Influence of Climatic Factors in a Subcarpathian Mountain Range on Fat and Protein Content of Raw Milk from Indigenous Breed

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Bulletin UASVM Veterinary Medicine 72(1) / 2015,

Print ISSN 1843-5270; Electronic ISSN 1843-5378

DOI:10.15835/buasvmcn-vm: 11033

Abstract

Geo-climatic conditions significantly influence the health and welfare of cattle, both through their direct action on animals, as well as indirectly, on the biodiversity of forage sources (Broom, 1991; Machiko *et al.*, 2014). In this regard, special attention must be given to the climatic factors with major impact on the expression of productive potential in lactating cows (Collier *et al.*, 2006). In this study, focused on investigation of raw milk, we propose to evaluate the influence of the main climatic factors (temperature, humidity, pressure, precipitation) on the seasonal evolution of fat and protein content of raw milk, obtained in the conditions of Carpathian Mountain range, Valea Gurghiului.

The research was conducted on (the) processed milk, from December 2011 to July 2013, in a private commercial unit in southwestern part of Western-Carpathians. The investigations were carried out in collaboration with a weather station in the area, from which we obtained data on seasonal dynamics of temperature, humidity, atmospheric pressure and rainfall. These were processed in order to quantify the influence of the main climatic factors on fat and protein content of raw milk that was submitted to physicochemical testing with the EKOMILK semiautomatic analyzer. Statistical analysis of the recorded data was carried out using *MedCalc* software; the analysis on the variables was carried out by means of the *Pearson r*. correlation coefficient test.

Following the correlative statistical analysis of the values recorded from the evaluation of the climatic factors - fat/protein content, positive and negative correlations were established, which were relevant to the objectives pursued. Among these, a special relevance had the increase of fat and protein content of milk in correlation with decreasing air temperature in the autumn season.

We consider that the correlated action of temperature and relative air humidity represents the main environmental factor, specific to mountain range that influences the overall composition of milk and especially its fat and protein content.

Keywords: *cattle, fat, mountain range, protein, raw milk.*

INTRODUCTION

Climatic factors exert a major impact on the overall productive performances of farm animals, their influences being particularly important on lactation (Collier *et al.*, 2006). Climate-animal relationship largely reflects both the level of animal welfare and the environmental quality, directly influencing the production capacity of

livestock (Broom, 1991). Climatic factors act directly on the animal organism, or indirectly through the flora, which constitutes forage basis, causing major seasonal and individual variations on the quantity and composition of the produced milk (Ponzoni *et al.*, 2009; Machiko *et al.*, 2014). Significant effects on lactation in cow are exerted by the following climatic factors: temperature,

humidity, atmospheric pressure, light, rainfall, altitude. Among these, the ambient temperature appears to exert the most important influence on milk production. In this context, we remind that the thermal comfort zone for dairy cows is between 9-16° C; between these limits the body does not resort to physicochemical processes that require the thermoregulatory system. In cattle, resistance to thermal fluctuations is influenced by various intrinsic factors, such as: species, breed, color and hair density. (Mahe, 1997).

Relative air humidity is optimal in the range of 65-75% and is directly related to the evolution of temperature. Thus, low humidity associated with high temperatures intensifies the processes of thermoregulation, whereas high humidity diminishes it, regardless of the temperature level. Light intensifies the metabolism and, thereby, exerts a favorable effect on milk production. Moderate altitude can positively influence oxidative processes in the body and, therefore, the milk synthesis. Humidity and especially excessive rainfall determine decreases in milk production, as they prevent proper feeding of cows and exert a stressful action (Nardone *et al.*, 2010). The arguments presented fully justify our study, focused on assessing the influence of the main climatic factors on compositional parameters of the raw milk, obtained in conditions of mountain areas.

MATERIAL AND METHODS

Investigations were conducted based on monitoring and evaluating the physicochemical parameters of raw milk (fat, protein, dry matter, freezing point, density and pH), processed in a private processing unit. This was produced in the conditions of a Carpathian mountain range (Valea Gurghiului), from predominantly indigenous cattle breeds, reared in traditional households and commercial farms. Small producers, with an average of 3 animals/ household, represented the main source of raw milk supply. They produce milk in traditional household conditions, with predominantly manual milking, the percentage of those using mechanical milking equipment being insignificant. Small farms in the area have an average of 79 cattle and have good hygienic conditions, being equipped with automatic milking equipment and having their own cooling tanks. The area placed under study also includes

two large farms, with the average effective of 200 cattle, which have excellent hygiene conditions, with automatic milking rooms, also equipped (also) with automatic mastitis signaling systems. *Romanian Spotted* breed and its half-breeds continue to be prevalent in the area; after a long selection, new breeds have been obtained, having a high adapting potential to the local conditions. They prove a high level of resistance to disease and are well adapted to the climate and care conditions from Valea Gurghiului area. Feeding of dairy cows is done with green fodder from the mentioned geographic area by grazing in summer. In winter, in stabulation, feeding is predominantly done with fiber (hay), supplemented with fodders (corn and various vegetable meals).

