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ABSTRACT

Of the dissertation for the degree of Doctor of Science

DEVELOPING TECHNOLOGIES AND TECHNICAL BASES OF ENERGY AND RESOURCE CONSERVATION PRODUCTION IN POULTRY BASED ON THE APPLIED ECOLOGY

Specialty: **3102.01 – Agricultural engineering**

Field of science: **Technical sciences**

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GENERAL DESCRIPTION OF THE RESEARCH

Relevance and degree of completion of the topic. One of the most critical problems facing humanity is producing the required amount of quality food products. Our republic is one of the countries in the world with natural and climatic conditions and sufficient natural resources for the production of high-quality agricultural products. The potential of our country is sufficient to ensure food security as well as to export agricultural products to other countries. This area is one of the most important non-oil sectors and has always been supported by the state.

At the last meeting of the Cabinet of Ministers, President Ilham Aliyev emphasized the importance of agricultural development under the current conditions. The president noted the necessity of the development of agricultural sectors. From this point of view, the development of poultry, which is one of the main areas of agriculture in the country, is especially important. Poultry farming is one of the oldest agricultural fields in Azerbaijan and it is known that poultry meat is widely used in Azerbaijani cuisine.

A distinctive feature of the modern stage of poultry development is the dynamic provision of the population with dietary foods and increasing efficiency of this area with the use of resource-saving technologies. Therefore, egg production in the world has enhanced by 30 % and poultry production by 44 % in recent decades.

The share of poultry in total meat reserves in our country is 31 %. In cities, this value reaches 50-60 %. It should be taken into account that at present the energy consumption of production is 1.5-2 times higher, and the share of poultry product cost is 12-16 %, and feed share is 60-80 %. In Europe, the cost of energy consumption of poultry products is around 3-5 %.

Therefore, the main task of this area is to find energy and resource conservation elements, which technology and physiology facilitate saving fodder and electricity, thus not affecting the productivity and health of poultry. However, the genetic potential of poultry productivity depends to a large extent on the conditions of their feeding and breeding. However, modern technology leads to the loss of the adaptive potential of the organism. As a result, productivity, and resistance are reduced.

Modern feeding and storage technologies for agricultural birds are based on keeping them in a special building. Thanks to the storage of birds in battery cages, the manufacturer uses each cubic meter with maximum efficiency.

Under these circumstances, the physical state and productivity of poultry are determined not only by important measures such as breeding process and proper feeding but also by the conditions of the premises. This factor is known to have a very significant effect on the physiological state of the poultry and may cause changes in productivity by 20-30 %. Micro-climatic indicators, which have the greatest impact on the poultry, include the temperature and humidity of indoor air, dust and gaseous pollutants, ventilation and the rate of air flow. Excess temperature causes both the deterioration of physiological state and decline in productivity. For example, when storing broilers for 5-8 weeks, the temperature dropped from 18 ^{o}C to 10^{0}C which caused a 48 % drop in weight, 6 % per each degree. When the temperature increased from 23 to 32 ^{o}C, the weight decreased by 26 %, which is 3 % per each degree. During the storage of laying hens, the temperature drop in the rational range decreased the egg output by 2 % and the temperature rose by 1.5 % per each degree. In both cases, a need for additional power consumption emerged. Intensive technologies are preferable for the realization of the efficiency potential of poultry farming. However, the intensification of the area increases the anthropogenic load on the environment. The main source of environmental hazards is the utilization systems of poultry droppings. Studies have shown that poultry and livestock wastes are accounted for 85 % of adverse environmental impacts.

On the other hand, under nutritional deficiency, the development of economically and environmentally friendly, machine-based technology for the utilization of poultry droppings in agriculture is a critical issue.

Lighting plays a significant role in poultry. Therefore, lighting is the basis for electricity consumption. Industrial lighting is important for bird physiology and very energy-consuming. Besides, the lighting of the premises should be performed in a manner that imitates sunrise and sunset, i.e. slow switching on and off.

On the other hand, it is necessary to use electrophysical disinfectants - bactericidal lamps to purify the air from micro-organisms that can cause respiratory diseases. The development of highly effective bactericidal devices based on these is also an important issue. Therefore, scientific and practical tasks emerge, such as the development of technical equipment based on resonance feeding systems and modern optical sources of radiation. From this point of view, the scientific substantiation of poultry-targeted energy-saving lighting and radiation equipment is also relevant.

In general, the development and implementation of new, effective, low-cost and environmentally friendly technologies are essential for large-scale research.

The purpose and tasks of the research.

The purpose of the study was to substantiate the energy-saving, environmentally friendly technology of poultry production and its technical solutions.

The following tasks have been set for achieving this purpose:

1. Investigation of the physicomechanical, thermophysical properties of materials involved in the process of thermal mass transfer;
2. Development of a mathematical model of energy balance in water evaporating coolers, substantiation of effective microclimate systems for the poultry building;
3. Reduction of the negative impact of poultry droppings on the environment and the substantiation of the efficient utilization technology that provides economic benefits;
4. Development of the model for the evaluation of nitrogen preservation in various technologies of the utilization of poultry droppings and estimation methods;
5. The study of energy-saving light regimes of poultry buildings;
6. Theoretical study of therapeutic and bactericidal radiation in the poultry building;
7. Experimental validation of theoretical considerations and determination of the economic profit.

Research methods. The problem was solved using theoretical and empirical research methods. Objects of the research included energy and resource protection, environmentally friendly technologies and techniques, plastic recuperators, utilization systems of bird droppings, lighting and irradiation processes in industrial poultry. Classical and specific methods, including the decomposition method for the functional analysis of utilization technology of poultry droppings; logical - linguistic method for the evaluation of nitrogen preservation during utilization; physical modeling for microclimate, feeding and keeping technology, lighting and radiation processes; methods of the planning experiments and a special computer program were used for laboratory and industrial tests. The obtained results were processed using the method of mathematical statistics, STATGRAPHICS centurion XV, Microsoft Office Excel 2016 and AutoCad 2015 packet programs.

Main points presented to the defense of the dissertation:

- engineering methodology developed to substantiate the economy mode of the poultry building, depending on the control parameters and external conditions;
- mathematical model of heat and mass transfer processes based on direct evaporation, occurring in the cooler, an improved scheme of cold processing of the air, rational method to normalize the air conditioning of the building;
- substantiation of the safe utilization technology of poultry droppings on the basis of the ecological indicator considering the distribution factor of nitrogen to the environment;
- improvement model and application scheme for the lighting of poultry buildings based on energy-saving LED lighting;
- criteria for the efficient use of heat-exchangers, considering the species, quantity, and method of storage of birds, the rationality of cooling depth and cooling efficiency;
- mathematical model directed to N preservation during the utilization of poultry droppings based on the formation of the expert knowledge with logical-linguistic method about the multidimensional fuzzy logic system;
- computer research methodology developed to substantiate

ways to increase energy use efficiency of the poultry building;

- economic benefit gained by the improved cooling system, utilization of poultry droppings and energy-saving lighting.

