Analysis of the Results of the Impact of the Laser Device on the Technological Process of Rearing Young Sheep

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Abstract. As the world's population grows, the demand for livestock products increases, economically profitable ways of obtaining high-quality products become in demand. As a result, the tasks of searching for methods, as well as the development, design and application of innovative devices, equipment, and apparatuses for use in agriculture become urgent. It is necessary to search and analyze new methods that can replace or at least reduce the number of drug interventions in the animal's body, for example, the introduction of antibiotics to stimulate the growth of animals and reduce their morbidity, with alternative environmentally friendly ways to stimulate the nonspecific immunity of the body of farm animals. Therefore, it is advisable to conduct research in the field of new high-tech environmentally friendly methods of influencing animal organisms, to introduce and develop equipment that allows to increase the productivity of animals, as well as to facilitate the work of agricultural workers. In this regard, sheep breeding is a very important industry, since animals can already be used as a source of meat products at the age of four months, therefore, it is necessary for lamb producers to possess techniques for fast and high-quality production.

1 Introduction

Lamb in the form of meat contains less cholesterol several times compared to pork and beef. Mutton contains a lot of fluorine, iodine, potassium, magnesium and sodium salts. Doctors recommend eating mutton for children and the elderly.

Mutton is most common in the Muslim regions of the country. This is due to the religious peculiarity of these territories. According to the specific production of animal protein, mutton is less than a percent. Therefore, an urgent task in this industry is to increase productivity and product quality. The issue of growing large, viable animals, increasing their productivity and obtaining high-quality environmentally friendly products with high consumer properties also deserves attention [1, 10, 12].

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The increase in the number of sheep is due to the fact that for their cultivation it is necessary to have natural grassland and pastures. The main diet of sheep is various grasses, hayfields, as well as waste from field farming. Therefore, the largest sheep breeding regions are the Stavropol Territory, the Republic of Dagestan, the Republic of Kalmykia where there are mountain slopes.

The problem can also be solved by applying various biological and physical factors that positively affect the most important structures of animal tissues. The impact contributes to the restoration of their functional reserves. Many publications present methods and practices of promising stimulation of productivity and resistance of animals. Such methods can be successfully attributed to pulsed variable laser radiation of the infrared range of relatively low intensity [6, 7, 9, 11].

2 Materials and methods

The purpose of the research is to develop a methodology and technique for increasing the productivity and resistance of the body of young sheep to the effects of various external factors based on methods of biological physics.

The physical experiment was performed on the infrastructure of the Stavropol State Agrarian University. The time interval reflects the period from 2017 to 2020 based on the general research scheme (Fig. 1).

