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SEASONAL TRENDS IN HOLSTEIN MILK TRAITS

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SUMMARY

The dairy industry acknowledges the seasonal nature of milk production and the fluctuations in milk component concentrations throughout the year. This variability in milk components, influenced by seasonal changes, assumes critical importance in light of the projected global population increase to 9.7 billion people within the next 20–50 years. Addressing the imminent need for major alterations in agricultural and livestock practices to accommodate this growth necessitates a comprehensive evaluation of all stages within the food production chain. An essential aspect of achieving sustainable agriculture involves identifying opportunities to reduce gaseous pollutants. This study aims to investigate how seasonal variations impact the specific properties of Holstein milk, with a focus on the daily milk yield, daily milk protein, daily milk fat, and urea content. Test-day records from Holstein dairy cows in Croatia, collected during routine milk assessments from January 2005 to December 2022, form the basis of this research. A meticulous process of logical scrutiny of milk recording data, compliant with the ICAR standards, and rectification of non-logical variable values ensured the inclusion of 5,164,920 Holstein test-day records in the refined database. Our analysis centers on the annual number of samples and the primary parameters of milk content (namely fat, protein, and urea). The examination of Holstein milk samples revealed recurring cyclical patterns, indicating higher values during winter and lower values in summer. These distinct variations likely correlate with the annual climatic fluctuations in Croatia. The implications of these findings warrant future research to monitor trends in the raw milk quality and assess the potential adverse effects of the identified changes on the milk properties.

Key words:
cattle farm, Holstein breed, milk, traits

Abbreviations:
DMY - daily milk yield (kg); DMF – daily milk fat (%); DMP – daily milk protein (%); UREA – daily urea content in milk sample (mg/dl); SD - standard deviation; CV - coefficient of variation; SE - standard error

INTRODUCTION

The animal's genetic potential for growth, production, and reproduction is influenced by the climate both directly and indirectly. A number of studies have examined the effects of extreme temperatures alone (McDonald & Bell, 1958; Johnson, 1965; Perera et al., 1986) and in combination with relative humidity (Johnson & Southwell, 1962; Ingraham & Stanley, 1979) and wind movement (McDowell, 1974; Thatcher et al., 1974) on the reproductive and productive performance of animals. Dairy producers recognize that milk production and milk component concentrations follow a seasonal pattern. The concentration of milk components varies throughout the year

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depending on the season (Auldist et al., 1998; Heck et al., 2009; Salfer et al., 2019; Kocsis et al., 2022). The dairy industry and the quality of milk products are affected directly by changes in raw milk composition (Li et al., 2019; Yener et al., 2021; Jensen, 2022; Kocsis et al., 2022)

In natural processes, a variety of gaseous pollutants are released, including greenhouse gases (GHG). However, human activity significantly increases their presence in the environment. Among the first gases to be recognized as contributing to these changes were carbon dioxide (CO2), nitrogen (N) compounds, and especially nitrous oxide (N2O) and methane (CH4) (Mackiewicz et al., 2011; Brennan et al., 2015; Wlazło et al., 2020; Szymula et al., 2021). According to the Intergovernmental Panel on Climate Change (IPCC) and Szymula et al. (2021), industry, transport, and agriculture are the most important sources of gaseous pollutant emissions.

It is noteworthy that the world population will increase to 9.7 billion people in the next 20–50 years, which will require major changes in agriculture and livestock production. In order to achieve sustainable agriculture, all stages of the food production chain must be evaluated to reduce gaseous pollutants (FAO; United Nations Population Division, 2019; Syzmula et al., 2021).

The presence of ammonia poses potential risks to human, animal, and environmental health. Previous studies indicate that animal husbandry contributes significantly to global nitrogen emissions, accounting for 76% of the total global nitrogen emissions (Leip et al., 2015), i.e. 36% of the nitrogen emissions in Europe (Rösemann et al., 2019). In livestock facilities, ammonia (NH_3) emissions primarily stem from the inadequate utilization of N compounds for animal growth and production, as highlighted by Grant & Boehm (2020) and Szymula et al. (2021). Nitrogen is excreted in urine and feces, representing between 50% and 80% of the ingested amount through feed.

