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Lipid profile of blood serum of chickens under conditions of long-term exposure to extremely low frequency variable pulsed electromagnetic field

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Article info

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It has been proven that electromagnetic fields (EMF) of various intensities have various effects on living organisms – from a therapeutic effect to the appearance of various functional disorders. The purpose of this study was to investigate the pattern of long-term continuous exposure of poultry with extremely low frequency variable pulsed electromagnetic field (ELF-PEMF) of weak intensity on indicators of lipid metabolism in chickens. 150–day-old Tetra X breed chickens were irradiated with ELF-PEMF at a frequency of 8 Hz for about 30 minutes for 174 days. The irradiation regime of experimental groups 1 and 2 was continuous, and in groups 3 and 4 it was alternated with weekly breaks. In 1 experimental group, poultry was fed according to the basic diet with a protein content increased by 10–15 %, and in 2 – with a protein content reduced by 10–15 %. In the control group of non-irradiated poultry, the protein content in the diet corresponded to generally accepted norms. The results of the experiment proved that the irradiation regimes of ELF-PEMF selected by us have an effect on lipid metabolism in the body of Tetra X breed chickens. On the 112th day of the experiment, regardless of the used regimes of irradiation of chickens with ELF-PEMF and the protein level in the diet, in the blood serum of the experimental groups, compared to the control, an increase in the level of free triacylglycerols by 1.56–2.76 times was found; cholesterol level – by 1.04–1.39 times; of high-density lipoproteins (HDL) – by 1.24–1.84 times and the reduction of atherogenic index – by 1.41–1.73 times, which is predicted to have a positive effect on their health and productive qualities. Meanwhile, during longer exposure of chickens to ELF-PEMF, the level of triacylglycerols in the blood serum of experimental groups of chickens did not differ significantly from the indicators of non-irradiated poultry (control group). In general, by selecting different modes of irradiation with ELF-PEMF with different supply of protein in the rations, it is possible to influence the indicators of lipid metabolism of Tetra X breed chickens.

Keywords: extremely low frequency variable pulsed electromagnetic field, blood serum, lipid profile, Tetra X breed chickens.

Ліпідний профіль сироватки крові курей в умовах тривалого впливу змінного імпульсного електромагнітного поля наднизької частоти

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Доведено, що електромагнітні поля (ЕМП) різної інтенсивності мають різноманітний вплив на живі організми – від лікувального ефекту до появи різноманітних функціональних порушень. Різновекторний вплив ЕМП на організм залежить зокрема від тривалості їхнього впливу, частоти, інтенсивності та інших факторів. Метою цієї роботи було дослідити тривалий безперервний вплив надзвичайно низькочастотного змінного імпульсного електромагнітного поля слабкої інтенсивності на показники ліпідного обміну у курей. Курей кросу Тетра Х 150-добового віку опромінювали ЗІЕМП ННЧ на частоті 8 Гц щодоби по 30 хвилин упродовж 174-х днів. Режим опромінення 1 і 2 дослідної груп був безперервним, а у 3 і 4 – чергувався з тижневими перервами. В 1 дослідній групі птахів годували згідно з основним раціоном з підвищеним на 10−15 % вмістом протеїну, а у 2 – з пониженим на 10−15 % вмістом протеїну. В контрольній групі неопромінених птахів в раціоні вміст протеїну відповідав загальноприйнятим нормам. Результати проведеного експерименту свідчать, що обрані режими опромінення ЗІЕМП ННЧ мають вплив на ліпідний обмін в організмі курей кросу Тетра Х. На 112-ту добу досліду незалежно від використаних режимів опромінення курей ЗІЕМП ННЧ і рівня протеїну в раціоні в сироватці крові дослідних груп порівняно з контролем виявлено зростання рівня вільних триацилгліцеролів в 1,56–2,76 рази; рівня холестеролу – 1,04–1,39 рази; ліпопротеїдів високої густини (ЛПВГ) – 1,24–1,84 рази і зменшення індексу атерогенності – в 1,41–1,73 рази, що прогнозовано впливає позитивно на їх здоров'я і продуктивні якості. До того ж у разі більш тривалого опромінення курей ЗІЕМП ННЧ рівень триацилгліцеролів у сироватці крові дослідних груп курей істотно не відрізнявся від показників неопромінених птахів (контрольної групи). Також на 174-ту добу опромінення ЗІЕМП ННЧ рівень холестеролу в сироватці крові дослідних курей залишався високим і перевищував контроль залежно від групи в 1,04–1,27 рази. Проте підвищення цього показника відбулось переважно через ліпопротеїди низької густини (ЛПНГ) і ліпопротеїди дуже низької густини (ЛПДНГ), і відповідно до росту індексу атерогенності, отже, до порушення ліпідного обміну в організмі дослідних курей. Загалом шляхом підбору різних режимів опромінення ЗІЕМП ННЧ за умови різної забезпеченості раціонів протеїном можна впливати на показники ліпідного обміну курей кросу Тетра Х.