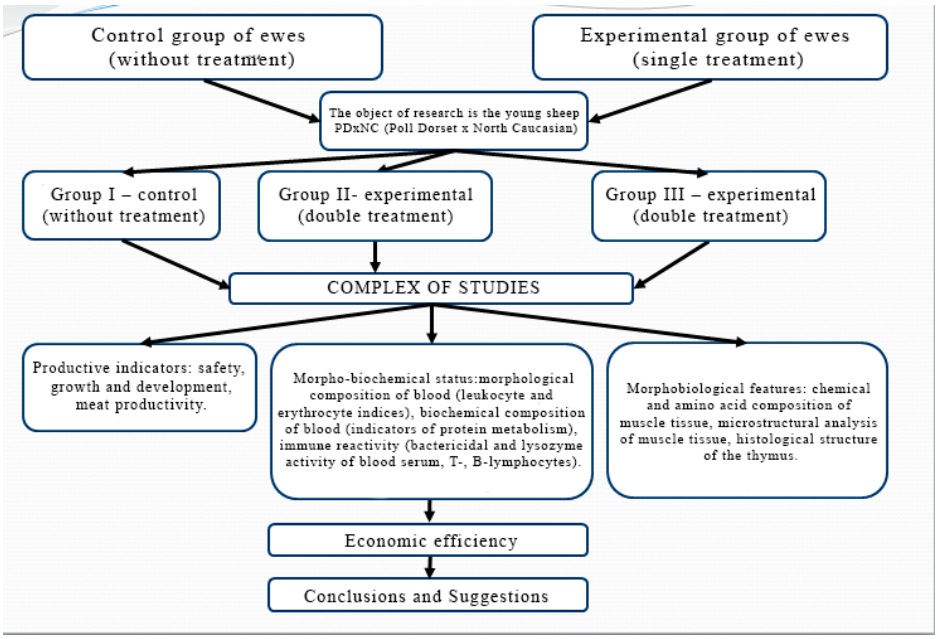

Fig. 1. Research scheme.

During the lambing period, three experimental groups of lambs were created. The necessary studies were carried out on these three groups. The first control group (experiment 1) (without the use of pulsed alternating laser radiation of the infrared range of relatively low intensity). The second control group (experiment 2) with the use of pulsed alternating laser radiation of the infrared range of relatively low intensity. The third control group (experiment 3) with the use of pulsed alternating laser radiation of the infrared range of relatively low intensity (PALRIRRLI). In this experiment, the effect was also carried out

on sheep, from which lambs were obtained for experiment 3. Lambs were exposed to radiation on nerve tissues, the nerve center responsible for the innervation of the thymus, located in the area of the first thoracic vertebra.

Laboratory and production studies were carried out in accordance with current methods. To obtain adequate results, the research was carried out with the involvement of scientists of the All-Russian Research Institute of Sheep and Goat Breeding in Stavropol. The place of the experiment: scientific-diagnostic and medical-veterinary center of the Stavropol State Agrarian University. In the process of work, special morphobiochemical blood parameters, zootechnical, histological, computational and statistical methods of research were used.

Processing of experimental lambs was carried out by means of a special laser device of factory manufacture. Its functionality is based on the periodic creation of pulsed low-intensity laser radiation in the near infrared region of the spectrum [2-5, 13-17] (Fig.2).

Fig. 2. Laser device.

3 Results and discussion

The emitter and the device itself are designed in such a way that the laser has a certain set of radiation frequencies, that is, there is a constant change in the frequency of the device from 20 to 2000 Hz, the device "sorts out" all frequencies, and the organism affected by the laser chooses the frequency that suits it specifically (Fig. 3).

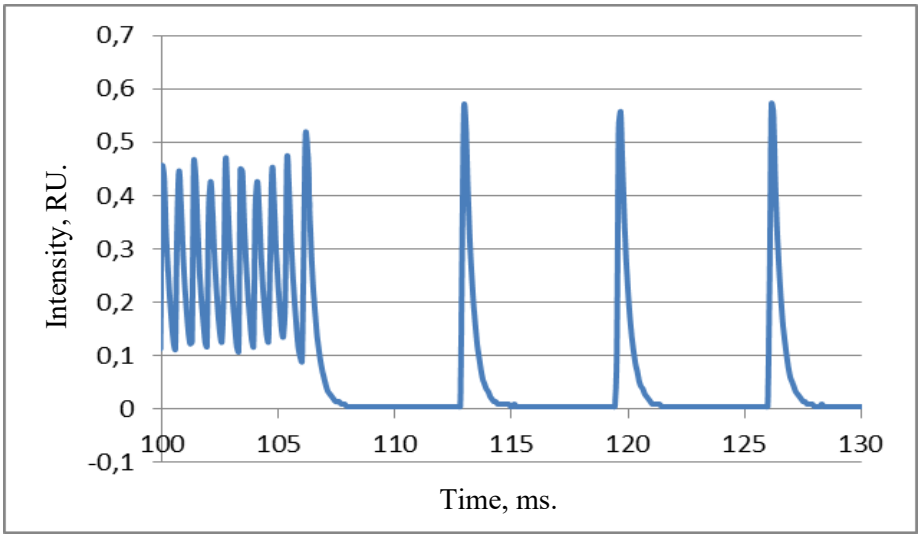

Fig. 3. The period of repetition of radiation pulses.

