ISSN: 0974-8369

Biology and Medicine

International, Open Access

Available online at: www.biolmedonline.com

Biology and Medicine

Avdeenko *et al.*, Biol Med (Aligarh) 2015, 7:3
http://www.biolmedonline.com

Research Article Open Access

Effect of Millimeter-Range Electromagnetic Radiation on Cows' Livestock Yield and Functional State of the Udder

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Abstract

The article discusses issues related to the study of physical, chemical, and biochemical composition of the milk of cows after the exposure of extremely high frequency (EHF) millimeter-range electromagnetic radiation. For the first time, we studied the effects of electromagnetic radiation on milk production and the improvement of the functional state of the udder during the cattle's lactation period. The milk yield of cows after 10 days of electromagnetic radiation of the udder's biologically active points (BAPs) was higher than the control at 245 kg. It was found that the milk ejection reflex due to the electromagnetic radiation manifested more intensely: the latent period of the reflex was less by 22.8%, the milking time decreased by 10.8%, the average intensity of milking was 22.7% more, inter-udder pressure decreased by 19.4%, and one-time milk yield increased by 15.3%.

Keywords

Milk yield; Electromagnetic radiation; The device "Orbita"; The functional status of the udder

Introduction

Every year the power level of electromagnetic radiation generated by all sorts of artificial sources of radiation increases and consequently living organisms surrounded by these electromagnetic fields are subjected to a specified influence [4,11,12,14].

It is clear that artificial electromagnetic fields are a new factor in the environment, and yet it is not clear what kind of effect they have on the metabolic processes occurring in biological systems [3,5,6,10,13,16]. The terahertz frequency range is increasingly attracting scientists' attention who study not only the electronics but also biomedical technology [8,9].

In recent times, among the producers of livestock products, using in their practice modern methods of diagnosis and treatment of diseases, biophysical techniques influence animals to increase their productivity, and they are more often used in the production of environmentally safe food [2,15].

In particular, the demand for equipment operating in the mode of the electromagnetic field of ultrahigh frequency electroacupuncture, magnetic-infrared-laser and low-intensity laser radiation increased.

The use of such technological innovation in dairy farming practice allows increasing the activity of mammary alveolar structures and consequently the relaxation time thus induced after cessation of an external physical factor that indicates the bioresonant nature of the process.

It is therefore necessary to develop such forms and methods of innovative technologies of production, which would unite all known biological, veterinary, technological, and economic development of efficient technologies in the production of milk, which would provide the greatest possible effect at a low cost of funds and labor [2].

In recent years, more attention is being paid to increase and maintain a high cow-milk production, reproductive health, prevention of diseases, and premature culling of highly productive cows [7]. Breeding animals on the basis of productivity contributed to the weakening of the adaptive capacity to changing habitat conditions, increased sensitivity to the permanent increasing of anthropogenic load.

The high genetic potential of animals is inextricably linked with the intensiveness of metabolic processes and neurohumoral regulation. However, increasing the productivity of cows is one of the factors reducing the resistance and reproductive function of animals [2].

In this regard, it requires constant monitoring and control over the reproductive state and resistance of the organism. The purpose of the study is to define the physical, chemical, and biochemical composition of the milk of animals after EHF millimeter-range electromagnetic radiation exposure.

Methods

This work was done in VPO "Saratov SAU" in 2010-2015. Experimental studies were carried out in the farms of the Saratov region (JSC "Agrofirm" "Volga" and educational and experimental farm RGAU-ICCA named after Timiryazev K.A. "Mummovskoe"). There were 1,450 cows under the supervision. The method of the study consisted of accounting cows' milk yield for 305 lactation days, the average daily milk production in kg, milking time (min), average intensity of milking, and milk ejection reflex.

Also, the method of the study consisted of clinical and gynecological studies of breeding stock and laboratory diagnosis of the milk. Status of the mammary gland was assessed by clinical examination and laboratory studies of cows' udder secretion (secretion response to a 2% mastidin solution, a 5% dimastin solution, Canadian and California mastitis test and trial advocacy).

Statistical processing of the data was carried out in the computer program Statistica 5.0.