Scientific novelty of the research. The interaction of air temperature and humidity parameters with the energy characteristics of cooling and heating complexes in poultry buildings has been clarified, arguments that confirm the superiority of the devices used to normalize the microclimate, the stages of research to ensure the specific recommendations for the design and construction of these devices, and the conditions that influence their effectiveness have been substantiated. Formulas have been developed to determine the temperature and humidity parameters of the poultry building using water evaporative coolers and recuperative heat exchangers. A mathematical model and algorithms for its realization have been developed to select parameters and operating modes of refrigeration units and a plate-type heat exchanger. A system of practical recommendations and program module have been developed to choose the system of normalization of temperature and humidity parameters based on the modeling of thermophysical processes in poultry buildings. The economic efficiency and environmental safety criteria of the proposed combined method of the utilization technology of poultry droppings for production conditions have been substantiated. Methods and algorithms have been developed to determine the constructive and working modes of the technical systems required for environmentally safe utilization of poultry droppings with minimal nitrogen loss.

The method of estimating resonance feed blocks of the light sources, methods for improving the efficiency of the resonance feed system, as well as the constructive parameters of the irradiation devices for the therapeutic effect on birds based on ultraviolet light (UV) source (diode lamp) have been substantiated. The feeding and storage efficiency of laying and meat hens and chickens in energy-saving lighting mode, using natural and adaptogenic minerals has been established.

Theoretical and practical significance of the research.

Constructive and technologically substantiated plate-type coolers and recuperators have theoretical importance for the development of innovative resource-saving projects to upgrade the industrial base of poultry farms. Ecologically safe utilization of poultry droppings and technological variants and technical facilities meet the requirements of ecology and green economy, which are of great economic importance. The program developed for modeling light technical characteristics of LED lamps enables the use of automatic lighting systems in poultry buildings. The development of high-efficiency variants of ultraviolet bactericidal radiators to render harmless air in poultry buildings and the substantiation of their optimal operation modes serve to improve veterinary control at these facilities.

The theoretical and practical knowledge gained from the research can be used in the teaching process of scientific and pedagogical personnel and in the process of scientific research. The practical significance of the research results has been discussed and approved by the Scientific and Technical Council of the Azerbaijan State Agrarian University (Protocol No. 2, May 15, 2019).

Approbation and application. The results of the research were discussed in the Scientific Council (Ganja, 2019) of the Azerbaijan State Agrarian University (ADAU), International Scientific-Practical Conference on “Modern Agrarian Science: Actual Problems and Prospects of Development in the Context of Globalization” (Ganja, 2014), at the scientific-practical conferences of the Azerbaijan State Agrarian University (Ganja, 2012 - 2018), in Novosibirsk (SIBAK)-IX International Scientific and Practical Conference on the “Main Tasks of Technical and Physico-mathematical Sciences in Modern Research” (2018), International Scientific and Practical Conference on “Actual Problems of Food and Light Industry”, Azerbaijan Technological University (Ganja, 2019), Proceedings of the 8th International Conference "Science and Society - Methods and Problems of Practical Application" (Vancouver, Canada 2019), 11th International Conference “Recent trend in Science and Technology management” (London, 27-29 July 2020). The plate-type cooling system proposed as a result of the dissertation work has been tested at the "Suliddinoghlu" farm of the Samukh region and its economic effect was 84187.1 manats, economic evaluation of the utilization technology of poultry droppings has passed a production test in the village of "Suliddinoghlu" of the Samukh region, and the economic efficiency of its implementation was 7945.58 manats. The evaluation of LED was performed at the “Ismayilli Zarat Broiler” poultry farm in the Ismayilli region, and the energy-saving was estimated to be 20910 kW/h.

Name of the organization where the dissertation was performed: The research was carried out at the Department of Electrical Engineering of the Azerbaijan State Agrarian University.

Total volume of the dissertation in characters with an indication of the separate volumes of the structural units. The dissertation consists of the introduction, seven chapters, results, recommendations for producers, a list of 236 references and appendices. The dissertation content contains 292 pages of computer typing, including Introduction - 8 pages (16431 characters), the I Chapter-40 pages (72997 characters), the II Chapter-58 pages (68607 characters), the III Chapter- 44 pages (55523 characters), the IV Chapter- 34 pages (35885 characters), the V Chapter- 26 pages (32547 characters), the VI Chapter- 34 pages (47605 characters), the VII chapter-13 pages (16255 characters), Rusults- 2 pages (3333 characters), Recommendations for producers - 1 page (790 characters). There are 80 figures, 31 tables, and 5 appendices in the dissertation. The total volume of the dissertation is 396782 characters (354740 characters, excluding the list of the used literature and appendices).

CONTENT OF THE WORK

The relevance of the research topic, aims and tasks, scientific innovation and the practical significance of the obtained results have been highlighted in **“Introduction”**.

The first chapter is entitled "Problem setting, research aims, and tasks". It covers the dynamics of poultry staged development in Azerbaijan, the peculiarities of industrial poultry in hot climates, negative impact factors of poultry farming to the environment, level of knowledge in poultry feeding and lighting regimes as a resource-saving factor, analysis of modern ways of improving the temperature-humidity regime in poultry buildings, analysis of artificial lighting systems in poultry buildings. At the end of the chapter, the aims and tasks of the study are outlined.

E.E.Duyunov, A.V.Zavodov, T.I.Lokhvinskaya, A.J.Isgandarova, E.S.Mammadov, V.Matrayev performed investigations on improving the keeping conditions of agricultural birds. General trends in improving the microclimate parameters in the bird building have 3 directions. The first is the organization of proper ventilation of the building. The second is to create a cooling system for the warm season. The third is to provide a heating system for the cold period.

Investigations performed by R.Barnwell, A.A.Akatov, V.A.Garanin, V.A.Gulevski, Y.V.Zakipnaya, E.M.Chaplgin, and S.Eduard contributed to the air ventilation concept as removal of dirty air and entering the clean air into the building.

The main tasks for the ventilation of the poultry building are as follows:

- maintaining temperature-humidity parameters of the air according to species and age of birds at the level established by zootechnical requirements;
- to provide the necessary repetition of air conditioning, i.e., the physiologically substantiated volume of fresh air per live weight bird;
- removal of harmful gases from the building, as well as excess moisture, mechanical impurities harmful for the health of birds;
- to distribute fresh air indoors evenly with no harmful concentrations within the building, without local stagnant areas;
- to increase the longevity of engineering facilities, construction structures of the bird building and the reliability of the used technology;
- creation of normal microclimate conditions for poultry complex staff.

The utilization of poultry wastes is of great importance for applied ecology. There are the following options applied in the world practice of poultry waste utilization: organic fertilizer, vermiculture, and feed preparation.

In terms of agrochemical (fertilizer), ecological (decontamination and deodorization) and energy (fuel and electricity production) efficiency, processing of poultry droppings under anaerobic conditions in special hermetic reactors - methantenk is considered to be the most promising.