The time dependences of the relative intensity on time were measured using a spectral complex based on the MDR-41 monochromator. The registration wavelength is 985 nm. The FEU-62 was used as a receiver. The power supply voltage is 600 V. The recording of time intensity dependencies was carried out using a PCS500 digital oscilloscope.

At the end of the pulse packet, they overlap with the appearance of a constant component of the glow at about 25%.

The shape of pulses in packets also has a complex nature of time dependence. It can be characterized as a sawtooth pulse with a characteristic exponential attenuation, Figure 4, 5.

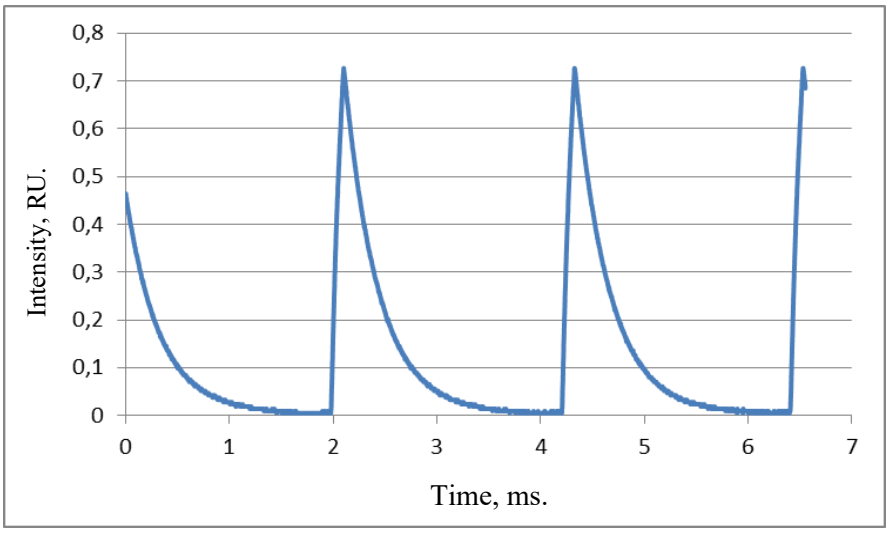

Fig. 4. The shape of the pulses with a repetition period of 2.2 ms.

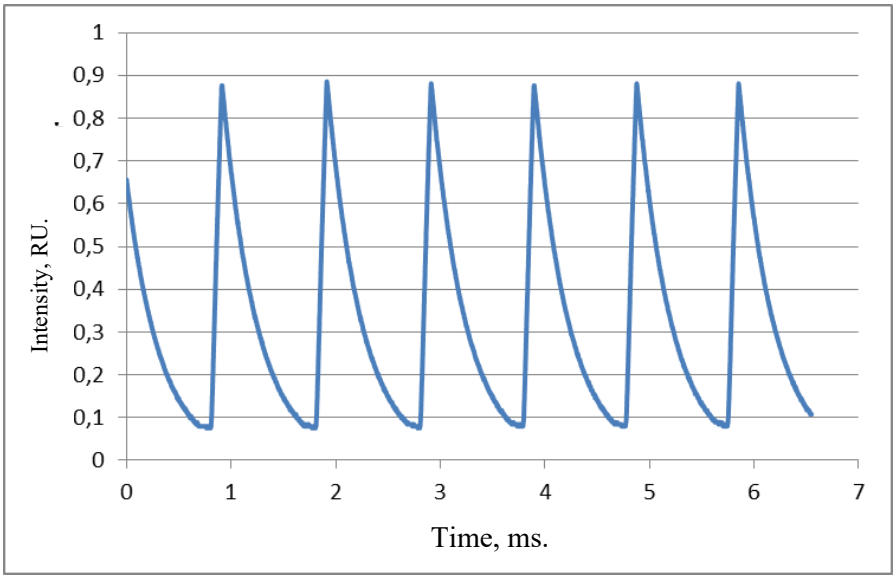

Fig. 5. The shape of pulses with a repetition period of 1 ms.