The primary objective of this study was to examine how seasonal variations impact the specific properties of Holstein milk, focusing on the daily milk yield, daily milk protein, daily milk fat, and urea content.

MATERIAL AND METHODS

This study utilized test-day records obtained from dairy cows of the Holstein breed, collected in Croatia during routine milk recording spanning from January 2005 to December 2022. The milk yield was measured and sampled every four weeks, employing the AT4 / BT4 milk recording method. Subsequently, these samples were appropriately labeled with the respective animal code and sampling date before being dispatched to the Central Laboratory for Milk Quality Control of the Croatian Agency for Agriculture and Food. At the Central Laboratory for Milk Quality Control, analyses were conducted in adherence to the accredited laboratory methods. Specifically, infrared spectrophotometry was employed to determine the proportions of milk fat, protein, and urea. The chemical quality of milk was assessed using the MilkoScan 7 RM device. The procedures for milk sample collection during milk recording, as well as laboratory testing protocols, were established by the International Committee for Animal Recording (ICAR). Following a comprehensive evaluation that ensured conformity to the ICAR standards and rectification of non-logical variable values, a total of 5,164,920 Holstein test-day records were included in the refined database. A variability analysis was executed using SAS/STAT (2019). Table 1 presents the basic statistical parameters of Holstein mil traits analyzed.

Table 1. Basic statistical parameters of Holstein milk traits analyzed

Variable	N	Mean	SD	CV	SE	Min	Max
DMY	5110454	23.205	9.707	41.830	0.004	3.000	99.900
DMF	5132767	4.153	0.972	23.415	0.000	1.500	9.000
DMP	5164920	3.428	0.459	13.402	0.000	1.020	7.000
UREA	5029042	22.068	9.584	43.429	0.004	0.500	60.000

Legend: DMY - daily milk yield (kg); DMF – daily milk fat (%); DMP – daily milk protein (%); UREA – daily urea content in a milk sample (mg/dl); SD - standard deviation; CV - coefficient of variation; SE - standard error

RESULTS AND DISCUSSION

This study aims to examine the influence of seasonal variations on specific properties of Holstein milk, concentrating on the daily milk yield, daily milk protein, daily milk fat, and urea content. As a result, Tables 2–5 present the basic statistical parameters of Holstein milk traits analyzed relative to the season of milk recording (spring, summer, autumn, winter).

Table 2. Basic statistical parameters of Holstein milk traits analyzed relative to the season of milk recording (spring)

SEASON SPRING							
Variable	**N**	**Mean**	**SD**	**CV**	**SE**	**Min**	**Max**
DMY	1346183	23.975	9.963	41.558	0.009	3.000	99.900
DMF	1370923	4.114	0.955	23.209	0.001	1.500	9.000
DMP	1379895	3.401	0.445	13.074	0.000	1.060	7.000
UREA	1327201	21.888	9.374	42.8267	0.008	0.500	60.000

Legend: DMY - daily milk yield (kg); DMF – daily milk fat (%); DMP – daily milk protein (%); UREA – daily urea content in a milk sample (mg/dl); SD - standard deviation; CV - coefficient of variation; SE - standard error

Table 3. Basic statistical parameters of Holstein milk traits analyzed relative to the season of milk recording (summer)

SEASON SUMMER							
Variable	**N**	**Mean**	**SD**	**CV**	**SE**	**Min**	**Max**
DMY	1154029	23.128	9.229	39.905	0.009	3.000	99.400
DMF	1165620	3.960	0.912	23.033	0.000	1.500	9.000
DMP	1173415	3.312	0.424	12.815	0.000	1.040	7.000
UREA	1155061	25.061	9.748	38.896	0.009	0.500	60.000

Legend: DMY - daily milk yield (kg); DMF – daily milk fat (%); DMP – daily milk protein (%); UREA – daily urea content in milk sample (mg/dl); SD - standard deviation; CV - coefficient of variation; SE - standard error

Table 4. Basic statistical parameters of Holstein milk traits analyzed relative to the season of milk recording (autumn)

