Ways of increasing the milk productivity of cows, improving the quality and safety of livestock products

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Abstract. The article presents the results of studies of the dependence of cows' milk productivity on the level of lipid peroxidation and antioxidant defense in their body. For the experiment two groups of lactating cows were formed, 10 animals each: group 1 – livestock with a high concentration of lipid peroxidation products in the blood and a low level of antioxidants; group 2 – livestock with the values of these indicators within the reference interval. The results of the research indicate that in animals of the group 1 the average daily milk yield was lower by 9.9% relative to the values of the group 2. According to the quality characteristics and safety factors of milk in cows with an imbalance in the LPO-AOD system relative to the group of animals with normal data, a decrease in the concentration of protein and fat was recorded with an increase in the concentration of somatic cells. Taking it into account, it seems relevant to use antioxidant substances for highly productive dairy cattle in order to increase milk productivity, improve the quality and safety of livestock products.

1 Introduction

A dairy cattle breeding is one of the most important branches of animal husbandry, providing humanity with milk, which serves as a source of complete proteins, essential amino acids, vitamins, microelements and many other nutrients and biologically active substances. [1-3].

In the industrial cultivation and maintenance of dairy cattle, modern technological modernization of farms is implemented through the creation of large complexes, where the keeping of cows as a rule is free, and the milking process is automated. At the same time, constant rearrangements, a highly concentrated type of feeding, an imbalance in the diet for nutrients and biologically active substances contribute to the deterioration of metabolism

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and reduce the resistance of cattle to diseases, which negatively affects its productivity and duration of economic use [4-7].

Lipid peroxidation (LPO) is a normal metabolic process in all organs and tissues, which plays an important role in the physiological and biochemical homeostasis of a healthy cell. However, with a pronounced negative impact of endogenous and exogenous factors on the body, free radical reactions take a pathological course, which leads to excessive accumulation of free radicals and gives this process a chain uncontrolled character. The damaging action of free radicals is resisted by a multicomponent system of antioxidant defense (AOD), which keeps the process of lipid peroxidation at a stationary level, which does not interfere with the normal functioning of the body. The resulting prooxidant-antioxidant balance is the most important mechanism of animal homeostasis [8-13].

The intensity of lipid peroxidation processes occurring in the cells of the body is likely to affect the milk productivity of animals, since the accumulation of lipid peroxidation metabolites in the body leads to a deterioration in the digestibility of diet components by animals, metabolic disorders, decrease in resistance, etc. [14-16].

However, the dependence of milk productivity of cows on the state of lipid peroxidation in their body has not yet been studied enough, and a more complete understanding of these processes will allow developing adequate strategies for antioxidant pharmacocorrection to rationalize the production of dairy products, improve their quality and safety.

The aim of the work was to study the dependence of milk productivity of cows on the level of lipid peroxidation and antioxidant defense in their body.

2 Materials and methods

The studies were carried out in spring period on highly productive cows of the Holstein breed, which were in the period of milking.

Blood was taken from 50 cows ranked by age, body weight and physiological state (second month of lactation) for laboratory tests. Blood sampling was performed from the jugular vein in compliance with the rules of asepsis from the caudal vein in the morning before feeding.

The intensity of lipid peroxidation processes in the body of cows was assessed by determining the blood concentrations of diene conjugates (DC), ketodienes (KD) and malonic dialdehyde (MDA), in accordance with the methodological recommendations of All-Russian Scientific Research Veterinary Institute of Pathology, Pharmacology and Therapy (2010). Ketodienes and diene conjugates are the primary products of lipid peroxidation and are formed during the oxidation of linoleic, linolenic and arachidonic acids. Malonic dialdehyde is one of the most significant among the secondary products of lipid peroxidation. All these LPO products are mutagens and have a pronounced cytotoxicity, leading to the disintegration of metabolism in the cell and as a result to its death.

In the blood of cows, the indicators of the non-enzymatic link of the body's antioxidant defense system, carotene and vitamin C, were determined (in accordance with the “Guidelines for the use of unified biochemical methods for testing blood, urine, milk in veterinary laboratories”). An Ecoview UV-1100 spectrophotometer was used to record the optical density of the samples.

Based on the results of screening laboratory blood tests, after determining the concentration of lipid peroxidation products, 20 animals were selected from 50 cows, from which two groups of 10 animals each were formed: group 1 – livestock with a high concentration of lipid peroxidation products and a low level of antioxidants; group 2 – livestock with the values of indicators within the reference interval.

When studying the dependence of milk productivity of cows on the level of lipid peroxidation and antioxidant protection in their body in a comparative aspect, milk yields were

estimated by groups within two weeks from the moment of blood sampling. To obtain data on the amount of milk produced during this time, the milk yield for each cow was recorded daily using an individual milk meter "MM-27 DELAVAL". To assess the quality of milk from cows, an average sample was taken from daily milk for three adjacent days, in which the mass protein fraction (MPF) and mass fat fraction (MFF) were determined on the "Lactan" device, the content of somatic cells was determined on the "SOMATOS" device.