In the course of the experiment, to facilitate labor, we designed a device for fixing sheep and lambs. The device received the RF IPC A61D patent No. 2698214 [8]. (fig. 6).

Fig. 6. A device for fixing sheep and lambs with the possibility of using low-intensity laser radiation.

Comparison of technical and consumer properties of the device for fixing sheep and lambs in Figure 6 with analogues and prototypes gave the following results. The device is collapsible, which allows you to perform research in the field. Reliable fixation of animals excluding injuries. Improves the quality of veterinary measures when exposed to pulsed alternating laser radiation of the infrared range of relatively low intensity. When operating this device, labor costs are reduced.

Studies have shown that lambs obtained after the use of pulsed alternating laser radiation of the infrared range of relatively low intensity have a higher survival rate. The lambs in experiment 2 and in experiment 3 were the most resistant to external influences. The survival rate of young animals in these experiments at the age from birth to weaning (about 4 months) was 95.3 and 95.9%. It is higher than in the lambs of the control group by 5.1 and 5.7 percent. After weaning the lambs and in subsequent age periods, the difference in safety between the groups remained in favor of the lambs in experiment 2 and in experiment 3.

Of particular importance in the period of individual development are the indicators of absolute and average daily weight gain. The development of young offspring is recommended to be evaluated by individual productivity for the selection of the best animals for subsequent breeding. In the first months of the development of lambs, the total factors of individual successive physiological transformations for the experimental groups were characterized by a sufficiently high value.

Analyzing the absolute growth of young animals, it is rational to note the following facts. The time period from the birth of lambs to the age of 4 months turned out to be the most productive in terms of weight gain and development of all groups of the studied groups of animals. Actually, this fact is a species pattern for sheep. The results of the study showed that in lambs in experiment 1, the absolute weight gain was 20.48 kg. For experiment 2 – 20.88. For experiment 3 – 21.42 kg. At the age of more than 4 months, the intensity of growth and weight gain of lambs significantly decreased both in the group of control animals and experimental ones. The dynamics of absolute growth for adult animals has also been studied. Indicators in animals of different groups are manifested in all periods of individual development of the organism. A significant difference between control and experimental animals is shown. The superiority of lambs in experiment 2 and in experiment 3 in the suckling period in terms of absolute weight gain over peers in experiment 1 was 3.11-4.82%, for the entire growing period (from birth to 7 months) - 3.22-4.32% ($P<0.01$) (Table 1).

Table 1. Absolute increase in live weight of sheep from birth to 7 months, kg.

Development period	**Characteristics of the studied animals**		
	Experiment 1	**Experiment 2**	**Experiment 3**
Development period of lambs up to 1 month	7,08±0,25	7,28±0,26	7,38±0,27
Development period of lambs up to 2 months	12,26±0,27	12,56±0,28	12,76±0,23
Development period of lambs up to 3 months	17,56±0,33	18,11±0,29	18,28±0,26
Development period of lambs up to 4 months	20,48±0,23	20,88±0,25	21,42±0,24
Development period of lambs up to 5 months	22,46±0,22	23,28±0,27	23,54±0,25
Development period of lambs up to 7 months	27,88±0,28	28,78±0,28	29,12±0,26

Regarding the average daily weight gain, it is necessary to note the ambiguity of the results of the change in the compared experiments and in the growing periods. For example, from the moment of birth to the age of one month in lambs, fluctuations in average daily

weight gain amounted to 235.68-245.77 g. It is characteristic that the most intense weight gain of lambs of all the studied groups was observed during this period. However, the lambs in experiment 2 and in experiment 3 outperformed the peers of the control group in experiment 1 in terms of the value of the studied indicator by 2.78-4.18% (Table 2).