The research begins by identifying the producers of raw milk, framed in product standards, in accordance with applicable legislation and set of rules from processing unit.

Following the assessments carried out in the activity area of the unit under study, we identified the following three sources supplying raw milk, including: small producers (n = 650), small farms (n = 11) and large farms (n = 2). In that mountain area, small producers delivered raw milk to the 10 milk collection centers". In case of small farms and large farms, the use of their own cooling tanks allowed milk reception directly from the farm. The average quantity of milk supplied daily from these 3 sources was of 24.6 l/individual producer, 909 l/small farm and 3000 l/large farm. Investigations were conducted over a period of 20 months (December 2011-July 2013), including the following three groups: A-milk originating from small producers; B-milk originating from micro farms; C-milk originating from large farms. From each group, monthly samples were collected (n = 16) and subjected to laboratory analysis. From each group, monthly samples were collected (n = 16) and subjected to laboratory analysis. The total number of analyses performed was 960 samples, 320 per each group.

Samples collected from each group were subjected to physicochemical testing with a semi-automatic analyzer type Ekomilk M (*Milkana kam 98-2a*), (including determination of) used in determining: fat, dry matter, protein, freezing point, density, and pH. In parallel, the results obtained with the semi-automatic analyzer were verified, in case of three basic parameters: fat

(butirometric method), dry matter (by drying stove) and density (with lactometer).

The data obtained from testing the three milk groups were collected for each parameter and their average was calculated, as follows: the values collected separately on manufacturer, small farms and farms and divided by 3. In our study we considered as being relevant the values obtained for fat and protein content.

Investigations were carried out in collaboration with a weather station in the area, from which we obtained data on seasonal dynamics of temperature, humidity, atmospheric pressure and rainfall. These were processed in order to quantify the influence of the main climatic factors on the fat and protein content of raw milk. Climatic parameters were monitored daily throughout the study, lasting 20 months (December 2011 - July 2013). (Data were) The obtained data was centralized and supplied to us by the Târgu Mureș Weather Department. The studied area is located at 530-570 m altitude and the grazing area extends up to 700-800 m altitude. The recorded data was statistically analyzed using the *MedCalc* program, designed for statistics in biomedical research. Descriptive data (distribution of variables) was analyzed using summary statistics and frequency analysis. Statistical analysis of the interrelation between the two variables was performed by *Pearson* correlation and interpreted using the *r*

coefficient. This coefficient is a number between -1 and 1, the more *r* approaches 1 in absolute value, the more the intensity of the linear relationship between the two variables is higher and the connection is stronger; in our study the variables are the climatic factor and the indicator from milk. The graphical representation of this relationship was made using the dispersion diagram which, by the orientation and dispersion of points, gives an overview of the relationship between those two variables.

RESULTS AND DISCUSSIONS

Seasonal evolution of fat content, depending on climatic factors. Statistical analysis of data revealed positive correlations between fat content (3.66-3.89%) and temperature (10.95-21°C) in the spring ($p=0.006$) and summer season ($p=0.047$), indicating an increase of both variables (Fig. 1). In contrast, in the autumn season ($p=0.0001$), the correlation between temperature (10.7°C) and fat content (3.94%) was negative ($r=-0.479$), indicating that the decrease of temperature induces an increase of fat content.

The evolution of humidity (76%) significantly influenced the fat content (3.94%) in the autumn season ($p=0.006$), indicating that, as much as the humidity will increase, it will also increase the fat content ($r=0.289$); in the summer season ($p=0.001$), a negative correlation between

Fig. 1. Correlation between temperature-fat content in milk, in summer season.

Fig. 2. Correlation between humidity-fat content in milk, in autumn season.

humidity (66%) and fat content (3.89%) indicated that the decrease in humidity determines an increase of fat content (Fig. 2).

Comparative data regarding air pressure (962.9-965.5mb) and fat content (3.86-3.94%) revealed statistically negative correlations in autumn seasons ($p=0.017$) and winter seasons ($p=0.047$), indicating that, as the pressure will decrease, the fat content will increase. In the spring season, the positive correlation ($r=0.185$) between pressure (961.2 mb) and fat content (3.66%) was statistically significant ($p=0.012$), indicating that once the temperature increases, the fat content will also increase.

The dynamics of rainfall did not significantly influence the evolution of fat content in any of the four seasons.

Seasonal evolution of the protein content depending on climatic factors. The results of statistical analysis revealed negative correlations between temperature (10.70-21°C) and protein content (3.28-3.29%) in summer seasons ($p = 0.036$) and in autumn seasons ($p = 0.0001$), indicating that the decrease of temperature determines an increase of protein content (Fig. 3). Dynamics of temperature did not significantly influence the evolution of protein content in winter and spring seasons.

Correlative statistical analysis concerning atmospheric pressure (962.9-965.5mb) and

protein content (3.28-3.29%) revealed negative correlations in the autumn ($p = 0.001$) and winter seasons ($p = 0.011$), indicating that, as the pressure will decrease the protein content will increase (Fig. 4).