The substance fermented in methantenk is a concentrated, liquid, organic fertilizer that is readily absorbed by plants, purified from disease causatives and weed seeds. It contains macro - and micro-elements, amino acids and phytohormones that stimulate the development of the plant. Such fertilizers can be used in all types of soils for the cultivation of vegetables, fruits, berries, fodder plants, lawns, decorative plants, etc. World experience shows that when such fertilizers are used in growing vegetables on irrigated lands, productivity has increased by 2 - 3 times.

Use of the poultry waste for the production of feed proteins and environmentally friendly fertilizers, earthworm breeding – vermi-composting techniques are more common in the USA, Canada, England, Japan, and Italy. This technology focuses on three challenges: waste utilization, obtaining protein feeds, and improvement of soil fertility.

The biomass of worms is an excellent protein feed for birds and pigs. They also have the ability to collect heavy metal salts and act as biological pumps. Some research has focused on the preparation of the microbiological environment from this biomass, and to prepare food for humans in China and Japan.

Another technology is based on the preparation of biohumus by processing poultry droppings with fly larvae. Experiments performed in this area abroad have shown that the productivity of agricultural crops has increased by 1.2 - 1.5 times as a result of the application of biohumus. The application of these technological variants can be used as a working hypothesis in the development of mathematical models of eco-friendly poultry production.

In poultry farming, which is one of the most important fields of agriculture, the use of optical radiation is one of the technological processes.

It is difficult to expect the optimal productivity of all birds when the poultry building is not sufficiently illuminated. According to the existing regulations, the best conditions for keeping birds are to provide 10-50 lux of light for 14-24 hours. It has been practically proven that the best lighting, including optimal light management, can increase the number and mass of eggs.

The traditional lighting system for poultry buildings is based on the application of incandescent lamps with 60 - 1000 W of power, compact luminescent lamps of 10 - 30 W, with light emission of 60 - 75 lm/W and the service life of 8,000 hours, or LB, LD tubular luminescent lamps. The light emission of the latter is 60 - 80 lm/W, and the service life is 10,000 hours. For bird keeping facilities, the “Dan - Gurub” lighting system is recommended, which is quite complicated when using conventional incandescent lamps, and very expensive with luminescent lamps.

The second chapter entitled "Theoretical Research of Resource-saving Ventilation System for the Poultry Building", covers the study of energy-efficient resources in poultry, analyzing parameters of the ventilation systems in the poultry building, searching for efficient ventilation, the study of the cold processing of the air, optimization of the condensation of the building.

As mentioned above, the microclimate in the poultry building is one of the most important parameters. The favorable veterinary conditions, and all production and economic indicators of the farm depend on these parameters. It is more difficult to maintain optimal microclimate in broiler breeding. Because the broilers are placed at higher density compared with other agricultural birds and also to their intensive growth and development.

Therefore, the optimization of microclimate in poultry buildings is a top priority, and the solution of this issue will allow providing the required temperature, high-quality air supply, reduced microclimatic stress, and the percentage of respiratory diseases, increasing the immune status of the bird flock. As a result, the activity of the birds, and their feeding are improved, and often the energy consumption for the over ventilation and heating of the building decreases. In each particular case, there is a need for measuring heat and heating in the air conditioning system.

In this regard, the economic substantiation of special thermal (cold) characteristics of modern bird buildings is of great importance for decreasing energy consumption in providing heat and cold and increasing productivity. The optimal variant of the bird building design is based on the specific costreduction per production unit. The technological effect can be expressed in the following formula:

$$З_i = \frac{K_i E_n + Э_i}{W} \rightarrow \min, \tag{1}$$

where K_i – investment, AZN;

E_n – normative coefficient considering the efficiency of investment;

$Э_i$ – i operating costs for the use of external coating and air conditioning equipment, AZN;

W_i – annual production, production unit/year.

i – investment in external coating and air conditioning is defined as:

$$K_i = K_{0i} + K_{ki} \tag{2}$$

$$K_{0i} = b_i\, \lambda_i\, F_i\, R_i \tag{3}$$

$$K_{ki} = [\eta_T e_T (t_{bx} - t_{HT}) n_{Ti} + \eta_x e_x (t_{Hx} + \Delta t_{HT} - t_{bx}) n_{xi}] \frac{F_i}{R_i}, \tag{4}$$

where b_i – i - value of the balance of 1m^3 exterior coating (or heat-insulating coating), AZN/m^3;

λ_i – heat transfer coefficient of the building i - external coating (or heat-insulating coating), W/m ^{o}C;

R_i, F_i – thermal resistance of the i-exterior coating of the building and its surface area, m^2 ^{o}C /W and m;

η_T, η_x – coefficients of heat and cold loss in the air conditioning system;

e_T, e_x – special balance of heat and cold conditioning systems, AZN.hour/kJ

t_{bT}, t_{bx}, t_{HT}, t_{Hx} – temperature for the heating and cooling periods, ^{o}C.

$$\Delta t_{Hi} = \frac{q_{Hi} E_{Hi} n_{Hi}}{\alpha_{Hi}}, \tag{5}$$

where q_{Hi}, E_{Hi}, n_{Hi} / α_{Hi} – special heat flow from solar radiation in the latitude of the building location W/m^2, absorption coefficient, and heat transfer coefficient from the exterior wall to the outer air, W/m^2 ^{0}C.

Operating expenses include the following:

$$Э_i=C_{0i} + C_{ki} + И_{Ti} + И_{xi} \tag{6}$$

$$C_{0i}= a_0\, k_{0i} \tag{7}$$

$$C_{ki} = a_k\, k_{ki} \tag{8}$$

$$И_{Ti} = \left[\eta_T c_T Z_T K_T (t_{gi} - t_{HT}) n_{Ti}\right] \frac{F_i}{R_i}, \tag{9}$$

$$И_{xi} = \left[\eta_x c_x Z_x K_x (t_{nx} - t_{ni} - t_{bx}) n_{xi}\right] \frac{F_i}{R_i}, \tag{10}$$

where C_{0i} və C_{ki} – costs of depreciation and current repair of i - exterior coating of the building and air conditioning, AZN/year;

a_0 və a_k – depreciation coefficients considering current repair of the building and conditioning system;

$И_{Ti}$ and $И_{xi}$ – annual costs for heating and cooling systems, AZN/year;

Z_T and Z_x – heating and cooling periods, hour/year;

K_T and K_x – coefficient of efficiency of heating and cooling systems during heating and cooling periods.

It is known that the cold surface of the outer cover absorbs hot rays intensely and it accelerates the heat radiation of the bird's body. As a result, the body consumes too much heat leading to a loss in productivity. Based on the results of numerous experiments it has been established that bird productivity in the field of physical thermosensitivity of living organisms can be determined as follows:

$$П=d_p – a_p q, \tag{11}$$

where a_p and d_p – linear dependence coefficients for bird species and bird genus, respectively, product unit/kJ, product unit /hour;

q – heat loss due to emitting heat by a bird, kJ/hour.