Raising lambs during the preweaning period (up to 3-4.5 months) is considered the most optimal for weight gain and development of lambs. According to the results of the study, sheep grew more intensively in experiment 2 and in experiment 3 of the studied groups. In these groups, the average daily weight gain of lambs was 175.79 and 179.18 g, respectively. Comparison of animals of different groups by weight gain found that during the suckling period, a more intense weight gain of lambs was observed in experiment 3. The preponderance of this group of lambs by the average daily weight gain over the animals of the control group was 8.38 grams or 4.48%.

Table 2. The gain of live weight per day of the studied young sheep, grams.

Age period of lambs	**Group of studied animals**		
	Experiment 1	**Experiment 2**	**Experiment 3**
Lambs up to 1 month old	236,66±2,480	243,27±3,27	245,98±2,58
Lambs from 1 to 2 months old	172,98±2,18	175,79±2,29	179,18±2,22
Lambs from 2 to 3 months old	175,89±2,61	179,12±2,48	182,78±2,14
Lambs from 3 to 4 months old	95,88±1,42	102,78±1,88	105,88±1,82
Lambs up to 4 months old	171,42±2,48	176,18±2,88	178,68±2,48
Lambs up to 7 months old	133,32±1,28	136,98±1,68	137,23±1,79

The analysis of experimental data on the age-related change in the weight of lambs, in absolute and average weight gain per day, confirms that the lambs of the experimental groups differed from the young of the control group by a higher live weight and weight gain. At the same time, the experimental groups of lambs significantly outperformed the control group of sheep.

The individual development of the organism in the early life of lambs (from birth to weaning) shows the greatest intensity of growth. After 4 months of life and with the release of lambs to pasture, the intensity of weight gain and growth decreased markedly. This factor is the result of the change of the milk-vegetable type of nutrition to the vegetable type of nutrition after weaning from sheep. An important element is the low productivity of the pastures used and the high ambient temperatures during the experiment. Even in these difficult conditions, the superiority of the experimental groups of lambs over the control group in terms of the studied indicator remained. The average daily weight gain of young animals in experiment 2 and in experiment 3 was higher compared to lambs in experiment 1 by 3.18-4.38%. The advantage in the growth of lambs was also retained by the animals in the experiment of the 3 experimental group.

Thus, the use of biophysical methods activated the metabolic processes occurring in the body of these animals, which had a stimulating effect on their growth and development.

Information about the nature of the microstructural structure of meat, in combination with other indicators, makes it possible to objectively assess the quality of the product.

Therefore, we found it necessary to supplement our research by studying the histostructure of muscle tissue in young animals aged 5 and 7 months using the example of the longest back muscle (m. longissimus dorsi). Histological studies of the longest back muscle indicate a general pattern of increasing the diameter of muscle fibers and decreasing their number with age (Fig.7).