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Received: Sep 4, 2015; **Accepted:** Sep 14, 2015; **Published:** Oct 19, 2015

Citation: Avdeenko AV, Molchanov AV, Avdeenko VS, Fedotov SV, Volkov AA (2015) Effect of Millimeter-Range Electromagnetic Radiation on Cows' Livestock Yield and Functional State of the Udder. Biol Med (Aligarh) 7(3): BM-124-15, 4 pages.

Results and Discussion

The experiments show that when the mammary gland was subjected to the EHF millimeter-range electromagnetic radiation (129-150 GHz) produced by the apparatus "Orbita," there is an increase in milk yield (4% fat) for 305 lactation days (Table 1).

The average daily milk yield of cows exposed to the electromagnetic radiation produced by the apparatus "Orbita" was 20.8 ± 0.2 kg in 8 min and 26.7 ± 0.2 kg in 12 min, against 18.7 ± 0.2 kg and 23.6 ± 0.4 kg in the control groups of cows. The increase in daily milk production is due to the Simmental strain. There was a direct proportional relationship between the increase in the dose of electromagnetic radiation (129-150 GHz) and the productivity of the cows. So, at 8 min radiation, the average milk yield increased by 15.7% ($p < 0.05$), and an increase in the dose to 12 min resulted in an increase by 19.8% ($p < 0.05$).

Consequently, the milk production of cows can be maintained and even improved on the basic diet with the inclusion of high-tech devices such as "Orbita."

In the experimental cows, there was a significant decline in the value of galvanic skin response (GSR) at 12.8% after the irradiation. Reaction of the GSR decline on milking carried out after the exposure was more pronounced. If we conditionally accept the 100% level of GSR before milking, then its decline in the 3rd min of milking in the background period was 32.1%, and 24.4% in the experimental period.

It was found that as a result of exposure to electromagnetic radiation at frequencies 129 or 150 GHz, the average daily milk production of cows increased by 6.1% compared with the control group. Taking into account the reduction in milk yield in the control group to 5.7%, the increase in average productivity of cows in the experimental group was 11.8%. Simultaneously, there was a fat increase from 4.03 to 4.07% and protein by 3.2%, whereas in the control group, these changes were 0.1 and 1.6%. Fifty percent of cows after the exposure to electromagnetic irradiation for 7-20 days had increased milk production, which shows a higher stimulating effect.

Therefore, the effect of electromagnetic irradiation (apparatus "Orbita") on the biologically active points (BAPs) of mammary gland during the lactation period increases milk production by 6-9% and in mid-lactation by 5.4-7.2%, and at the end of lactation prevents cows self-starting (Table 2).

Studies have shown that as a result of electromagnetic stimulation, latency period reduced in relation to the control by 12.5%; milking for 1 min in cows in the experimental farm RGAU-ICCA "Mummovskoe" increased by 18.1%, and in cows in SPC "Krasavskiy" by 11.6% (Table 3).

The average intensity of milk excretion increased by 17.7 and 11.8%, respectively. The maximum intensity of milk excretion increased by 15.8 and 10.1%; milking time in the first group declined by 6.7%, and in the second—by 5.4%. The fullness of milking, as a result of additional stimulation, increased in both experimental groups and the increase in milk production in cows was in 1-4 days. On average, over the period of additional stimulation, milk yield in cows that had electromagnetic stimulation increased by 9.5%.

We investigated the possibility of using EHF millimeter-range electromagnetic radiation to stimulate the functional activity of the mammary gland of cows of different genotypes (Table 4).

For this purpose, according to the principle of analogues, we formed three groups of six animals with 2-3 lactations in each and studied the process of lactation after a 7-day BAP udder exposure with the apparatus "Orbita" on the background of premilking stimulation adopted by each farm. After the 7-day exposure, there was an increase in milk yield of cows in all groups. At the same time, for the purebred cows from the experimental farm RGAU-ICCA "Mummovskoe," it was 12.9%, and in cows from HCC "Krasavskiy"—6.9%. Milking ratio increased from 640 to 664 in cows from the experimental farm RGAU-ICCA "Mummovskoe" and in cows from HCC "Krasavskiy" from 592 to 646.