The effect of i – exterior cover on bird productivity can be determined by the following formula:

$$W_i = (Z_T + Z_x)(\sigma_0\, d_n F_i - a_n Q_n), \tag{12}$$

$$\sigma_0 = \frac{m}{\sum F_i}, \tag{13}$$

$$Q_n = m q_{ni}, \tag{14}$$

Where m – number of birds in the building.

q_{ni} – heat loss of the bird towards the exterior cover, kJ/hour.

According to the estimation method of the indoor heat exchange, the poultry building is divided into conventional thermal radiation units.

The final heat flow is defined as

$$\Gamma_{ni} = \sum_{j=1}^{N} C_0 E_{ji} t_{ji} \psi_{ji} F_i \left[\left(\frac{T_n}{100} \right)^4 - \left(\frac{T_i}{100} \right)^4 \right], \tag{15}$$

$$E_{ji} = \frac{1}{\frac{1}{E_j} + \frac{1}{E_i} - 1}, \tag{16}$$

where E_{ji} – degree of darkness of reciprocal radiation surfaces;

E_i=E_n and E_i – degree of darkness of the bird and *i* - exterior cover;

C_0 – radiation of the absolute black surface, W/m^{2}K^4;

F_j – surface of the *i* - radiation zone where the birds are located, m^2;

T_j=T_n and T_i – absolute temperature of the bird body and the exterior cover, K;

N – number of the heat radiation zones where the birds are located;

ψ_{ji} – radiation absorption coefficient of the technological equipment.

The temperature range from 0 to 40 ^{o}C can be adopted with sufficient accuracy for practical calculations:

$$\left(\frac{T_n}{100} \right)^4 - \left(\frac{T_i}{100} \right)^4 \approx (0{,}81 + 0{,}001 t_b)(\Delta t_n + \Delta t_i), \tag{17}$$

$$\Delta t_n = t_n - t_b, \qquad \Delta t_i = t_b - t_i, \tag{18}$$

where t_b, t_n and t_i – indoor air temperature, the body surface of birds, and temperature of the *i* - exterior cover surface, respectively, ^{o}C;

Within the same temperatures we assumed:

$$\Delta T_{nT} = C_n - b_n t_{bi} \quad \text{and} \quad \Delta t_{nx} = C_n - b_n t_{bx} \tag{19}$$

where b_n and C_n – linear dependence coefficients for a given bird species, 1/^{o}C and ^{o}C;

It is known that,

$$\Delta t_{Ti} = \frac{n_{Ti}(t_{bT} - t_{HT})}{\alpha_{bi} R_i} \tag{20}$$

$$\Delta t_{xi} = \frac{n_{xi}(t_{Hx} + \Delta t_{HT} - t_{bx})}{\alpha_{bi} R_i} \tag{21}$$

where α_{bi} – heat transfer coefficient from the indoor air to the internal surface of the i - exterior cover, W/m^2 ^{o}C.

Assuming that $\psi_{ji}F_j = \psi_{ji}F_{i,}$ and after finding α_{bi} value and putting (15)-(21) ratios in (12), a formula for the estimation of the volume of products was obtained:

$$W_i = \{(Z_T + Z_x)\sigma_0 d_n - a_n A_1 [(Z_T \alpha_T \Delta t_{nT} + Z_x \alpha_x \Delta t_{nx}) + \\ + (Z_T \alpha_T P_{Ti} + Z_x \alpha_x P_{xi}) 1/R_1]\} F_i, \tag{22}$$

where $\alpha_T = C_0(0{,}81 + 0{,}01 t_{bi})$; $\alpha_x = C_0(0{,}81 + 0{,}01 t_{bx})$;

$$A_i = \sum_{j=1}^{N} E_{ji}\psi_{ji}\varphi_{ji}, \qquad P_{Ti} = \frac{K_T(t_{bi} - t_{Hi})n_{Ti}}{\alpha_{bi}},$$

$$P_{xi} = \frac{K_x(t_{Hi} + \Delta t_{Hi} - t_{bx})n_{xi}}{\alpha_{bi}} \tag{23}$$

Putting expression (11) to formula (1) and performing necessary simplifications we obtained the formula for the calculation of the specific cost-reduction of the production:

$$З_i = \frac{\psi_i R_i^2 + (X_{Ti} + X_{xi}) + (M_{Ti} + M_{xi})}{[(Д_T + Д_x) - (Б_{T_i} + Б_{xi})]R_i - (B_{Ti} + B_{xi})}. \tag{24}$$

where $\varphi_i = (E_n + a_k)\lambda_i b_i$;

$X_{Ti} = (E_n + a_k)\eta T_e T_n T_i (t_{bi} - t_{nx})$;

$X_{xi} = (E_n + a_k)\eta x_e x_n x_i (t_{nx} + \Delta t_{in} - t_{bx})$;

$M_{Ti} = \eta_T C_T Z_T k_T n_{Ti}(t_{bT} - t_{nT})$;

$M_{xi} = \eta_x C_x Z_x k_x n_{xi}(t_{nx} + \Delta t_{ni} - t_{bx})$;

$Д_T = Z_T\, \sigma_0\, d_n$;

$Д_x = Z_x \sigma_0 d_n$; $Б_{xi} = Г_{xi}\Delta t_{nx}$;

$B_{Ti} = Г_{Ti}\, P_{Ti}$;

$B_{xi} = Г_{xi}\, P_{xi}$;

$Б_{Ti} = Г_{Ti}\, \Delta\, t_{nT}$;

$Г_{Ti} = A_i a_n\, Z_T\, \alpha_T$;

$$Г_{xi}=A_i a_n Z_x \alpha_x.$$

After differentiation of expression (12) we obtained the formula for the calculation of the optimal heat transfer resistance of any cover of the building:

$$R_{iopt} = \frac{B_{Ti} + B_{xi}}{(Д_T - Б_{Ti}) + (Д_x - Б_{xi})} + \sqrt{\left[\frac{B_{Ti} + B_{xi}}{(Д_T - Б_{Ti}) + (Д_x - Б_{xi})}\right]^2 + \frac{(X_{Ti} + X_{xi}) + (M_{Ti} + M_{xi})}{\varphi_i}}. \tag{25}$$

The choice of optimum heat-transfer resistance for different exterior covers with the formula (14) does not generally guarantee the minimum specific cost-reduction for the building. Because this is also determined by the ratio of the surfaces of various exterior covers of the buildings. According to formula (25), $Z_i=Z_{i\min}$ when $R_i=R_{iopt}$.

The optimum condition for air conditioning of the poultry building can be expressed as:

$$З_n = \frac{2З_{T\min}BH + 2З_{C\min}LH + (З_{n\min} + \delta З_{k\min})LB}{2BH + 2LH + 2LB} \rightarrow \min, \tag{26}$$

where L, B, and H – dimensions of the exterior cover of the poultry building, m.

The method, used to optimize air conditioning in the poultry building, provides veterinary control for birds, zootechnical and economic efficiency, maintaining the optimal microclimate parameters within the building.

The third chapter is entitled "Developing the theoretical considerations of the project of the utilization of the poultry droppings". An analysis of the approach to machine technologies, development of a mathematical model of the utilization of poultry droppings using machine technology, characteristics of utilization processes and operations, substantiation of the basic constructive and mode parameters of the utilization device have been presented in this chapter.