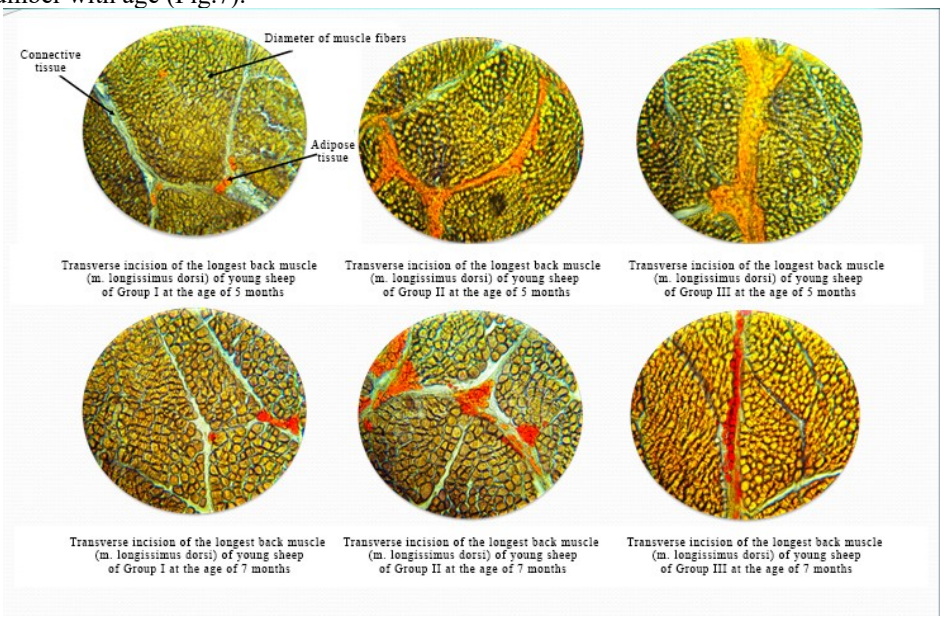

Fig. 7. Histostructure of muscle tissue in young sheep aged 5 and 7 months.

Table 3. The results of the study of the microstructural muscle tissue of young sheep of different groups in the temporal aspect.

Group of animals and the experiment number	Presence of muscle fibers, pcs.	Thickness of muscle fiber, microns	Category of "marbling", point	Percentage of connective tissue, %
Age of the animal - 5 months				
Experiment 1	435,34±4,24	27,19±0,59	25,09±2,88	8,29±0,19
Experiment 2	441,42±2,59	26,78±0,71	28,14±2,88	8,28±0,28
Experiment 3	462,48±3,58	26,42±0,64	31,22±2,34	7,24±0,31
Age of the animal - 7 months				
Experiment 1	427,34±7,34	31,92±0,68	27,12±2,34	8,82±0,21
Experiment 2	415,58±8,13	32,28±0,67	28,22±1,22	8,62±0,22
Experiment 3	446,24±6,68	31,33±0,68	30,64±1,32	7,32±0,19

Analysis of the data obtained when studying the histostructure of the longest back muscle in the studied animals at different age periods indicates that the muscle tissue of sheep in experiment 3, both at 5 and 7 months, was characterized by the largest number of muscle fibers per unit area by 4.9-7.9%, ($P<0.05$; $P<0.01$) smaller diameter of muscle fibers by 2.8-4.0%, ($P>0.05$; $P<0.05$) compared to young animals of groups I and II. At the same time, the animals of this group had a greater number of fatty fiber and fiber inclusions, which led to the highest assessment of "marbling" - by 8.3-20.5%, ($P>0.05$) a lower content

of connective tissue - by 1.1-1.54 abs. percent, ($P<0.01$) compared with the young of other studied groups.

The histological studies of the longest back muscle indicate a general pattern of increasing the diameter of muscle fibers and decreasing their number with age. Since animals with more moderate-sized muscle fibers produce more meat of good quality, the third group largely meets this conclusion, and the muscle tissue of these animals is characterized by greater tenderness, juiciness and has higher quality and consumer properties in aggregate. The revealed pattern indicates a favorable effect of low-power infrared laser radiation on the animal body.

4 Conclusions

The obtained results of studies of the effect of pulsed low-intensity laser radiation in the near infrared region of the spectrum on young sheep have shown that the method we propose allows us to increase the productivity of animals and can be used in technological processes when raising sheep, is low-cost and allows to increase productivity, reduce the risk of animal disease during growth, to obtain high-quality products. Thus, the obtained research results complement and expand the theoretical knowledge base in the field of increasing the competitiveness of the sheep industry by developing effective techniques and is of not only theoretical but also practical interest.

