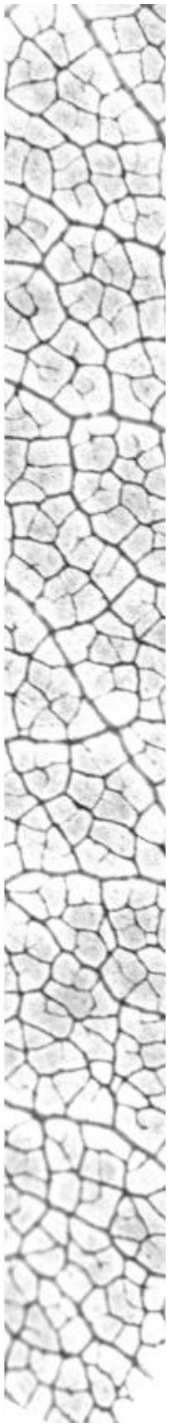

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Quality of milk-raw materials at different level of solar activity and methods and practices of detecting milk quality

A. Norezzine [1*], A. A. Nikishov [1], V. G.Plushikov [1], N. Y. Rebouh [1], Yu. A. Vatnikov [1], N. V. Babichev [1], E. V. Kulikov [1], A. A. Terekhin [1], M. I. Shopinskaya [1], M. V. Bolshakova [1], E. A. Kostitsyna [1]

[1] Veterinary medicine of the agrarian-technological institute of the Peoples' Friendship University of Russia (RUDN University), 6 Miklukho-Maklaya St, Moscow, 117198, RUSSIA
*Corresponding author: Assissnor@gmail.com

Abstract
The history of dairy farming goes back thousands of years, evolving from a traditional small-scale production to the industrialized manufacturing of fermented dairy products. Commercialization of milk and its derived products has been very important not only as a source of nourishment but also as an economic resource. However, the dairy industry has encountered several problems that have to be overcome to ensure the quality and safety of the final products, as well as to avoid economic losses. The results of studies of the relationship between cosmophysical activity and animal productivity are presented. obtained the following results, the synchronization of milk yield in cows of black-motley breed in the years of high solar activity was 76%; 5. The synchronicity and rhythm of milk yield of cows was established, regardless of the phase of lactation of cows, approximately 33% of the time the milk yield increases, 33% decrease and 34% remain at the same level (p□0.99); An increase in the relationship between the studied indicators was observed when the animals achieved maximum productivity. With an increase in milk yield from to 8500 kg, the correlation coefficient was + 0.52. It was noted that all the components of milk decreased on days of increasing solar activity. The correlation coefficients for protein and milk fat content with Wolf (sunspot) numbers were r = –0.34 and r = –0.22, P ≥ 0.95. Correlation analysis revealed a reliable correlation of bacterial contamination and the number of somatic cells r = +0.28 and r = +0.31 (at P ≥ 0.95), respectively, with the Wolf (sunspot) numbers. In the collection milk, the negative correlation by fat content r = –0.12, density r = –0.18, acidity r = –0.17, protein content r = –0.19, sugar content r = –0.14, minerals r = –0.17 was observed with an increase in solar activity. Prospects for further research. The results of studying the effect of solar activity on milk productivity and the quality of raw milk provide the basis for predicting the productivity of cows and the possibility of using cosmophysical changes, to increase productivity and improve the quality of milk, by technological methods.

Keywords: dairy cattle, milk, chemical composition, acidity and density of milk

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INTRODUCTION

The interconnection of biological objects of the Earth with cosmic manifestations was noted in their writings by V. Vernadsky. and Chizhevsky A.L. in the 20th century. Their research laid the foundation for the development of a new scientific direction about cosmic-biosphere relationships - space biology (Agulova 2001). A huge contribution to the study of rhythms and cycles in the life processes of biological objects of the Earth, their connection with cosmic radiation, atmospheric phenomena, cycles of solar and geomagnetic activity was made by A. Chizhevsky (1964), Vernadsky V.I. (1981), Gushchin P.Ya. (1996), Shnol S.E. (2002), Vladimir B.M. (2000), Temuryants N.A. (2000) and other scientists (Agulova 2001, Agulova et al. 1989, Agulova 1998, Alyabina et al. 2007, Aksenov 2007).

