MULTIVARIATE ANALYSIS IN ASSESSMENT RELATIONSHIPS BETWEEN MILK CHARACTERISTICS INFLUENCED BY THE SEASONAL VARIATIONS

Silvia MIRONEASA[1], Georgiana Gabriela CODINĂ[1]

[1] „Ştefan cel Mare" University, Faculty of Food Engineering, 13th University Street, 720229, Suceava - Romania, e-mail address: silviam@usv.ro; codina@usv.ro
*Corresponding author
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Abstract: *The present research aimed to investigate the effects of seasonal variation on microbiological and technological characteristics of raw cow milk from Suceava County. The cow milk samples were collected and investigated during four seasons in three years consecutively. The first period was the winter season covering the months December – January – February, the second one was the spring season covering the months March – April – May, the third was the summer season covering the months June – July – August and the fourth period was the autumn season covering the months September – October - November. Milk characteristics measurements were examined by multivariate data analysis, using Principal Component Analysis (PCA). The analysis of the principal components sheds light on the correlations between the characteristics of the raw cow's milk, similarities and differences among these in four seasons. The values of the correlation coefficients indicate positive relations between the number of total germ and somatic cell count during spring and summer seasons, between protein content and solids non fat during autumn season. Regarding relationships amongst milk characteristics influenced by the seasonal variation, negative correlations were obtained between fat content and somatic cell count in spring season, between lactose content and somatic cell count in winter and autumn seasons, between somatic cell count and solids non fat content in autumn season.*

Keywords: *cow milk, chemical characteristics, microbiological characteristics, seasonal variations, Principal Component Analysis*

1. Introduction

In Suceava the dairy sector is a significant part of the local economy because stock farming is an important and traditional occupation in rural areas, especially in mountain regions. The nutritional quality associated with the technological quality of raw cow milk has great importance for human health and milk products. The milk composition varies according to certain factors, such as genetics [1], age, stage of lactation, daily variation, parity, type of diet, milking conditions [2-4] udder health [5] and season [2], [6-8]. Bruhn and Franke (1997), Lacroix *et al*. (1996) have reported that percentage of fat, protein e.g. have been influenced by the seasonal variations. The fat content decreased when the environmental temperature increased [9-11]. Casati *et al*. (1998) states that the light-to-dark ratio can also induce marked changes in milk yield and composition. Region, climatic conditions and lactation periods are known as seasonal changes which have influences on the milk composition; the negative correlations were found between environmental temperature, fat and protein milk content [12-13].

In this research the important county of north the Romania, Suceava according to milk yield and milk products and geographic location has been selected. In our study, the aim was to determine the composition of

cow's milk and to find out the effects of seasonal variation on this composition.

2. Materials and methods

2.1. Materials. The raw cow's milk samples were supplied from different collecting points from Suceava county. The milk was collected in three years consecutive. The research was carried out in four periods. The first period (I) was the winter season covering the months December-January-February, the second one (II) was the spring season covering the months March-April-May, the third (III) was the summer season covering the months June-July-August and the fourth period (IV) was the autumn season covering the months September-October-November. Collecting samples was conducted daily taking into account the season.

2.2. Metods. Milk quality tests were accomplished according to Romanian standard methods for fat content (SR EN ISO 1211:2010), somatic cell counts (SR EN ISO 13366-3:2001) and solids-non-fat content (SR ISO 6731:1996). Protein and lactose content were analyzed using a infrared milk analyzer unit Bentley 150 (Bentley Instruments Inc., Chaska, MN, USA) and number of total germs were done by flow cytometry count analyzer unit BactoCount IBC 50 (Bentley Instruments Inc., Chaska, MN, USA).

2.3. Data analysis. All analytical determinations were performed at least in triplicate. Values of the characteristics are expressed as the mean ± standard deviation to a confidence interval of 95%. Treatment of data was analyzed using SPSS software, version 16.0. Multivariate exploratory technique, Principal Component Analysis (PCA) was used to highlight the correlations between the components of the raw cow's milk, similarities and differences among biochemical and microbiological characteristics of milk from four seasons, reducing the dimension to two PCs, while keeping most of the original information found in the data. Only PCs with eigenvalue larger than one were retained for further analyses.

3. Results and discussion

Chemical and microbiological analysis. The chemical and microbiological characteristics of the samples set from four seasons are shown in Table 1. It can be seen that the mean milk fat percentage was the highest during the autumn season and the lowest during the spring season. The amount of fat in milk composition was the most variable component among the milk characteristics. This variation may be due seasonal variation and lactation period. The more pronounced variation of autumn was due to outdoor grazing in summer and bar feeding in winter. The seasonal variation was due to many important differences between the feeds composition which were given to animals during these four periods. The lowest the mean value milk fat was detected during the spring season probably due to the fact that the feed diet was based on hay the herbage was not available due to long winter. According to Waldner et al. (2005) the cows feeding with low fiber diets leads to an increase in milk fat levels.

Comparing the mean protein content detected in winter season to the mean protein content detected in summer season, the highest concentration was obtained in summer season. The protein in raw cow's milk does not fluctuate as much as milk fat, confirming the results obtained by Ozrenk and Selcuk (2008).

The mean lactose concentration ranged from 4.18 ± 0.06 % to 4.31 ± 0.03 %; the highest concentration was detected in spring season.

The mean solids non fat content of the cows' milk was 8.42 ± 0.07 %. The highest solids non fat percentages (8.51 ± 0.01%) was obtained during the summer season.

