers on comfort ingredients. As mentioned earlier, keeping cows indoors and exposing them to dirty floors on cool days might be the main reason for this fact. Additionally, relatively low CL_{100} values for both seasons reflected the remarkable deficiencies in animal welfare applications.

Correlations in Table IV have shown the importance of cow hygiene on total cow comfort level. Andreasen and Forkman (2012) revealed the association of cow cleanliness with cow welfare in Danish Holstein herds. Sadiq *et al*. (2017) reported the close relations among hygiene and welfare indicators. Similarly, a moderate correlation of BCS_{100} with $RLHS_{100}$ in the present study is remarkable. In this sense, conducting further studies including other comfort parameters related to barn conditions and movement facilities of the cows would be more beneficial.

Distributions of CL_{100} and TdMY were found as unfavorable (Fig. 2). According to frequency analysis, the percentage of the cows with CL_{100} lower than the mean (59.48±0.975 p) was calculated to be 50.3%. Similarly, the percentage of the cows with low TdMY according to the mean (24.94±0.220 kg) was found to be 38.1%. These cases might be noted as unfavorable cases in terms of the sustainability of the evaluated enterprise.

CONCLUSION

Based on the findings, it can be concluded that the cold season had an adverse effect on cow-comfort levels compared to the cool season. Additionally, rechecking herd management programs is necessary to achieve a high-producing and well-being dairy herd in the evaluated farm.

DECLARATIONS

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Ethical statement

The research proposal was approved by Institute of Natural Science of University of Ondokuz Mayis, Samsun, Türkiye (Decision No: 2016/772) prior to the field work. Milking process is excluded from the ethical approval by Local Ethics Committee (HADYEK), and no stress has been given to the animals during the all procedures.

Statement of conflict of interest

The authors have declared no conflict of interest.

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