Today there is no doubt about the existence of such connections and the existence of various kinds of rhythms and cycles that occur in biological, biochemical and chemical reactions of the body, the life of animal populations in general, epidemic processes and much more, which is not a small fraction of those

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manifestations that are the process of organic the existence of life on Earth (Alexandrov and Alexandrov 2017, Antipenko et al. 2012).

The problem of the influence of solar activity on the biosphere of the Earth is considered by a branch of science that studies the interaction of man with the environment. In the modern world, it has become obvious that in the concept of the external environment it is necessary to take into account the influence of cosmophysical factors. First of all, one cannot but take into account the influence of solar activity on the biological objects of the Earth and their vital functions.

At present, studies of the influence of cosmophysical factors on the biosphere are included in the programs of the Russian Academy of Sciences. The question of the influence of space activity on man as a biological object of the Earth from the point of view of medicine is currently deeply studied. But the influence of cosmophysical factors in animal husbandry has not been fully disclosed and investigated. Based on the results of previous studies, a relationship was established between solar and geomagnetic activity with the animal organism, its vital activity, productivity, as well as qualitative and quantitative indicators of livestock production - milk, etc. (Aristarkhov and Piruzyan 1975, Afanasyev 2004).

In addition, many scientists in their studies revealed the presence of various kinds of rhythms in the growth and development of agricultural animals, the manifestation of hunting, productivity, milk yield, milk quality, as well as the work of internal organs. (Fedorov V.I. (1973), Khaynatskaya G.T. (1964), Shikhiev H.G. (1996), Chibisov S.M. et al. (2004), Alkuare I, Afanasyev V.A (1998) and etc.)

New scientific developments and further studies are a promising scientific field that allows more fully and reasonably to predict the milk productivity of farm animals (in particular cattle) and the quality of livestock products (milk) relative to the predicted solar activity, which ultimately will lead to more rational use economic resources. At the moment, the dairy industry is one of the priority sectors for the development of the Russian economy. Our country has a high production and economic potential in the production and processing of milk (Afanasyev et al. 2010, Afanasyev et al. 2009). According to the Federal State Statistics Service, 30759 thousand tons of raw milk were produced in farms of all categories in 2016. As a result, 14.174 million tons of milk were sent for processing (excluding small businesses), which is 2.3% more than in 2015. As for milk production in Russia, according to official data, it decreased by 0.2% to 30.724 million tons. At the same time, the number of cows decreased by 1.9% and amounted to 8.250 million heads.

A study of the relationship between livestock milk productivity and raw milk quality indicators with the solar activity index will explain to dairy producers and processors one of the reasons for the instability in livestock production related to the rhythm of lactation and milk yield of cows under stable conditions of keeping and feeding animals on dairy farms (Afanasyev et al. 2008, Afanasyev et al. 2017).

The relevance of this study lies in the fact that knowledge of the nature of the influence of solar activity on the milk productivity of cattle and on the qualitative and quantitative indicators of raw milk will help to effectively influence these indicators, to predict the number and quality of milk yield of cattle relative to the predicted solar activity. In addition, it will help to solve some problems of quality and safety of raw milk, which is directly related to the level of public health (Afanasyev et al. 2007, Afanasyev and Nikishov 2007).

MATERIAL AND RESEARCH METHODS

The experimental part of the work and computer processing of numerical material was carried out on the basis of the Department of Veterinary Medicine of the Agrarian and Technological Institute of the Peoples' Friendship University of Russia and the laboratory for the acceptance of raw milk from the Lianozovsky Dairy Plant in 2016-2019.