One of the most important steps in the development of the utilization technology of bird droppings is considering the regularities in the realization of each process and determination of their parameters. First of all, these processes are directly related to processing (bioconversion). Thus, these processes ensure the quality of the final product - organic fertilizer.

Bird excrements are the basis of organic fertilizer production. In the process of their moving from animals to plants, random and targeted changes occur. Both physical mass and quality indices are affected by this change. The type of the obtained fertilizer usually depends on the gathering technology of droppings, the high-quality storage and processing technology, consumption by plants and the technology of its application to the soil.

Given the above, the system is considered as a whole, aimed to maximize the efficiency of application and the productivity of agricultural plants according to the model "farm - the facility for processing and storage of droppings-soil". All impacts on the subject of labor are aimed at the full utilization of all the fertilizer resources as waste.

Processing of ecologically dangerous resource (excrement) to high-quality organic fertilizer is followed by improved quality (biological activity, humus gathering increases, neutralization occurs, weed seed germination is inactivated), and enrichment by supplements (moisture absorbent, lime and mineral elements), which lack in plants. When calculating gathering and quality indicators of the poultry droppings, normative materials on the excrement output, usage of the floor material and water consumption are used depending on the age group and structure of the flock.

The daily excrement output in the farm is determined by the following formula:

$$G_e = \sum_{j=1}^{N_1} g_j N_j ,$$

where g_j – is a norm of excrements excreted by a bird per day in *j* group, kg;

N_j – the number of birds in *j* - group.

Consumption of flooring material

$$P = \sum_{j=1}^{N_1} p_j N_j , \tag{27}$$

where p_j – consumption of normative flooring material for a bird in *j* group, kg.

Daily water consumption

$$B = \sum_{j=1}^{N_1} b_j N_j, \tag{28}$$

where b_j – direct daily water consumption, kg.

The output of poultry buildings of the farm

$$M_z = (G_e + P + B)T, \tag{29}$$

where T – storage period, days.

It should be noted that for many years most of the norms have remained unchanged. However, during these years there have been significant changes in the productivity of birds and technology and construction of the system for obtaining poultry droppings.

Based on some experimental and theoretical studies, it is recommended to use the coefficients given in Table 1 to determine the amount of accumulated poultry droppings.

Table 1. Daily output of poultry droppings in a facility

Bird species	**Technology, type of the factory**	**Daily output, kg**	**Designation**
Chicken	Egg chicken factory	0.13*X* + 0.12*x*	*X*-industrial herd chickens (aged chickens); *x* – young chickens (10 – 12- week-old)
	Broiler chicken factory keeping on the floor	0.11*X*	*X* –number of broilers
	Broiler chicken factory, keeping in the cage	0.09*x*	*x* - number of broilers

The moisture content of the collected poultry droppings is calculated using the following formula:

$$W_z = \frac{\sum_{j=1}^{N_1} g_j N_j W_e + PW_D + 100B}{G_e + P + B}, \tag{30}$$

where W_e, W_D – humidity of the excrement and floor material, %.

The concentration of *NPK* is calculated by the formula:

$$K_j^Q = (1 - f_j^{çix})\frac{K_j^e \sum_{j=1}^{N_1} G_{ei}(100 - W_{ei}) + (100 - W_D)P_D K_j^D}{\sum G_{ei}(100 - W_{ei}) + (100 - W_D)P_D}, \qquad (31)$$

where K_j^Q – concentrtion of *NPK* in the mixture;

$f_j^{çix}$ – *NPK* loss when poultry droppings are collected and derived;

The processing of poultry droppings includes the separation into fractions, mixing with moisture-absorbing materials, composting or biofermentation, as well as storage of the droppings and acquired organic fertilizer.

When the poultry droppings are separated into fractions, the mass of each fraction is determined by the following formula:

$$m_1 = \frac{m_{baş}(W_{baş} - W_2)}{W_1 - W_2}, \quad m_2 = m_{baş} - m_1, \qquad (32)$$

where $m_{baş}$, m_1, m_2 – mass of the initial poultry droppings and their fractions, respectively, kg;

$W_{baş}$, W_1, W_2 – humidity of the initial poultry droppings and their fractions, respectively, kg;

When poultry droppings are mixed with the moisture absorbent, the requirement for the latter is determined by the formula:

$$M_1 = M_z \frac{W_z - W_Q}{W_Q - W_T},$$

$$M_Q = M_z + M_T, \qquad (33)$$

where M_T and M_Q – mass of the absorbent and mixture, kg;

W_T, W_Q – humidity of the absorbent and mixture, %.

The moisture of compost after fermentation the mixture:

$$W_k = 100 - \frac{(1-\varepsilon)(100 - W_Q)100}{100 - 6\varepsilon(100 - W_Q)}, \qquad (34)$$

where ε – decomposition rate of organic substances during processing.

The mass of obtained compost is as follows:

$$M_k = M_Q\left[1 - 6\varepsilon(1 - 0{,}01W_Q)\right]. \qquad (35)$$

The amount of *NPK* in compost is determined as follows:

$$K_j^{emal} = (1 - f_j^{emal}) \frac{K_j^Q M_Q (100 - W_Q)}{M_k (100 - W_k)}, \qquad (36)$$

where f_j^{emal} – loss of *NPK* during the processing of poultry droppings, kg;

M_k – mass of the prepared fertilizer, kg.

Amounts of *NPK* in the content of the fertilizer applied to the soil

$$K_j^{ver} = (1 - f_j^{ver}) K_j^{güb}, \qquad (37)$$

where f_j^{ver} – loss of *NPK* when applying fertilizers, kg.

The maximum area for applying fertilizer is calculated as follows:

$$S_j = \frac{1000 G_{güb} (1 - 0{,}01 W_{güb}) K_j^{güb} K_j^{ver} \cdot 100}{100 U_{pl} B_j - Y_j K_{Yj}} \to \max, \qquad (38)$$

where $G_{güb}$ – mass of the organic fertilizer, kg;

K_j^{ver} – coefficient of the use of *NPK* in fertilizers;

B_j – *NPK* in the production;

U_{pl} – planned production, kg;

Y_j – amounts of the nutrients in the soil, kg;

K_{Yj} – coefficient of the use of nutrients of the soil.

Demand for additional fertilizers is determined as follows:

$$R_j^{\min} = \frac{(100 U B_1 K_{Yj}) S_{\max} - G_{güb} K_j^{güb} K_{güb}^{ver}}{10 K_j^{\min} K_{güb}^{\min}}, \qquad (39)$$

where $S_{\max}$ – fertilizer application area, ha;

$K_j^{\min}$ – coefficient of the active substance in mineral fertilizers;

$K_{güb}^{\min}$ – coefficient of the use of *NPK* in mineral substances;

The fourth chapter is entitled “Theoretical study of the energy-saving system of the lighting-irradiation application”. Substantiation of the artificial lighting parameters of the poultry building, the modeling of the illuminated area, the development of the mathematical model of the poultry building illumination in view of optimum energy, and the study of the air decontamination in the poultry building using a bactericidal lamp have been presented in the chapter.