Analysis of the data showed that the milk production of cows after a 10-day electromagnetic radiation exposure of BAP udder is above the control at 245 kg ($p < 0.01$). Overall, in the first month of lactation, the average yield of the experimental cows was 18.8 kg and of the cows

Cow groups	Indicators	
	Yield of milk for 305 lactation days, kg	Average daily yield of milk, kg
1. Control (HCC "Krasavskiy")	3,986 ± 12.56	18.7 ± 0.2
2. Experiment (HCC "Krasavskiy")	4,270 ± 13.45*	20.8 ± 0.2*
3. Control experimental farm RGAU-ICCA "Mummovskoe"	5,128 ± 11.76	23.6 ± 0.4
4. Experiment experimental farm RGAU-ICCA "Mummovskoe"	5,654 ± 0.65*	26.7 ± 0.2*

*$p < 0.05$; **$p < 0.01$.

Table 1: The milk production of the cows exposed to electromagnetic radiation

Indicators	UHF "Leda" ($n = 20$)	LIL "STP-3" ($n = 20$)	"Orbita" ($n = 20$)	"Rikta-MB" ($n = 20$)
Yield of milk during lactation, kg	3,719 ± 41.8	3,746 ± 53.8	4,295 ± 69.3	4,173 ± 62.4
Fat content, %	3.91 ± 0.04	3.92 ± 0.07	3.89 ± 0.04	3.88 ± 0.06
Protein content, %	3.33 ± 0.08	3.52 ± 0.06	3.47 ± 0.05	3.54 ± 0.09
Butterfat amount, kg	98.5 ± 1.6	110.3 ± 3.3	128.2 ± 2.7	123.1 ± 3.6
The amount of milk protein, kg	83.8 ± 3.2	96.4 ± 3.3	114.3 ± 2.9	112.3 ± 5.6

Table 2: Cows' milk yield after the electromagnetic irradiation on the mammary gland after giving birth

Udder parts	HCC "Krasavskiy"		Experimental farm RGAU-ICCA "Mummovskoe"	
	Before	After	Before	After
Front	230.4 ± 13.1	269.6 ± 11.3*	283.0 ± 10.0	321.8 ± 12.0*
Back	269.8 ± 10.6	299.9 ± 11.2*	299.2 ± 11.0	338.6 ± 12.1*
Difference	39.4	10.3	16.2	8.8

*$p < 0.05$.

Table 3: Average intensity of milking after electromagnetic irradiation of the BAP, g/min

Indicators	Experimental farm RGAU-ICCA "Mummovskoe"		HCC "Krasavskiy"	
	Before	After	Before	After
Milking time, min	4.44 ± 0.05	4.28 ± 0.01*	4.41 ± 0.02	4.30 ± 0.09*
Average intensity of milking, kg/min	1.09 ± 0.03	1.23 ± 0.04*	1.10 ± 0.09	1.18 ± 0.01

*$p < 0.05$.

Table 4: Indicators of milk excretion in cows of different genotypes after electromagnetic irradiation

from the control group—17.8 kg, and in the 2nd month—20.1 and 18.2 kg, respectively. Thus latency period in cows of the control group remained practically unchanged (55-61 s), while in the cows from the control group, it decreased by 33.3%.

Inter-udder pressure before the premilking preparation of the udder on the 4-7 days use of the electromagnetic radiation ($p < 0.05$) is lower in cows from the experimental groups. The reaction to the premilking preparation was higher (130.0%) in the experimental group, while in the cows in the control group, it was only 89.0%.

Studies of the effect of electromagnetic radiation of the mammary gland on the ejection reflex was conducted on 30 cows with 2-3 lactations on the lactation plateau (3-4 months after calving) and on 20 cows on the its decline (7-8 months after calving). BAP udder irradiation was performed one time per day for 10-15 min before the start of the evening milking with an exposure of 5-15 min on the basis of teats within 7 days.

Analysis of the data presented in Table 5 showed that the milk ejection reflex under the electromagnetic irradiation appears more intensely: latency reflex period decreased by 22.8%, milking time decreased by 10.8%, the average intensity of milking increased by 22.7%, inter-udder pressure decreased by 19.4%, one-time milk yield increased by 15.3%.

In 10 pairs of cows—analogues (7-8 months after calving), we studied the effect of electromagnetic irradiation on the udder BAP of lactating cows, which were in the second half of lactation. In the control animals in calendar terms, which are relevant to the period of exposure of experimental animals, there was a decline in milk production; a one-time milk yield was 82.1% of the initial level. In animals of the experimental group that were exposed at the start of milking, there was also a decrease in milk production. But less: milk yield was 92.3% from the initial level. Duration of milking in the control group remained practically unchanged (5.0 ± 0.22 and 5.1 ± 0.21 min) during the experiment. In the experimental group, it decreased by 16.4% ($p < 0.05$). The intensity of milking in the control group decreased by 19.6% ($p < 0.05$).