To study the effect of solar activity on the milk productivity of cattle, archived data were collected and processed on milk yield of dairy cows of the ZAO Lenin State Farm in the Moscow Region for the period from 2010 to 2019. The number of animals participating in the study was taken equal to 420 dairy cows with a holsteinization level of 1/32 - 1/64. The number of dates for each indicator was: 3274 for daily measurements from 2010 to 2019 inclusive; 364 - 365 measurements per year, as well as 10 measurements for annual average. The average gross milk yield of cows varied from 7800 kg in 2010 to 9200 kg in 2019.

In addition, raw cow milk obtained from more than 150 dairy farms and Russian farms and sent to the Wimm-Bill-Dann OJSC Lianozovsky Dairy Plant (LMK) for processing milk and dairy products served as a material for the study (Achkasova et al. 1982, Afanasyev 1999, Babaev et al. 2007).

In the process of studying dairy raw materials, both classical and modern physico-chemical and microbiological control methods were used. Physico-chemical analysis of raw milk was carried out for each batch of raw milk received for processing at LMK, according to the express method on a special MultiSkan device. The control of raw milk was also carried out by measuring titratable acidity using the Turner titrometric method in accordance with GOST R 54669-2011. The content of somatic cells was carried out according to the procedure described in GOST 23453-2014 and GOST ISO 13366-2-2014. KMAFAnM - according to the method described in GOST R 52415-2005 and GOST 32901-2014.

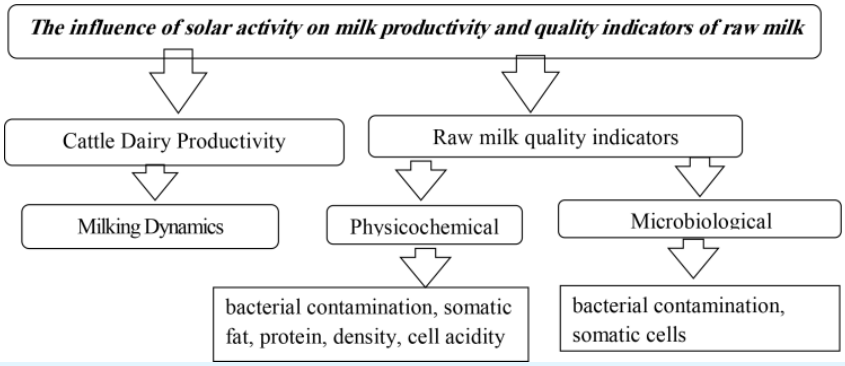

Fig. 1. Research diagram

Normalization coefficients k are derived for each observer and telescope, which makes it possible to share the Wolf numbers found by different observers.

The data on the solar activity index (Wolf number) were taken for the period 2010-2019 from the global computer network (Internet), on the website of the Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Russian Academy of Sciences (Troitsk), as well as on the website of the International Standard Database for heliogeophysical indices. The data were processed using software: MS Excel 2010, Statistica 9.0 for Windows (Afanasyev 1999).

The following statistical methods were used in the studies: Spearman rank correlation analysis, one-way analysis of variance according to the Fisher criterion (ANOVA), the method of reliability of the difference in average values by the Student criterion, Fourier analysis.

The research scheme provides for an integrated approach to studying the influence of solar activity (according to the index - the Wolf number) on the milk productivity of cattle and qualitative and quantitative indicators of raw milk (Achkasova et al. 1982).

The research was carried out according to the diagram shown in **Fig. 1**.

Thus, the scheme examines the following areas of research:

1. A study of the milk productivity of cattle in various levels of solar activity.
2. The study of the physico-chemical parameters of raw milk (fat, protein, density, acidity) regarding changes in solar activity;
3. The study of microbiological indicators of raw milk (bacterial contamination, somatic cells), taking into account changes in the index of solar activity.

Lianozovsky Dairy Plant.

LMK produces 1800 tons of finished products 163 items per day. The plant employs more than 1,100 employees and 37 production lines. The structure of the enterprise includes a separate plant for the production of baby milk for young children.