SEASON AUTUMN							
Variable	**N**	**Mean**	**SD**	**CV**	**SE**	**Min**	**Max**
DMY	1302626	22.259	9.424	42.338	0.008	3.000	99.300
DMF	1291145	4.221	0.987	23.389	0.001	1.500	9.000
DMP	1299238	3.500	0.475	13.560	0.000	1.030	7.000
UREA	1278623	21.392	9.283	43.395	0.008	0.500	60.000

Legend: DMY - daily milk yield (kg); DMF – daily milk fat (%); DMP – daily milk protein (%); UREA – daily urea content in a milk sample (mg/dl); SD - standard deviation; CV - coefficient of variation; SE - standard error

Table 5. Basic statistical parameters of Holstein milk traits analyzed relative to the season of milk recording (winter)

SEASON WINTER							
Variable	**N**	**Mean**	**SD**	**CV**	**SE**	**Min**	**Max**
DMY	1307616	23.424	10.042	42.869	0.009	3.000	99.500
DMF	1305079	4.299	0.997	23.186	0.001	1.500	9.000
DMP	1312372	3.490	0.466	13.353	0.000	1.020	7.000
UREA	1268517	20.212	9.314	46.083	0.008	0.500	60.000

Legend: DMY - daily milk yield (kg); DMF – daily milk fat (%); DMP – daily milk protein (%); UREA – daily urea content in a milk sample (mg/dl); SD - standard deviation; CV - coefficient of variation; SE - standard error

During the spring season, the highest recorded daily milk yield reached 23.975 kg, whereas the lowest yield was observed in autumn at 22.259 kg. The maximum values of milk fat were recorded during the winter months. The minimum values of fat content in daily milk were typically measured in summer. The daily protein content reached its peak during autumn and winter. A cyclical pattern emerged in the measured milk protein content, frequently indicating lower values during summer. Additionally, summer displayed the highest urea content, whereas winter exhibited the lowest urea content among the seasons.

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The variations in milk yield among the cows were notably significant across different seasons, a phenomenon that has been supported by various researchers. Studies conducted by Johnson & Southwell (1962), Maust et al. (1972), Wood (1980), and Susanto et al. (2019) have all highlighted the impact of seasonality on milk yields. Perera et al. (1986) noted in their research that the monthly milk yield tended to peak during the spring season. Azimi et al. (2022) reported that genotype, environment, and their interaction are major influencers in milk production, lactation length, and dry period, with the lowest milk yields occurring between September and November compared to mid-summer (Salfer et al., 2019). Salfer et al. (2019) observed consistent annual rhythms in fat and protein concentrations, reaching their peaks in mid-winter and their lowest levels in July. However, Bailey et al. (2005) indicated that maximal fat and protein concentrations were observed in December and January. These fluctuations in milk composition parameters are likely attributable to climatic influences, as indicated in the study conducted by Nagy et al. (2019), which found that environmental factors, such as the photoperiod, significantly impact the composition of bulk dromedary camel milk. Ruska et al. (2017) reported a significantly higher urea content in milk produced during summer, which they associated with the appropriate protein and energy balance in fodder for cows with varying productivity traits. Furthermore, Ruska et al. (2017) noted that in a farm setting where cows are not classified and are grazed during summer, there was a notably higher urea level in milk produced in a tie-stall housing system. Spohr & Wiesner (1991) and Spann (1993) associated excessive urea in milk with the utilization of fodder dosages that provided sufficient energy and protein to highly productive dairy cows.

CONCLUSION

The primary objective of this study was to investigate how seasonal variations impact the specific properties of Holstein milk, namely the daily milk yield, daily milk protein, daily milk fat, and urea content. By focusing on the annual sample numbers and the essential parameters of milk content—fat, protein, and urea—our analysis of Holstein milk samples revealed recurring cyclic patterns. These cycles exhibited higher values during winter and lower values during summer. It is highly probable that these notable differences are closely linked to the annual fluctuations in climatic conditions in Croatia. In light of these findings, it is recommended that this research be continued in the future. The continual monitoring of raw milk quality trends is essential to comprehend any potential adverse impacts on milk properties resulting from the observed changes.

Conflict of interest: The authors declare that they have no conflict of interest.

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