To obtain the correct analyzer readings, the following conditions were met: the sample must be homogeneous; in the presence of a settled layer of fat (cream), the milk sample was heated in a water bath to 40-45 °C, mixed, cooled to a temperature of 25 ± 2 °C and mixed again.

All obtained digital data were processed by the methods of variational statistics with the determination of Student's t-test and the level of significance of differences in indicators by groups.

3 Results

The results of laboratory studies to determine the concentration of LPO-AOD indicators in the blood of cows by groups are presented in Table 1.

Table 1. Concentration of LPO-AOD in the blood of cows (M±m; n=10).

Indicators	Reference interval	1 group	2 group
DC, opt. density units / mg of lipids	0.120–0.250	0.272±0.006*	0.198±0.005
KD, opt. density units / mg of lipids	0.050–0.100	0.137±0.003**	0.087±0.004
MDA, μmol/l of blood	0.50–1.50	0.188±0.004*	0.138±0.006
Vitamin C, mg%	0.5–1.5	0.42±0.02**	0.55±0.05
Carotene, mg%	0.4–1.0	0.33±0.03*	0.41±0.07

Note: significance level * p≤0.05; ** p≤0.01

In accordance with the methodology of the experiment, group 1 included animals, in which the concentration of lipid peroxidation in the blood exceeded the upper limit of the norm and the level of antioxidants, on the contrary, was reduced. In group 2 the values corresponded to the reference interval. When calculating, the difference between the groups was: DC – 37.4% (p≤0.05); KD – 57.5% (p≤0.01); MDA – 36.2% (p≤0.05); vitamin C – 23.6% (p≤0.01); carotene – 19.5% (p≤0.05).

When assessing the milk productivity of cows, it was revealed that in animals of group 1 the average daily milk yield for a two-week period was 25.4 ± 0.51 kg, and in group 2 – 26.4 ± 1.23 kg with a significant difference between groups of 9.9% (Table 2).

Table 2. Indicators of milk productivity of cows (M±m; n=10).

Indicators	1 group	2 group
Milk yield, kg	25.4±0.51*	28.2±0.37
Organoleptic indicators of milk		
Color	White with a yellowish tint	
Consistency	Homogeneous liquid without inclusions	
Taste and smell	Smell characteristic for natural fresh milk, sweetish taste	
Quality indicators of milk		
MPF, %	3.31±0.023	3.43±0.016
MFF, %	3.65±0.012	3.72±0.017
Somatic cells, thousand / ml	284.8±3.98*	238.8±4.42

Note: significance level * p≤0.05

Milk supplied for processing must meet the requirements for both the food product and the raw materials for the production.

In the organoleptic evaluation of cows' milk there was no significant difference between the groups. The milk had a white color with a yellowish tint, the consistency was homogeneous, without inclusions, the smell was characteristic for natural fresh milk, the taste was sweetish.

According to the quality characteristics of milk in cows of the group 1 (with an imbalance in the LPO-AOD system), the worst indicators were recorded relative to the group 2. There was a decrease in protein by 0.12 abs. % and milk fat by 0.07 abs. %.

The primary requirement for raw milk is its compliance with safety standards, while the number of somatic cells is a determining factor. The conducted studies found that the concentration of somatic cells in milk was significantly higher in cows of the group 1 with a difference of 19.3% ($p \leq 0.05$) relative to the group 2.

The results of the correlation analysis of milk productivity of cows with the level of indicators of the LPO-AOD system are presented in Figure 1 in the form of a heat map.

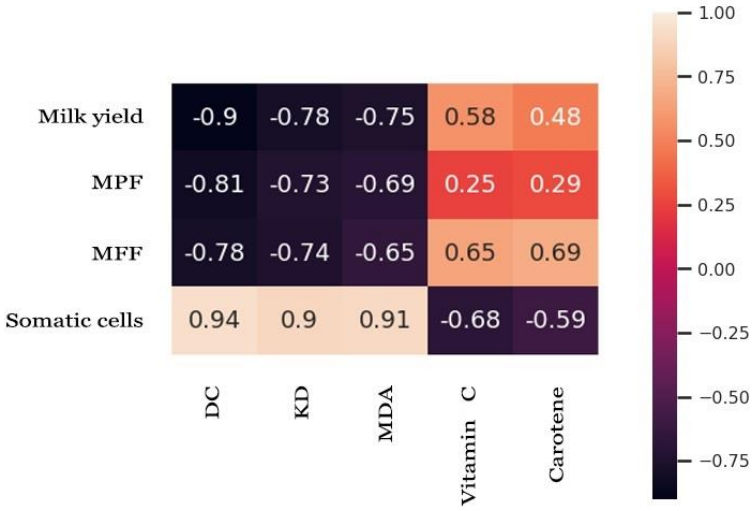

Fig. 1. Correlation analysis of the dependence of milk productivity of cows on the level of indicators of the LPO-AOD system.