Production quality control begins with the input control of strategic raw materials in order to ensure high quality of finished products. About 50 raw milk machines are received per day in Lianozovo.

Before cooperating with the farm, the dairy plant analyzes the state of the farm and the content of the cows.

The basic principles of work:

• Work only with farms that are equipped with modern equipment;

• Conducting scheduled farm audits to control milk quality;

• Cooling milk for 2 hours after milking and storage at + 4 °C;

On the way to the factory, the following conditions are met:

• Analysis of the presence of antibiotics in milk before loading milk into the milk carrier;

• Maintenance of temperature not higher than + 4 °C in the milk tanker;

• Milk is delivered to the plant within 1-10 hours (depending on the remoteness of the farm).

Cattle milk productivity and milk quality indicators at different levels of solar activity

RESEARCH RESULTS

In this work, we used data on the index of solar activity (Wolf numbers), which were taken from the site of the Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Russian Academy of Sciences (Troitsk) for the period 2010-2019. This period was in the first half of the 24th eleven-year cycle of solar activity, in the phase of an increase in the activity of the Sun and an increase in the Wolf index. Although it is necessary to clarify that, compared with the previous 22 and 23 cycles, the 24th cycle is characterized by a general decrease in the activity of outbreaks in the sun (**Fig. 2**). The average value of Wolf numbers varied from 0 to 100. In general, the cycle is characterized by the speed of changes occurring on the Sun and the expectation of reaching the highest values (Babaev et al. 2007, Baybakova and Sobolev 2014).

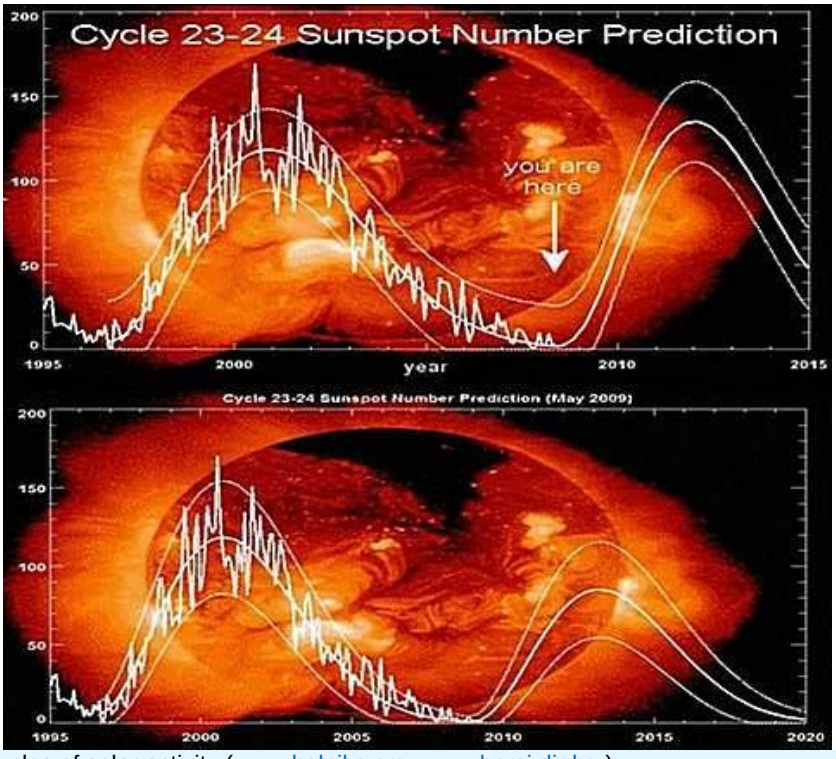

Fig. 2. Eleven-year cycles of solar activity (www.helpiks.org, www.borsi.dir.bg,)