As mentioned above, the main parameters for the lighting of the poultry building are the number of LEDs (N) and the unequal illumination coefficient (Z). The mathematical model of the poultry building illumination is based on the estimation of the optimal value of N by limiting the inequality of illumination.

Formulation of the problem and assumptions made for the model.

The illumination inequality coefficient (Z) is an important parameter, which determines the quality of the illumination and is recommended to be within the interval $1{,}1 \le Z \le 1{,}2$. It is assumed that the Z-coefficient in the LED lighting system of the poultry building corresponds to the condition $1 < Z < 1.1$ (40). This is considered as a highly uniform distribution of illumination.

The illumination of all LEDs at the point $E(x,y)$ with coordinates x and y is determined by the superposition principle in the horizontal and vertical directions:

$$E(x,y) = \sum_k E_k(x,y,k), \tag{41}$$

the number of terms here is equal to the total number of LEDs (N) in the poultry building. The power (P) required for the lighting system in a bird building is obviously dependent on N:

$$P = Np_1, \tag{42}$$

where p_1 – the power required by the LED.

Thus, the number of LEDs (N) and the unequal illumination coefficient (Z) determine the energy use and the quality of the lighting. The evaluation of the k_0-reserve coefficient and optimal values of the key parameters of a bird building lighting (E_0) is necessary for the improvement of the energy efficiency and lighting quality.

The illumination generated by the dot LED number k is inversely proportional to the square of the distance (r) from the LED to the given point:

$$E_k(x,y,k) = \frac{I_\alpha \cos\theta(x,y,k)}{r^2}. \tag{43}$$

We think that a circular symmetric light used for real LEDs has a distribution:

$$I_\alpha = I_0 \cos^m \theta(x, y, k), \tag{44}$$

where $\theta(x,y,k)$ – angle between the axial line of the LED force curve and the direction towards the point with coordinates x and y, and I_0 axial force of the light of the LED number k.

The degree indicator (m) is associated with the opening angle (α_0) of the luminous flux of the LED:

$$m = \frac{\ln(0,5)}{\ln[\cos(0,5 \cdot \alpha)]}, \tag{45}$$

The distance r is expressed with the coordinates x_s, y_s, z_s of the LED:

$$r_s = \sqrt{(x - x_s)^2 + (y - y_s)^2 + z_s^2}. \tag{46}$$

If the LEDs are located on the line with λ steps and the lamps are set at the height H on the lines and the distance between them is L_0, then x_s, y_s, z_s can be expressed as λ, L_0, and H, respectively. For y_s and z_s, the angle between lines γ and the number of lines given in the j line must be known. Usually, H is known in advance. To perform the calculation with (41) and (43) the parameters γ, j, λ, L_0 and parameters of the LED in (44) and (45) must be known.

α_0 (m) is given in the chosen LED. The angle between the (j) lines is estimated:

$$\gamma = \frac{\pi}{2(j-1)}. \tag{47}$$

For m=100 the number of lines is proposed j=7. Using more than 7 lines (j) complicates the construction of the lighting appliance. However, reducing their number limits the possibility of equal light adjustment. In addition to these parameters, for the estimations (41) N, its distribution along illuminators, the length of the illumination source and the distance between the lines are also must be known. Dependence between λ and N is possible by assuming the following: the length of the illuminators and the distance between them are 1 m. This condition does not conflict with the size of the LEDs. Then the number of illuminators in the poultry building is as follows:

$$S_0 = \frac{aN_L}{2}, \tag{48}$$

where a – length of the poultry building, m;

N_L – number of lines.

The width (b) of this poultry building is dependent on the distance (y_b) between the first, last lines and the building wall:

$$b = (N_L - 1)L_0 + 2y_b. \tag{49}$$

N, j və n_1 are respectively, the number of LEDs, lines and LEDs on the line for one illuminator. Then

$$N = S_0 N_1;\ N_1 = j\Pi_1;\ \lambda = \frac{1}{\Pi_1}. \tag{50}$$

Using the formulas (47), (48) and (49), we established a relationship between λ and N:

$$\lambda = \left(\frac{aj}{2N}\right)\left(1 - \frac{b - 2y_b}{L_0}\right) = \left(\frac{aj}{2N}\right)N_L. \tag{51}$$

We refer to the physical modeling method to determine the interrelations between basic and constructive parameters (which include geometric dimensions of the poultry building and lighting system).

Physical modeling of the poultry building lighting. It is known that in physical modeling, the mathematical analogy of different processes with contrasting physical origin occurring under the regulations expressed by the same equations is used. Thus, various physical phenomena characterized by the same ratios are the basis for the physical model. We used the analogy between the lighting generated by the dot LED and the voltage of the electric field generated by a point charge. The analogy is based on the fact that the intensity of the lighting and the electric field vary inversely proportional to the square of the distance from one point to the point LED and the point charge.

In the normal direction to the surface, this ratio is expressed in the same way for both events:

$$E_k(x, y, k) \approx \frac{\cos\theta}{r^2}, \tag{52}$$

where θ – the angle between the normal toward the plane and the direction of “*r*” vector.

We also note the superposition principle implemented for two events:

$$E(x, y) = \sum E_k (x, y, k). \qquad (53)$$

The distance between the lines is $L_{0,}$ and the lines are a parallel charged thread with an infinite length. The field intensity of the charged infinite thread is inversely proportional to the distance (*R*) from the field. If the thread is on the plane *xOy*, and parallel to the x-axis, then *E*(*y*,*z*) is not dependent from *x*

$$R=(y_2+z_2)1/2$$

$$E(x, y) \approx \frac{1}{R}. \qquad (54)$$

In other words, charged threads are visible as the point charges (e.g. positive) within the plane *yOz*, under any *x*. They are at the L_0 distance from each other (Figure 1).

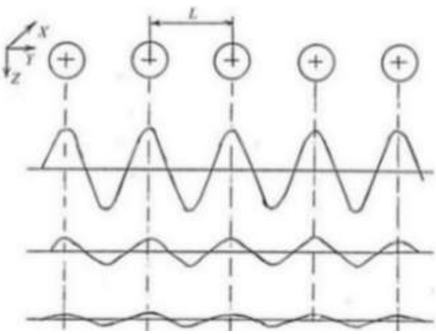

Figure 1. Distribution of potential under the parallel charged threads of infinite length.

The potential of the point charge (*φ*) is inversely proportional to the distance from the charge, which is similar to the voltage of the charged infinite thread. According to this analogy, using *φ* - potential we model illumination. Therefore, we will use the results obtained for potential in our research.

According to Feynman, potential created by the point charge at any point on the *yOz* plane can be expressed by the potential function:

$$\varphi(y,z) = F_n(z)\cos\left(\frac{2\pi ny}{L_0}\right), \tag{55}$$

where n=1, 2, 3, ... – the number of oscillation.

The area under the thread should fit with the potential Laplace equation and should be the only solution in the given boundary conditions.