Ключові слова: змінне імпульсне електромагнітне поле наднизької частоти, сироватка крові, ліпідний профіль, кури кросу Тетра Х.

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Introduction

It is known that electromagnetic fields (EMF) are a carrier of information in the biosphere [1, 2]. It has been proven that EMF of extremely low frequency (ELF) range is used as a time sensor of biological rhythms, as a carrier of prognostic information about the approach of earthquakes and weather changes [3, 4].

Along with this, there is a fairly large number of works that testify to the therapeutic and protective effect of the magnetic field (MF) [5, 6]. Conversely, external EMFs can modulate an individual's electromagnetic signals, leading to disturbances in electromagnetic homeostasis [7, 8]. It is believed that the basis of the occurrence of various types of pathologies is a violation of the resonance of electromagnetic frequencies of the body's cells [7, 9, 10]. In this regard, the idea of using an artificial MP, which corresponds to the Earth's geomagnetic field in terms of its physical characteristics, to combat the negative consequences of anthropogenic electromagnetic pollution is of particular interest [11]. The further development of this direction of scientific research is connected with the application and selection of EMF of different exposure and intensity and the study of their influence on the physiological processes of the body [12]. Therefore, works on the study of the biological effect of EMF are increasingly relevant.

The purpose of the study

The purpose of this study was to investigate the pattern of long-term continuous exposure of poultry with extremely low frequency variable pulsed electromagnetic field (ELF-PEMF) of weak intensity on indicators of lipid metabolism in chickens.

Materials and methods

In order to determine the main regularities of long-term continuous exposure of poultry with extremely low frequency variable pulsed electromagnetic field (ELF-PEMF) of weak intensity on indicators of lipid metabolism of chickens, an experimental scheme was developed (Table 1).

Table 1
Experimental scheme

Group	Number of livestock	Irradiation mode	Scheme of feeding chickens
1 − experimental	15	Irradiation of chickens with ELF-PEMF for 30 minutes, approximately for 174 days	Feeding according to the basic ration (BR) with increased protein content of 10–15 %, compared to control
2 − experimental	15	Irradiation of chickens with ELF-PEMF for 30 minutes, approximately for 174 days	Feeding according to the BR with reduced protein content of 10–15 %, compared to control
3 − experimental	15	Irradiation of chickens with ELF-PEMF for 30 minutes, approximately with weekly breaks for 174 days	Feeding according to the basic ration (BR) with increased protein content of 10–15 %, compared to control
4 − experimental	15	Irradiation of chickens with ELF-PEMF for 30 minutes, approximately with weekly breaks for 174 days	Feeding according to the BR with reduced protein content of 10–15 %, compared to control

For the experiment were taken 150-day-old chickens of the Tetra X breed, which were kept in cage batteries. Poultry was irradiated with ELF-PEMF at a frequency of 8 Hz.

In the blood serum of chickens of experimental and control groups, the main indicators of lipid metabolism were determined by the spectrophotometric method using a BioSystem A-15 biochemical analyzer (Bio-Systems SA, Spain) using standard reagents of this company.

Statistical processing of the obtained results was carried out by analysis of variance. Data are presented as x±SD (mean ± standard deviation). The reliability of the obtained data was assessed by the F-criterion with a confidence level of $P<0.05$, $P<0.01$, $P<0.001$ (taking into account the Bonferroni correction).

Results and discussion

It was found that the indicators of lipid metabolism in the blood serum of chickens that were not exposed to irradiation with ELF-PEMF did not change significantly during the experiment (6 months) and generally corresponded to physiological norms.

Meanwhile, irradiation of Tetra X breed chickens with an electromagnetic field for 112 days contributed to a significant increase in the content of triacylglycerols in the blood serum of the 1st, 2nd, 3rd and 4th experimental groups, respectively, by 140.00 % ($P<0.01$), 56.00 ($P<0.01$), 176.00 ($P<0.001$) and 116.00% ($P<0.01$) compared to a similar indicator in the control (Table 2).

In this regard, we can say that the increase in the content of triacylglycerols in the blood serum of chickens after 112 days of irradiation with ELF-PEMF, regardless of the level of protein feeding, has a positive effect on the energy supply of the chickens' body, and, accordingly, on the level of their productive qualities.

Analyzing the cholesterol content in the blood of experimental chickens after 112 days of irradiation with ELF-PEMF, it is necessary to note its significant increase in the 1st and 3rd experimental groups by 30.52 % ($P<0.001$) and in the 4th group by 39.38 % ($P<0.001$), respectively, in comparison with chickens that were not exposed to electromagnetic radiation. Also, compared to the control, the tendency to increase this indicator was observed in the 2nd experimental group, but the difference was statistically improbable.