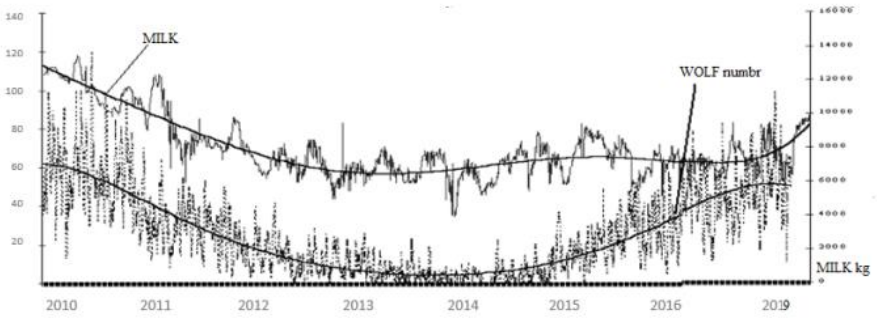

Fig. 3. Change in average daily gross milk yield for CJSC "State Farm named after Lenin" with different Solar activity (Wolf numbers) (2010 - 2019)

The Dynamics of Cow Yields at Different Levels of Solar Activity

From the literature there are enough experimental data that indicate a direct effect on the biological, and even physiological processes in animals, of solar activity. In our studies, we studied the dynamics of the daily gross productivity of the livestock of cows and daily average milk yield per head of animals of ZAO Lenin State Farm in the period 2010-2019. against the background of different levels of solar activity.

The statistical method of linear correlation calculated how the dynamics of gross productivity of animals correlates with changes in the background of solar activity. The cross-correlation method was used to evaluate the delay in the development of the influence of solar activity on animal productivity (Bakunets et al. 1980, Belaya and Belaya 2011).

An analysis of the results of a linear correlation of daily gross milk yield by household and daily indicators of solar activity revealed a positive and reliable correlation between them. This is clearly shown in **Fig. 3**. On the graph of changes in the average daily gross milk yield at different levels of solar activity (Wolf number) along the trend lines (rough estimate), we can distinguish in-phase, according to the trend, dynamics of both gross milk yield and solar activity throughout the entire temporary interval (2010-2019).

This is also evidenced by the highly reliable correlation coefficient r = + 0.48 with a confidence level of p≥0.99. The trend in phase of the studied data persists despite significant fluctuations in value. An increase in

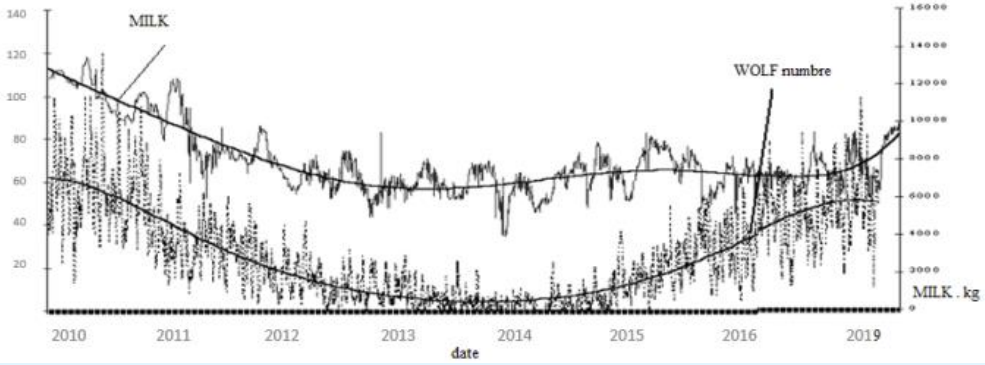

Fig. 4. Change in average daily milk yield per cow for ZAO Lenin State Farm for different solar activity (Wolf numbers) (2010 - 2019)

Table 1. Correlation coefficients of solar activity (Wolf number) and average productivity per head

Year	Average annual Wolf numbers	Average annual Wolf numbers. Correlation coefficient cf. milk yield per head per day and Wolf numbers (r))	Confidence level p ≥
2010	60,7014	+0.33	0.99
2011	54,3496	+0.30	0.99
2012	51,5237	+0.22	0.99
2013	39,9415	+0.14	0.99
2014	37,4924	-0.01	-
2015	38,6437	+0.27	0.99
2016	43,56739	+0.28	0.99
2017	68,94521	+0.36	0.99