Analysis of lactation curves showed that after a period of exposure of 7 days, when there was an increase in milk yield, subsequent changes were diverse: after the cessation of electromagnetic exposure, the milk yield of 50.0% of the cows did not change and was at the same level; for 33.3% of the cows, the level of milk production increased after 7-20 days, which indicates a higher stimulating effect; 16.7% of the cows did not respond to electromagnetic irradiation.

Analyses carried out after 7 days after the last use of the apparatus "Orbita" revealed a positive impact on the individual parts of the udder. In the milk the content of muramidase significantly increased from 0.43 ± 0.02 to 0.56 ± 0.03 units and immunoglobines class G from 2.49 ± 0.13 to 3.58 ± 0.12 mg/ml and decreased the amount of LF more than by two times (Table 6).

Indicator	Experiment			
	Experimental farm RGAU-ICCA "Mummovskoe"		HCC "Krasavskiy"	
	Background	7 days	Background	7 days
Inter-udder pressure	4.75 ± 0.20	5.67 ± 0.13*	4.70 ± 0.17	5.35 ± 0.12*
Latent period, s	33.2 ± 2.3	25.7 ± 2.0*	32.7 ± 1.9	27.3 ± 1.3*

*$p < 0.05$.

Table 5: Influence of BAP udder electromagnetic irradiation on the milk ejection reflex

Indicators	Before irradiation ($n = 35$)	After irradiation ($n = 27$)		
		7 days	14 days	21 days
SC, thousands/ml	$4,003.7 \pm 534.7$	$1,513.4 \pm 157.6$	954.7 ± 85.6	270.9 ± 20.5
IgG, mg/ml	3.55 ± 0.13	2.36 ± 0.17	2.00 ± 0.24	1.90 ± 0.12
IgM, mg/ml	0.22 ± 0.02	0.32 ± 0.03	0.36 ± 0.04	0.20 ± 0.03
MoH, units	0.39 ± 0.04	0.57 ± 0.05	0.67 ± 0.04	0.65 ± 0.05
LPO, units	992.7 ± 47.5	802.4 ± 72.3	635.0 ± 64.5	532.4 ± 49.1
LF, mcg/ml	359.5 ± 64.8	274.4 ± 22.2	110.2 ± 29.5	101.5 ± 14.5

Table 6: Change of informative parameters of milk in cows after electromagnetic irradiation

More pronounced changes in the milk indices of lactating cows came in 21 days after the exposure of the low-intensity laser radiation on the udder of lactating cows, which is reflected to a greater extent on the performance of content of somatic cells (SC), the activity of lactoperoxidase (LPO), the concentration of lactoferrin (LF), and increased activity of muramidase (MoH).

After applying electromagnetic radiation to lactating cows in early lactation and late lactation, there was a significant decrease in the somatic cells of the udder secretion by 37% and the concentration of lactoferrin by 2.5 times; muramidase—from 0.42 ± 0.2 to 0.63 ± 0.05 units; and lactoperoxidase—by 1.59 times. More pronounced changes in informative parameters of the mammary gland secretion after the complete course of the irradiation by the apparatus "Orbita" on the udder of lactating cows occured at the beginning and at the end of lactation. So, all the animals had a decrease of SC by 6.36 times compared with the indicators on the 7th day of the exposure; immunoglobulins: G at 8.4%, M at 37.04%; lactoperoxidase at 21.72%; and lactoferrin at 31.05%, with an increase in the enzyme muramidase at 16.67% with a statistically significant difference of $p < 0.05$.

Conclusion

During the study it was found there was an increase in milk production in cows and the improvement of the functional state of the udder during lactation after the application of electromagnetic radiation of extremely high frequency millimeter wave. To increase the milk production and functional activity of the udder, it is recommended to use the apparatus "Orbita" that stimulates milk production in cows by 18.45-22.0% and the functional activity of the udder by 16.45-26.34% in comparison with analogues. In consideration of these results, we plan further research in this direction, in particular clarification of the biological and therapeutic significance of electromagnetic waves in the millimeter wave length range during the life of animals.

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