The analysis shown in the figure demonstrates a high negative relationship between the amount of milk yield in cows and the indicators of lipid peroxidation in the blood. Correlation coefficients for pairs of values are equal: milk yield – DC (r = – 0.9); milk yield – KD (r = – 0.78); milk yield – MDA (r = – 0.75). An average positive relationship was determined between the amount of milk yield and the concentration of vitamin C in the blood (r = 0.58) and a weak relationship with carotene (r = 0.48). The MDA indicator in milk has a high negative correlation with the value of DC (r = – 0.81) and KD (r = – 0.73), as well as an average negative relationship with the MDA indicator (r = – 0.69). MFF has a high negative correlation with DC (r = – 0.78) and KD (r = – 0.73), an average negative correlation with MDA (r = – 0.65). Correlation coefficients for pairs of values of MFF and antioxidants in the blood have an average positive relationship and are equal: MFF – vitamin C (r = 0.65); MFF – carotene (r = 0.69).

A very high positive relationship between the concentration of somatic cells in milk and the level of lipid peroxidation in the blood is confirmed by the correlation coefficients: DC (r = 0.94); KD (r = 0.9); MDA (r = 0.91). An average negative relationship was found with vitamin C (r = – 0.68) and carotene (r = – 0.59).

4 Conclusion

Thus, the obtained data indicate that the intensity of lipid peroxidation processes and the state of antioxidant defense in the body of lactating cows significantly affect the level of milk productivity of cattle, as well as the quality and safety of the milk obtained. Taking it into account, it seems relevant to use antioxidants for highly productive dairy cattle in order to increase milk productivity, improve the quality and safety of livestock products.

Acknowledgments

«The study was supported by the grant from the Russian Science Foundation (RSF) No. 22-26-20074, https://rscf.ru/en/project/22-26-20074/ and the grant from the Kuban Science Foundation»

References

1. I. N. Tuzov, M. G. Grigoryeva, Modern problems in cattle breeding: textbook. Allowance (Krasnodar, KubGAU, 2016)
2. S. Tao, R. M. Orellana, X. Weng, T. N. Marins, G. E. Dahl, J. K. Bernard, Journal of Dairy Science **101(6)**, 5642-5654 (2018) doi: 10.3168/jds.2017-13727.
3. G. Stocco, A. Summer, M. Malacarne, A. Cecchinato, G. Bittante, Journal of Dairy Science **102(11)**, 9727-9739 (2019) doi: 10.3168/jds.2019-16834.
4. A. M. Ulimbashev, Z. M. Aisanov, M. B. Ulimbashev, Zootechnics **4**, 30-32 (2017)
5. N. A. Yurina, D. V. Osepchuk, M. P. Semenenko, E. V. Kuzminova, E. G. Chuprina, Agronomy Research **18(2)**, 640-649 (2020) doi: 10.15159/AR.20.146.
6. J. J. Gross, R. M. Bruckmaier, Journal of Dairy Science **102(4)**, 2828-2843 (2019) doi: 10.3168/jds.2018-15713.
7. G. E. Dahl, S. Tao J. Laporta, J Anim Sci. **95(12)**, 5701-5710 (2017) doi:10.2527/jas2017.2006.
8. V. A. Grin, E. V. Kuzminova, A. A. Abramov, M. P. Semenenko, Veterinary Kuban **5**, 10-11 (2019) doi: 10.33861/2071-8020-2019-5-10-11.
9. V. Unsal, M. Cicek, İ. Sabancilar, Rev Environ Health **36(2)**: 279-295 (2020) doi: 10.1515/reveh-2020-0048.
10. R. L. Smathers, J. J. Galligan, B. J. Stewart, D. R. Petersen, Chem Biol Interact **192(1-2)**, 107-12 (2011) doi: 10.1016/j.cbi.2011.02.021.
11. M. Morita, N. Ishida, K. Uchiyama, K. Yamaguchi, Y. Itoh, M. Shichiri, Y. Yoshida, Y. Hagihara, Y. Naito, T. Yoshikawa, E. Niki, Free Radic Res. **46(6)**, 758-65 (2012) doi: 10.3109/10715762.2012.677840.
12. T. Ž. Semren, S. Žunec, A. Pizent, Arh Hig Rada Toksikol **69(2)**, 109-125 (2018) doi: 10.2478/aiht-2018-69-3118.
13. H. Sies, C. Berndt, D. P. Jones, Annu Rev Biochem. **86**, 715-748 (2017) doi: 10.1146/annurev-biochem-061516-045037.
14. E. N. Rud, E. V. Kuzminova, M. P. Semenenko, A. G. Koschaev, O. V. Koschaeva, Proceedings of the Kuban State Agrarian University **92**, 238-244 (2021) doi: 10.21515/1999-1703-92-238-244.
15. T. S. Denisenko, I. V. Kireev, International Bulletin of Veterinary Medicine **2**, 28-33 (2018)

16. I. A. Plyushchik, Problems of Biology of Productive Animals **1**, 53-58 (2014)