References

1. M. A. Afanasyev, Biophysical methods of increasing productivity and resistance of sheep: monograph, 120 (Volgograd: LLC "SPHERE", 2021).
2. A. G. Bedrin, A. P. Guryev, V. M. Gromovenko, G. A. Sokolova, Boosting the power supply of a pulsed xenon lamp to create a powerful irradiation system, Lighting Engineering, **2**, 62-66 (2022).
3. O. Yu. Kovalenko, T. A. Chuvatkina, N. P. Nesterkina, S. A. Mikaeva, Yu. A. Zhuravleva, Characteristics of the powerful UV lamp – EPRA, Lighting engineering, **3**, 15-18 (2021).
4. O. Yu. Kovalenko, Yu. A. Dashkina, Yu. A. Zhuravleva, S. A. Mikaeva, Analysis of the characteristics of halogen incandescent lamps, Lighting Engineering, **2**, 58-61 (2021).
5. V. A. Panin, M. A. Fedorishchev, Mobile installation and methodology for measuring the distribution of irradiance over the technological area, Lighting Engineering, **4**, 27-29 (2022).
6. V. I. Kozlov, Fundamentals of laser physiotherapy and reflexology, 216 (1993).
7. S. V. Moskvin, Fundamentals of laser therapy, 256 (Tver: Triad, 2006).
8. M. A. Afanasyev, A.-M. M. Aibazov, L. N. Skorykh, M. A. Mastepanenko, V. A. Kisyuk, D. V. Kovalenko, O. S. Kopylova, D. I. Fursov, A. S. Sergienko, A. S. Labyntsev, Pat. 2698214 Russian Federation, IPC A61D 3/00 (2006.01), A01K 1/06 (2006.01) Machine for fixing small cattle; patent holder Stavropol State Agrarian University. – No.2018139580; announced 08.11.2018; published 23.08.2019, 6 (2019).
9. V. L. Petukhov, The effect of low-intensity laser radiation on the mineral composition of blood serum and piglet bristles, Scientific notes of the educational institution "Vitebsk Order "Badge of Honor" State Academy of Veterinary Medicine, **49(21)**, 310-314 (2013).

10. M. I. Slozhenkina, A. O. Reshetnikova, I. V. Tserenov, M. A. Afanasyev, New in the production of high-quality lamb, Scientific foundations of the creation and implementation of modern health-saving technologies. Materials of the VIII International Scientific and Practical Conference dedicated to the Year of Science and Technology in the Russian Federation, 322-327 (Volgograd, 2021).
11. S. A. Talalaev, The effect of laser acupuncture on the growth, development and meat productivity of young sheep of the North Caucasian meat-wool breed: dissertation for the degree of candidate of agricultural sciences: 06.02.04, 113 (Stavropol, 2008).
12. M. Afanasyev, S. Shlykov, R. Omarov, A. A. Mosolov, Yu. V. Starodubova, M. P. Petrovich, A. O. Reshetnikova, Low-intensity laser radiation effect on protein metabolism in young sheep, IOP Conference Series: Earth and Environmental Science, Krasnoyarsk Science and Technology City Hall of the Russian Union of Scientific and Engineering, 32011 (Krasnoyarsk, 2021).
13. Z. M. H. El-Qahtani, S. Abdel-Khalek, K. Berrada, Quantum coherence and degree of mixedness for a system of two superconducting qubits under decohe\rence conditions, Journal of Russian Laser Research, **43(2)**, 139-147 (2022).
14. O. V. Man'ko, Coherent states of a free particle with varying mass in the probability representation of quantum mechanics, Journal of Russian Laser Research, **43(1)**, 90-95 (2022).
15. S. Li, X. Gao, H. Li, X. Zhang, Photonic generation of frequency-doubled triangular-shaped waveforms based on a pm-mzm modulator, Journal of Russian Laser Research, **41(5)**, 521-527 (2020).
16. T. L. Kulova, A. M. Skundin, S. A. Li, E. V. Ryzhikova, Possible causes of lithium–sulfur battery degradation, Russian Journal of Electrochemistry, **58(5)**, 391-397 (2022).
17. Y. G. Chirkov, V. N. Andreev, V. A. Bogdanovskaya, O. V. Korchagin, V. I. Rostokin Lithium–oxygen power source: the influence of positive electrode thickness on the overall discharge characteristics, Russian Journal of Electrochemistry, **56(7)**, 596-604 (2020).