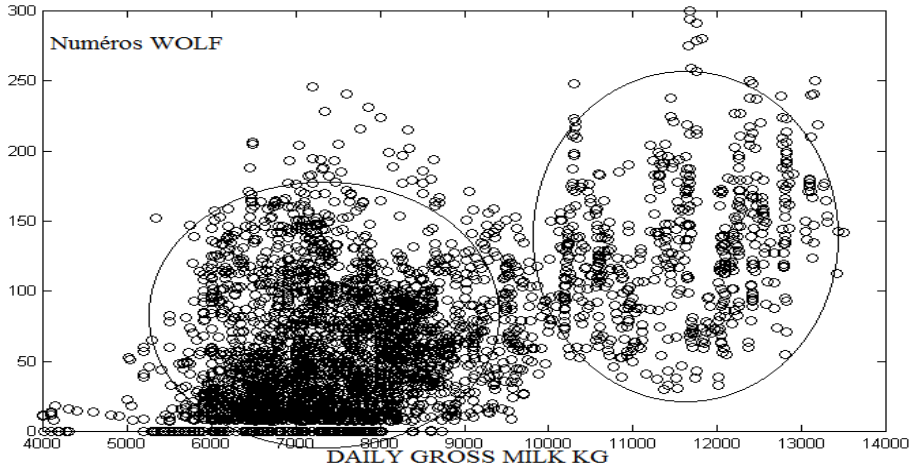

Fig. 5. Distribution of daily gross milk yields relative to solar activity (Wolf numbers) (2010 - 2019)

the relationship between the studied parameters was observed when the animals reached maximum productivity. With an increase in milk yield from 7500 kg to 8500 kg, and then up to 10000 kg, the value of the correlation coefficient was + 0.37; + 0.52 and + 0.64, respectively.

Similar average values of the correlation coefficient (r = + 0.51) at a confidence level of p≥0.99 were obtained by studying the dynamics of daily milk production per cow for the farm at different levels of solar activity (Wolf number) (**Fig. 4**).

It can be assumed that the influence of solar activity (Wolf numbers) on the average farm productivity of one animal is manifested at the peak of solar activity growth in years of high Wolf numbers. The values of the correlation coefficients, both in gross milk yield and in average productivity per head with Wolf numbers in years of increasing (high) solar activity, are significantly higher than in years of relatively low activity (**Table 1**).

Based on this, it can be assumed that the influence of solar activity (Wolf numbers) on the average productivity of one animal in the household appears (which is most clearly seen) in years of higher solar activity. During the years of growth (2010-2019), a decrease in the severity of the influence of solar activity is obvious. It is assumed that this phenomenon can be explained by the fact that in addition to solar activity, the average productivity of one animal is influenced by other environmental factors, which are also poorly understood and make up the so-called “noise”.

The scattering diagram (**Fig. 5**) of gross milk yield against the background of changing solar activity