Regarding the mean value obtained for somatic cell counts (SCC), the lowest mean concentration ($296.33 \pm 19.85 \times 10^3$ cells · mL^{-1}) were detected in autumn season; the highest mean value of SCC ($314 \pm 71.68 \times 10^3$ cells · mL^{-1}) was detected during the spring season. The increase of SCC

can be due poor health condition of cow's udders [5]. A greater number of the somatic cells affects quality processing of milk, mainly has effect on cheese production [14-15].The highest mean value of number of total germ (NTG) (266 ± 6.08 x 10^3 no · mL^{-1}) was detected in winter season and the lowest mean value NTG in autumn season (258.33 ± 31.53 x 10^3 no · mL^{-1}).

Table 1.

The chemical and microbiological characteristics of cow's milk obtained from Suceava county

		Fat (%)	**Protein** (%)	**Lactose** (%)	**Solids non fat** (%)	**Somatic cell counts x 10^3** (cells · mL^{-1})	**Number of total germ x 10^3** (no · mL^{-1})
Period I	Minimum	3.83	3.27	4.15	8.33	285	262
	Maximum	3.90	3.30	4.22	8.38	335	273
	Mean ± SD	3.86 ± 0.03	3.28 ± 0.01	4.19 ± 0.03	8.34 ± 0.02	303.66 ± 27.30	266 ± 6.08
Period II	Minimum	3.69	3.27	4.29	8.38	236	208
	Maximum	3.86	3.31	4.35	8.51	377	304
	Mean ± SD	3.80 ± 0.09	3.29 ± 0.02	4.31 ± 0.03	8.44 ± 0.06	314.00 ± 71.68	260 ± 48.49
Period III	Minimum	3.79	3.39	4.20	8.50	275	234
	Maximum	3.92	3.44	4.33	8.53	358	309
	Mean ± SD	3.87 ± 0.07	3.41 ± 0.02	4.24 ± 0.07	8.51 ± 0.01	310.33 ± 42.85	264 ± 39.68
Period IV	Minimum	3.78	3.30	4.12	8.30	282	226
	Maximum	4.15	3.45	4.25	8.45	319	289
	Mean ± SD	3.94 ± 0.18	3.39 ± 0.08	4.18 ± 0.06	8.39 ± 0.08	296.33 ± 19.85	**258.33 ± 31.53**
General	Mean ± SD	3.86 ± 0,10	3.34 ± 0.07	4.23 ± 0,07	8.42 ± 0.07	306.08 ± 39.05	**265.33 ± 37.23**

Relationships between chemical and microbiological raw cow's milk characteristics during the four seasons. The correlation between the results of the chemical characteristics during seasonal variation – the fat, protein, lactose, solids non fat content and microbiological characteristics – somatic cell counts and number of total germ are shown in Figure 1.

The first two principal components explain 83.60 % and 16.39% of the total variance. The first component (PC 1) was characterized mainly by the mean value of somatic cell count during winter period (SCC I), autumn period (SCC IV), number of total germs during summer (NTG III) and autumn period (NTG IV). In respect to the first principal component PC 1, one can notice there is a very good correlation between the mean protein content (P_II), mean values of number of total germs (NTG_II) and somatic cell count (SCC_II) in spring season.

The second component PC 2 distinguishes the mean protein content during spring (P_II) and the mean protein content during summer seasons (P_III) which are opposed. Regarding winter season, negative correlation (r = - 0.985) was obtained between mean value of lactose (L_I) and mean value of somatic cell count (SCC_I).

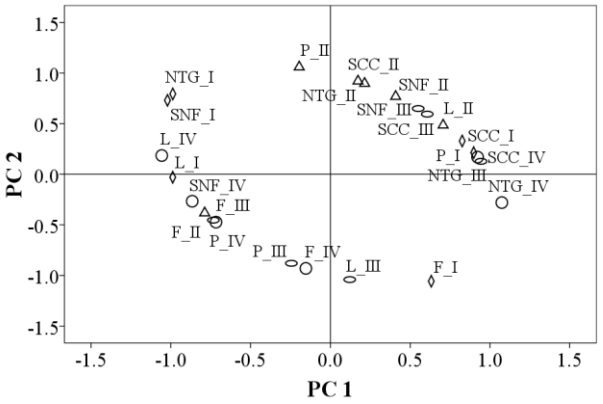

Figure 1. Principal component analysis of the combined chemical and microbiological characteristics of raw cow's milk from period I, period II, period III and period IV.

In the spring season, positive correlation was reported between the mean values of number of total germ (NTG_II) and somatic cell count (SCC_II) (r = 0.99) and negative correlation between mean fat content (F_II) and mean value of somatic cell count (SCC_II) (r = - 0.79). Positive correlation was reported between the mean values of number of total germ (NTG_III) and somatic cell count (SCC_III) (r = 0.89)

during summer season. In the autumn season, positive correlation between mean protein content (P_IV) and mean solids non fat (SNF_IV) (r = 0.98) on the one hand and negative correlations between mean values of lactose content (L_IV) and somatic cell count (SCC_IV) (r = - 0.94), between mean values of somatic cell count (SCC_IV) and solids non fat content (SNF_IV) (r = - 0.99) on the other hand were reported.

4. Conclusions

According to the results obtained in this study, the fat and the protein contents of cows' milk have been affected importantly by the seasonal variations. Principal component analysis was performed between different technological and microbiological characteristics of raw cow's milk samples. Regarding the correlations established with PCA method between the characteristics of milk from the four periods, a positive correlation was obtained between number of total germ and somatic cell count during spring and summer seasons, between protein content and solids non fat during autumn season. Negative correlations were obtained between lactose content and somatic cell count during winter and autumn seasons, between fat content and somatic cell count during spring season, between somatic cell count and solids non fat content during autumn season.

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