When we put $\varphi(y,z)$ function in the Laplace equation $\Delta\varphi=0$, the Fourier component - n is obtained (the nth harmonic of the $F_n(z)$ area at the distance $z=H$ from the charged thread):

$$F_n(H) = A_n \exp\left(-\frac{2\pi nH}{L_0}\right). \tag{56}$$

It is known that the Fourier coefficient (A) decreases and when n=1 and n=2

$$\exp\left(-\frac{2\pi H}{L_0}\right) > \left[\exp\left(-\frac{2\pi H}{L_0}\right)\right]^2, \tag{57}$$

In this case, it is sufficient to consider the only n=1.

When A_1 is an average value (potential intensity or illumination):

$$F_1(H) = A_1 \exp\left(-\frac{2\pi H}{L_0}\right). \tag{58}$$

In the considered variant, A_1 equals to E_0 illumination having k_0 reserve coefficient:

$$A_1 = \frac{E_{\max} - E_{\min}}{2} = k_0 E_0. \tag{59}$$

Using the amplitude of oscillations of illumination $E_1(H)$

$$E_1(H) = \frac{E_{\max} - E_{\min}}{2} \tag{60}$$

and coefficient of illumination non-uniformity

$$z = \frac{E_{\max} - E_{\min}}{2E_{\min}}$$

We can write $f(z)$ function, where, H is a hanging height:

$$\frac{H}{L_0} = f(z) = \frac{1}{2\pi}\ln\left(\frac{z}{z-1}\right). \tag{61}$$

According to this function (Figure 2), for z<1.1

$$\frac{H}{L_0} > 0{,}382 \text{ or } L_0 \leq 2{,}62H \tag{62}$$

Illumination was studied in the *y* direction (transverse direction) of the working area of the poultry building (when $z=H$). According to (55), potential $\varphi(y, z)$ is a periodic function. Therefore, the intensity and illumination of the field are also periodic functions (with L_0 in the transverse direction).

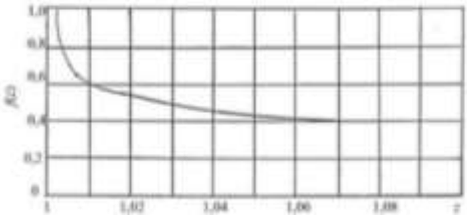

Figure 2. Dependence between the ratio H/L_0 and unevenness coefficient (z) of illumination

$z<1.1$ when a high level of equal lighting condition is provided $H/L_0>0.382$.

When assuming an arbitrary periodic function as a Fourier series with the number of oscillations $n=1$, the illumination $E(y)$ in the transverse direction can be expressed as:

$$E(y) = \frac{a_0}{2} + A\cos\left(\frac{2\pi y}{L_0} + \theta_1\right), \tag{63}$$

where, $\frac{a_0}{2} = \frac{E_{\max} + E_{\min}}{2}$, $A = \frac{E_{\max} - E_{\min}}{2}$ is the amplitude of oscillations of illumination in the transverse direction (Figure 3).

Expression (63) must satisfy the following boundary condition

$$E(0) = \frac{E_{\max} + E_{\min}}{2} = k_0 E_0; \quad E(b) = \frac{E_{\max} + E_{\min}}{2} = k_0 E_0. \tag{64}$$

This means that the illumination of the floor and walls should be uniform and close to normalized E_0 with the safety coefficient k_0. Thus, $E(y)$ is expressed as:

$$E(y) = \frac{a_0}{2} + A\sin\left(\frac{2\pi y}{L_0}\right). \tag{65}$$

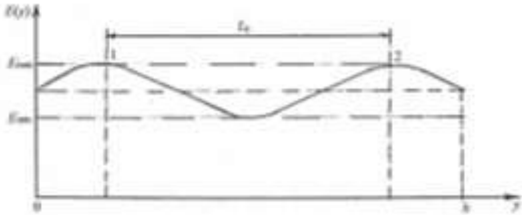

Figure 3. Illumination *E(y)* in the transverse direction for a periodic function L_0

to meet boundary condition $E(b)=k_0E_0$

$$\frac{2\pi b}{L_0} = \pi n \tag{66}$$

where n=1, 2, 3, ...

Since the width of the poultry building is greater (or equals to) than L_0 distance,

$$\text{when } n \geq 2, \qquad b = \frac{nL_0}{2}. \tag{67}$$

Based on formulas (61) and (66), the following relationship exists between H, b, and n:

$$\frac{Hn}{2b} = f(z). \tag{68}$$

Therefore, to meet the condition $z<1.1$, it must be

$$n > 0{,}764\frac{b}{H} \tag{69}$$

Thus, for the known b/H ratio, we obtain the rounded value for n using the formula (69) and calculate the distance between the lines (L_0):

$$L = \frac{2b}{a}. \tag{70}$$

This can be used as an initial parameter to calculate illumination of the poultry building.

Based on (49):

$$b-(N_L-1)L_0 = 2y_b > 0. \tag{71}$$

Using this formula, the number of the illuminator lines can be found:

$$N_1 < \frac{b}{L_0} + 1. \qquad (72)$$

It is known that the dimensions of poultry building with standard width (b) are as multiples of 6.

$$b=12 \text{ m};\ b=18 \text{ m};\ b=24 \text{ m}. \qquad (73)$$

In this model, the distance L_0 between threads charged at the same height (H) is the same and should not depend on n and the width of the building. This is confirmed by the indicators in Table 2, where the lighting source is on the height of 5.0 m.

Table 2. Estimation of the L_0 and N_L parameters for the poultry building with standard width (b) at H=5.0 m

***b*, m**	**0.764*b*/*H***	***n***	**2*b*/*n*, m**	**L_0, m**	**N_L**
12	1.83	2	12.00		2
18	2.75	3	12.00	12.00	2
24	3.67	4	12.00		3

Usually, the hanging height of lamps is in the range of 3-4 m. Therefore, when evaluating the parameters L_0, N_L, and the distance of the first and last lines from the wall of the building (y_b), we assume H=3 m; H=3.5 m and H=4 m.

In the model of charged threads with the same height (H), we take the average value for L_0 (Table 3, Table 4, Table 5).

Values obtained for L_0 və N_L can be used as initial parameters required for the estimation of the illumination of the poultry building.

Table 3. Estimation of the L_0, N_L and y_b parameters for the poultry building with standard width (b) at H=3.0 m

***b*, m**	**0.764*b*/*H***	***n***	**2*b*/*n*, m**	**L_0, m**	**N_L**	**y_b, m**
12	3.06	4	6.00	6.69	2	2.66
18	4.58	5	7.20	6.69	3	2.31
24	6.11	7	6.86	6.69	4	1.97

Table 4. Estimation of the L_0, N_L and y_b parameters for the poultry building with standard width (b) at H=3.5 m

***b*, m**	**0.764*b*/*H***	***n***	**2*b*/*n*, m**	**L_0, m**	**N_L**	**y_b, m**
12	2.62	3	8.00	8.33	2	1.84
18	3.93	4	9.00	8.33	3	0.67
24	6.11	6	8.00	8.33	3	3.67

Table 5. Estimation of the L_0, N_L and y_b parameters for the poultry building with standard width (b) at H=4.0 m

b, m	$0.764b/H$	n	$2b/n$, m	L_0, m	N_L	y_b, m
12	2.29	3	8.00	8.87	2	1.57
18	3.44	4	9.00	8.87	3	0.13
24	4.58	5	9.60	8.87	3	3.13

Chapter Five is entitled "Program and Methods of Experimental Research". The research program provides information on the equipment and devices used in the study, the methods of experimental research and the method for determining the adequacy of the mathematical models.