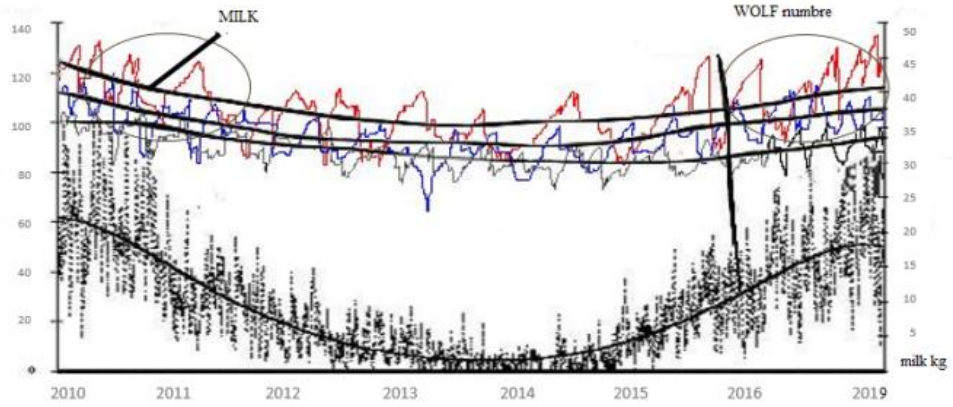

Fig. 6. Distribution of daily milk production of cows with different productivity relative to solar activity (2010 - 2019)

according to Wolf Numbers showed that there is a tendency to divide the entire array of gross milk yield into two groups (clouds), marked by ovals in the region of 9950 kg.

A group with a lower gross milk yield (main part) is characterized by low values of Wolf numbers, while a group with large milk yields does not meet low values of Wolf numbers. This means, in particular, that during the years of rising solar activity with a low absolute value of Wolf numbers, low milk yields are more likely, and in years with high solar activity, extremely high milk yields (record-breaking) are more likely.

In this regard, we compared data on milk productivity in cows with milk yield above 10,000 kg, cows with milk yield from 8,000 to 10,000 kg and relatively low milking, with productivity less than 8,000 kg (**Fig. 6**).

Looking at the graphs, it is necessary to note a more stable dynamics of average productivity per head in a year of high solar activity compared to a less stable, in a year of low solar activity.

Spearman's ranking correlation analysis revealed that depending on the level of daily milk production of cows, the value of the correlation coefficient increases from +0.31 to +0.54 ($p \geq 0.99$).

An increase and decrease in proteins in milk was observed for approximately 25% of the duration of lactation, and a stable content of about 50% of the length of lactation. The fat content in milk was not stable. These indicators were inversely correlated with milk yield, which reflects the generally accepted opinion. However, these connections are not straightforward. With an increase in milk yield during 34.0% of lactation days, the fat content in milk decreased, respectively, 23.6 and 22.4% of the time. With a decrease in milk yield during 32.5% of lactation days, the fat content did not change, respectively, for 45.8 and 44.4% of days.

A correlation analysis of the milk protein and milk fat data of milk of cows of black motley breed with indicators of Wolf numbers revealed a reliable correlation of r = -0.34 and r = -0.22 (at P□ 0.95) with Wolf numbers.

Similar results were obtained in terms of the density and acidity of milk. It should be noted that over the entire period of research, the acidity of milk did not exceed 18 degrees Turner.

The rhythm of milk production indicators of cows depending on different levels of solar activity

The synchronization and rhythm of milk production of cows was established, regardless of the phase of lactation of cows, approximately 33% of the time the milk yield increases, 33% decrease and 34% remain at the same level. These changes in most animals took place unidirectionally, that is, synchronously. The milk yield of 40% of the cows reliably correlated with the Wolf numbers on the day of taking the data or with a lead of 1-2 days. There were cows that responded to solar activity ahead of 14 or with a delay of up to 11 days. The synchronization of milk yields in black and white cows in the year of high solar activity in 2016 was 76%. The lactation curve was not a smooth curve with an ascent, but then with a smooth descent, but looked like a harmonic, both during dividing and during lactation. These data are consistent with similar results by A. Shitikov (2006). In this case, the following periods of rhythm of daily milk yield during lactation are found: 2.8; 3.5 to 5.6, as well as 9.5-10.7; 14.3; 16.1; 22-26; 35; 48; 56.8; 72; and 96 days (**Table 2**).

The most pronounced was the interval of rhythmic concentration of fat and protein in milk from 2 to 2.6 days with an average value of 2.3 days. In addition, rhythms lasting 2.6; 3.3; 4,5; 8; 31.7; 41.0; and 72 days. Apparently, the rhythm of the vital activity of organisms should be considered as a generated reaction, that is, adaptation, to the perception of external environmental factors that repeat with the indicated natural cyclicity.