Table 2
Dynamics of lipid metabolism in blood serum of experimental chickens after 112 days of irradiation, x±SD

Indicator	Group of animals				
	Control	1 – experimental	2 – experimental	3 – experimental	4 – experimental
Triacylglycerols, mmol/l	0.25 ± 0.16	0.60±0.52***	0.39±0.24**	0.69±0.06***	0.54±0.8**
Cholesterol, mmol/l	2.26±0.16	2.94±0.25***	2.4±0.11	2.94±0.05***	3.15±0.31***
HDL, mmol/l	0.95±0.01	1.53±0.06***	1.18±0.08*	1.62±0.09***	1.75±0.09***
LDL, mmol/l	0.51±0.14	0.54±0.05	0.47±0.07	0.60±0.04*	0.57±0.05
VLDL, mmol/l	0.80±0.12	0.8±0.12	0.69±0.12	0.72±0.12	0.83±0.12
Atherogenic index	1.38	0.93**	0.98**	0.81***	0.80***

Note: * – P<0.05, ** – P<0.01, *** – P<0.001 compared to control.

The conducted analysis shows that the content of total cholesterol in the blood plasma of Tetra X breed chickens did not depend on age, but was dependent on long-term exposure to ELF-PEMF at different levels of protein feeding. It is known that the level of total cholesterol reflects the state of general lipid homeostasis [13, 14]. In this regard, its increase in the blood serum of experimental chickens indicates the effect of ELF-PEMF on lipid metabolism.

Free and bound cholesterol in the form of transport forms is contained in chylomicrons, very low-density lipoproteins (VLDL, pre-ß-lipoproteins), low-density lipoproteins (LDL, ß-lipoproteins), high-density lipoproteins (HDL, α-lipoproteins), and is mainly associated with ß-LDL, which are considered to be the transport form of cholesterol [15, 16, 17].

In this aspect, to find out the effect of irradiation with ELF-PEMF on lipid metabolism, it was interesting to analyze the distribution of cholesterol fractions in the blood serum of chickens.

The results showed that after 112 days of irradiation under different ELF-PEMF regimes with increased or decreased protein content by 10–15 % in all experimental groups of chickens compared to non-irradiated poultry that received only the basic diet, there was a statistically significant increase in HDL within the range of 24.21–84.21 %, but the level of LDL and VLDL did not undergo significant fluctuations and did not go beyond the limits of statistical error. Thus, the increase in the level of cholesterol in the blood serum of experimental chickens was mainly due to HDL. This fraction of lipoproteins is one of the main lipoprotein fractions, their main function is the delivery of cholesterol molecules from cells to the liver and other tissues. HDL is synthesized in the liver and intestinal wall, actively removes cholesterol from the cells by esterification, which facilitates its entry into the liver and its removal as bile into the intestines [18]. In addition, HDL is a transport form of phospholipids in the blood, which prevent the deposition of cholesterol on the walls of blood vessels [15, 19].

In addition to the transfer of excess cholesterol from peripheral cells to the liver, high-density lipoproteins have other properties, in particular: anti-apoptotic, antioxidant, anti-thrombotic, anti-inflammatory [20, 21].

Considering the abovementioned, we can talk about the positive effect of ELF-PEMF exposure for 112 days. Moreover, the maximum effect was achieved under the regime of irradiation of chickens for about 30 minutes, after a week for 6 months with increased or decreased by 10–15 % protein level in the diet.

Also, after 112 days of the experiment, regardless of the selected modes of ELF-PEMF irradiation and the level of protein feeding, the value of atherogenicity index was lower in all experimental groups in the range of 28.99–42.03 % compared to the control group. At the same time, the degree of probability, depending on the experimental group, ranged from P≤0.01 to P≤0.001, which indicates a significant effect of ELF-PEMF on the lipid metabolism of Tetra-X breed chickens.

After 174 days of irradiation, the content of triacylglycerols in the blood serum of experimental chickens of the 1st group was probably lower by 29.03 % at P≤0.01 compared to chickens of the control group (Table 3). At the same time, this indicator was higher by 9.68 % in chickens of the 2nd experimental group, however, compared to non-irradiated chickens, it did not acquire a statistically significant difference.

Table 3
Dynamics of lipid metabolism in blood serum of experimental chickens after 174 days of irradiation, x±SD

Indicator	Group of animals				
	Control	1 – experimental	2 – experimental	3 – experimental	4 – experimental
Triacylglycerols, mmol/l	0.31±0.13	0.22±0.03**	0.34±0.02	0.28±0.03	0.32±0.03
Cholesterol, mmol/l	2.26±0.06	2.35 ±0.07	2.59±0.19*	286±0.02**	2.73±0.03**
High-density lipoproteins, mmol/l	0.90±0.04	0.85±0.04**	0.72±0.02***	1.01±0.07	0.94±0.05
Low-density lipoproteins, mmol/l	0.54±0.05	0.67±0.02*	0.81±0.06***	0.76±0.04***	0.80±0.03***
Very low-density lipoproteins, mmol/l	0.82±0.02	0.83±0.02	1.06±0.03**	1.09±0.02**	0.99±0.01**
Atherogenic index	1.51	1.76*	2.60***	1.83**	1.90**

Note: * – p < 0.05, ** – p < 0.01, *** – p < 0.001 compared to control.