The evolution of humidity (66-76%) significantly influenced the protein content (3.28-3.29%) in summer seasons ($p = 0.0001$) and in autumn seasons ($p = 0.013$), indicating an increase of both variables. In the winter season ($p = 0.024$), the correlation between humidity (86%) and protein content (3.28%) was negative $r = (-0.167)$, indicating that the decrease of humidity determines the increase of protein content in milk.

Dynamics of rainfall (1.5 l/m²) negatively influenced ($r=-0.424$) the evolution of protein content (3.29%) in the autumn season ($p = 0.025$), indicating that the more the rainfall will decrease, the more the protein content will increase. In spring, summer and autumn seasons, the influence of rainfall on the protein content was insignificant.

Regarding the comparative analysis of the obtained results, they reveal, for all four seasons, an increase of 0.26-0.74% over the product standard (with 0.26-0.74%) for average fat content, and of 0.08-0.09% for the average protein content. Compared to the average percentage of fat reported nationally in 2012 (National Institute of Statistics, 2013), there are notable decreases with

Fig. 3. Correlation between temperature-protein content in milk in summer season.

Fig. 4. Correlation between pressure-protein content in milk, in winter season.

0.15%, reported for the spring season, respectively the increases with 0.02-0.03% for protein content, recorded in all the four seasons.

In comparison, the evolution of temperature had a higher influence on the fat content (spring, summer and autumn seasons) than on the protein content (summer and autumn seasons), although the statistical correlations were indicated at temperature values between 10.7-21°C for both variables. The intervals outlined in our study, both for the temperature variable, as well as for the fat/protein variable, were also registered in other studies in the literature of speciality (Sharma *et al.*, 1988). Evolution of humidity influenced both the fat content and the protein content; the most significant statistical correlations were indicated for protein content in summer, autumn and winter seasons.

Regarding the influence of atmospheric pressure, the significance level of the correlations established was higher in case of fat content, regarding three seasons (autumn, winter, spring); statistically significant correlations were registered in the case of protein content, but only during two seasons (autumn, winter).

Dynamics of rainfall didn't significantly influence the evolution of fat content; instead, it significantly influenced the evolution of protein content in the autumn season. Taken as a whole, the results obtained indicated average levels of fat content that were in the range of 3.66-3.94%, in terms of temperature average values of 10.7-21°C, a humidity of 66-76% and an atmospheric pressure of 961.2-965.5 mb (sunny days, moderate humidity and pressure, lack of rainfall).

Regarding protein content, the average levels were in the range of 3.28-3.29%, in terms of temperature average values of 10.7-21°C (for), a humidity of 66-86% and an atmospheric pressure of 962.9-965.5 mb (sunny days, moderate humidity and pressure, low rainfall or even the lack of it).

The results obtained showed that the evolution of the fat and protein content and, thus, the milk composition varies depending on the environmental conditions, the most important factor being the temperature, followed by humidity and pressure, as shown by the results of other studies in the field (Sharma *et al.*, 1988).

The latest research (Liang *et al.*, 2013; Bernabucci *et al.*, 2014) focused on the effects of the environmental conditions on milk

composition indicated that cows with high milk production are more sensitive to heat stress than cows with low milk production, parity having an important role. The effect of heat (thermic effect) on milk production has also been quantified, by investigating climatic factors (temperature, humidity, wind speed and brightness), the results suggesting the decrease of milk production due to heat stress (Bohmanova *et al.*, 2007).

Modern practices in this segment of production attempt to reduce the negative effects of climatic factors on the health and performance of animals, although, in a large production system, they cannot be applied to each individual. Therefore, is necessary an intensification of concerns in this segment of production and the implementation of effective strategies to ensure the welfare and productive performance of lactating cows.

CONCLUSION

Overall statistical analysis of data recorded on groups of raw milk revealed that seasonal fluctuations in temperature (10.7-21°C) influenced (more) the fat content ($p=0.006$, $p=0.047$, $p=0.0001$) more than the protein content ($p=0.036$, $p=0.0001$), and humidity fluctuations influenced the protein level ($p=0.0001$, $p=0.013$, $p=0.024$). Regarding the influence of atmospheric pressure, the significance level of the correlations established was higher in case of fat content, regarding three seasons than the lipid level. Atmospheric pressure exerted also significantly influences (on) the evolution of fat content during the spring, autumn and winter seasons ($p=0.012$, $p=0.017$, $p=0.047$) and of protein content in the autumn and winter seasons ($p=0.001$, $p=0.011$). Dynamics of rainfall hasn't exerted significant effects on the evolution of fat content, but it statistically significantly influenced the evolution of protein content in autumn season ($p = 0.025$).

Acknowledgments. The authors would like to thank to the Târgu Mureş Weather Department, the Department of Biostatistics and Epidemiology in Târgu-Mureş Faculty of Medicine.

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