Table 2. Periods of rhythmic milk production

Indicator	Mesorhythms, days										
	0-3	3-5	5-7	7-10	10-15	15-25	25-35	35-50	50-70	70-90	90-100
Milk yield	2.2 2.8	3.4 4.5	5.6 6.7	9.5	14.3	16.1	25.6	35.0	56.8	72.0	96.0
Mass fraction of fat	2.4	4.3	5.4	7.5 9.4	14.4	16.2	32.0	36.7			96.0
Mass fraction of protein	2.8	3.4 4.4		8.0			32.0	41.1		72.0	96.0
Density	2.3	3.5 4.3		9.5	12.2	14.4 16.5		36.5 48.0			
Acidity	2.2 2.8	4.5	6.5		10.7				57.0		
Minerals	2.2 3.3		5.5			19.2	32.0	41.1		72.0	96.0

Table 3. Coefficients of correlation of quality indicators of raw milk with solar activity

Milk quality indicators	U measurement	Correlation coefficient (± r)	Confidence level P ≥
Mass fraction of fat	%	-0.12 ± 0.073	0.99
Mass fraction of protein	%	-0.19 ± 0.026	0.99
Density	г/см^3	-0.18 ± 0.058	0.95
Acidity	°T	-0.17 ± 0.071	0.95
Milk sugar	%	-0.24 ± 0.084	0.95
Minerals	%	-0.17 ± 0.037	0.99

Dynamics of Physico-Chemical Quality Indicators of Raw Milk at Different Levels of Solar Activity

According to physicochemical and microbiological indicators, milk must comply with the norms of the Technical Regulation of the Customs Union “On the Safety of Milk and Dairy Products”. Deviation from normative indicators leads to an increase in the costs of normalizing raw materials in order to obtain a high-quality finished product. During the research period, milk return to suppliers amounted to no more than 7.3%. In the skim milk, a negative correlation was observed for fat content r = -0.12, density r = -0.18, acidity r = -0.17, protein content r = -0.19, sugar amount r = -0.14, mineral substances r = -0.17 with an increase in solar activity (**Table 3**).

CONCLUSION

During the study, the goal was achieved and the tasks were solved. Based on the information received and analyzed, the following conclusions can be drawn: - average daily milk yield per cow (average daily milk yield per cow 27.5–3.57 kg): significantly increased with increasing solar activity in Wolf numbers. Correlation coefficient r = + 0.48 (p≥0.99); - The presence of cycles in the dynamics of milk productivity for the period from 2010 to 2019 was established: 22.8; 3.5 to 5.6, as well as 9.5-10.7; 14.3; 16.1; 22-26; 35; 48; 56.8; 72; and 96 days. The revealed rhythms of milk productivity (about 3.5 - day rhythms, about 7 - day rhythms, about 14 - day rhythms) correlate with similar rhythms of processes occurring in the sun; - The intervals of rhythmic concentration of fat and protein in milk from 2 to 2.6 days with an average value of 2.3 days were identified. (p≥0.99); - A reliable correlation was revealed between bacterial contamination data and the presence of somatic cells in the milk of black-motley cows with Wolf numbers: r = +0.28 and r = +0.31, respectively (p≥0.95); - The synchronicity and rhythm of milk production of cows was established, regardless of the phase of lactation of cows, approximately 33% of the time milk production increases, 33% decrease and 34% remain at the same level (p≥0.99); - The synchronization of milk yield in cows of black-pied breed during the years of high solar activity was 76%. In the raw milk, a negative correlation was observed for fat content r = -0,12, density r = -0,18, acidity r = -0,17, protein content r = -0,19, sugar amount r = -0,14, minerals r = -0.17 with increasing solar activity.

Prospects for Further Research

The results of a study of the influence of solar activity on milk productivity and the quality of raw milk provide a basis for predicting the productivity of cows and the possibility of using cosmophysical changes, to increase productivity and improve milk quality, by technological methods

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