According to reports [22, 23], the level of triglycerides is one of the parameters important for lipid homeostasis, which shows the concentration of one of the main energy-saving substrates in the body. They are a form of deposition and transport of substances (free fatty acids), the breakdown of which releases a large amount of energy, and a structural component of cell membranes [19, 24].

In this regard, it can be said that the decrease in their level in the blood serum of chickens after 174 days of irradiation with ELF-PEMF with an increased level of protein feeding has a negative effect on the energy supply of the chickens' body, and, accordingly, on the level of their productive qualities.

The level of total cholesterol in the blood serum of the 1st experimental group of chickens did not acquire a statistically significant value, but it was significantly higher in the 2nd group by 14.60 % ($P \le 0.05$) in comparison with the similar indicator of the control group.

The content of high-density lipoproteins (HDL) in blood serum was lower in the 1st experimental group by 5.56 % and had no statistically significant difference compared to the control group of poultry. Meanwhile, this indicator in the 2nd experimental group, compared to the control, decreased to probable values by 20.00 % at $P \le 0.05$.

Also, the obtained results indicate a statistically significant increase in the blood serum of chickens of the 1st and 2nd experimental groups in the content of low-density lipoproteins (LDL) and very low-density lipoproteins (VLDL), respectively, by 24.07 % ($P \le 0.05$) and 1.22 %; 50.00 and ($P \le 0.001$) and 29.27 % ($P \le 0.01$) compared to the control group of non-irradiated chickens.

The obtained data prove that the level of LDL and VLDL in the blood serum of experimental chickens significantly increases during long-term exposure with ELF-PEMF. It was this fact that led to a significant increase in the value of the atherogenicity index in the 1st experimental group by 16.56 % ($P \le 0.05$), and in the 2nd by 72.19 ($P \le 0.001$) compared to the control group of chickens that was not exposed to irradiation.

Therefore, longer exposure with ELF-PEMF leads to an increased level of cholesterol, LDL and VLDL in the blood serum of chickens of the experimental groups, regardless of the level of protein feeding. At the same time, the difference between the control and experimental groups was statistically significant in the absolute majority of cases.

LDL are formed in the liver and blood from VLDL and are the main transport form of cholesterol, the content of which in the structure of these particles is the highest (reaches 58 %), therefore they and their predecessor – VLDL – received the name of atherogenic lipoproteins and their increased content indicates a violation of lipid metabolism in organism [24, 25, 26].

Therefore, it can be stated that long-term exposure of chickens with ELF-PEMF causes disruption of their lipid metabolism and redistribution of lipoprotein fractions of the chickens' blood in the direction of an increase in LDL, VLDL and atherogenicity index.

Conclusions

Under the conditions of long-term exposure with ELF-PEMF, with different rations provided with protein, significant changes in lipid metabolism were revealed, which was manifested by a change in the level of its main indicators in the blood serum of Tetra X breed chickens. According to the results of 112 days exposure with ELF-PEMF for 30 minutes, regardless of the exposure regimes used and the level of protein in the diet, a significant increase in the level of free triacylglycerols in the blood serum was found, which was predicted to activate energy metabolism and, accordingly, improve the productivity of chickens. A longer 6-month daily exposure with ELF-PEMF for 30 minutes, with or without weekly breaks, did not significantly affect the level of triacylglycerols in the blood serum of experimental chickens, and with a 10–15 % increase in the amount of protein in the diet even led to decrease of this indicator. Long-term exposure with ELF-PEMF for 30 minutes for 112 days, with or without weekly breaks, regardless of the deficiency or excess of proteins in the diet, caused an increase in the blood serum of chickens, mainly due to HDL, and, accordingly, a decrease in the atherogenic index, which in particular, indicates the activation of the process of delivering cholesterol molecules from cells to the liver and other tissues, the active removal of cholesterol from cells by esterification, and the prevention of cholesterol deposition on vessel walls. Increasing the duration of ELF-PEMF irradiation up to 174 days under the regimes mentioned above, on the contrary, led to an increase in the blood serum cholesterol level mainly due to the so-called "harmful" lipoprotein fractions of LDL and VLDL and, accordingly, to an increase in the atherogenicity index, hence to a negative influence on lipid metabolism of experimental chickens.

Conflict of interest

The authors declare no conflict of interest.

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