One of the main objectives of the experimental studies was to evaluate the adequacy of the developed mathematical models of heat and mass transfer in the heat transfer channels. For this purpose, during the test period, the experimental results were compared with theoretical values obtained by mathematical models. The comparison was made based on objective air temperature and humidity values at the inlet and outlet of the cooler and other indicators. The method of determining the relative errors was used for the comparison of the theoretical and experimental values.

Relative errors are calculated using the following formula:

$$g = \left| \frac{\sum g_i}{S_i} \right| \cdot \frac{100\%}{n_{nöq}}, \tag{74}$$

where g – relative error;

g_i – absolute value of the deviation of the i-experimental point from the theoretical point;

S_i – experimental value in the i- point;

$n_{nöq}$ – number of the studied pair of points.

To process empirically derived values, knwn elements of probability theory and mathematical statistics were used. When measuring, it is assumed that they are carried out with constant accuracy and that significant errors are distributed by normal law.

When determining the validity of the obtained values, the difference between the average values and the experimental results was analyzed using the following method. Considering the multiplicity of the measurements, the average value was found as follows:

$$\overline{X} = \frac{\sum_{i=1}^{n} X_i}{n}, \tag{75}$$

where X_i – the result of each i-measurement during an experiment;

n – the number of observations.

Knowing the average value for each observation, the deviation was determined as follows:

$$\Delta X = X_i - \overline{X}. \tag{76}$$

Then the average squared deviation was calculated:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} X_i^2}{n-1}}. \tag{77}$$

Error limits were calculated as follows:

$$\Delta \lim = \pm 3\sigma. \tag{78}$$

All experimental values out of this range ($\overline{X} \pm 3\sigma$) were considered to be errors and the experiments were repeated.

The error of each experiment was determined according to the formula:

$$\Delta\sigma = \frac{\sigma}{\sqrt{n}}. \tag{79}$$

The reliability interval is as follows:

$$E = i(n)\Delta\sigma, \tag{80}$$

where *i(n)* is the value of the Student's criterion, taken from the table, and based on the number of the experiments and reliability. It is known that the number of measurements (observations) in the course of an experiment is determined not only by the methods of the measurement but also by the required reliability of the result and the quadratic deviation. In the experiments for objective evaluation, the measurement error threshold was assumed to be 3σ with a reliability of 98 %. In this regard, 5 experiments were performed to obtain one experimental value.

The sixth chapter is entitled "Results and Analysis of the Experimental Research". The effect of air temperature and humidity on the indoor cooling device during the summer period, the effect of air consumption on the cooling depth of the water evaporative block and cooling block channels and impact on efficiency were studied. The research on air humidification system, substantiation of the utilization technology of bird droppings, computer and experimental studies of LED lighting and use of modern adaptogens were performed.

One of the factors determining the efficient operation of the evaporative cooler is the consumption characteristics of the applied ventilator. Particularly, the amount of air provided by the fan is crucial. This indicator influences the intensity of physical processes occurring in the cooler channels. Thus, it determines not only the cooling depth but also the cooling efficiency of the water evaporative block.

Figure 4 shows the changes in the evaporative block depending on air consumption. It should be noted that the temperature and humidity parameters of the air were stable.

Based on the definition of cold efficiency, the directly proportional relationship between the mentioned parameter and air consumption was obtained.

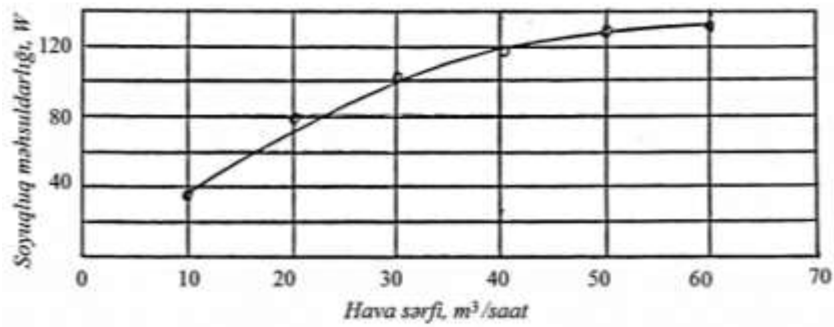

Figure 4. Influence of air consumption on cooling efficiency.

At certain levels of the air consumption (35 m^3 / h and over), a decline in cooling efficiency is explained by the decrease in the cooling depth. Figure 5 shows its changes depending on the ventilator efficiency.

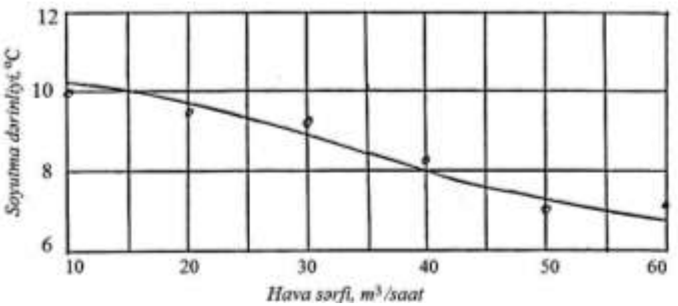

Figure 5. The effect of air consumption on the cooling depth.

As shown in the diagram, the cooling depth decreases with increasing air consumption. This is explained by the fact that, as the fan performance increases, there is a sharp increase in air rates in the cooling channel at constant volumes. Because of this, it quickly passes through the channel and is unable to be saturated with moisture due to the reduction of thermophysical processes. Thus, the air does not get enough moisture even at the exit of the evaporative tube, and as a result, the temperature is higher.

However, the analysis of the dependence presented shows that, despite a 5-6-fold increase in the air amount per time unit, and a 3-5 ^{o}C decrease in the cooling depth, the cooling efficiency of the block increased by 4-5 times.

Thus, we can conclude that, as air consumption has a decisive influence on cooling performance, in some cases, there is no need to achieve the maximum cooling depth.

Undoubtedly, to provide ceratin temperature in the closed room, the temperature of the incoming air should be slightly lower than that established for the building, as indicated by the heat balance.

Based on this, it can be concluded that the design of the cooling unit makes it unnecessary to achieve the maximum cooling depth. It is enough to choose such a regime that in case of the minimization of the cooling capacity, the required temperature can be provided inside the building.

The utilization of bird droppings is usually assessed based on nitrogen preservation or loss. The assessment of the nitrogen balance is used for this purpose. In many countries, agricultural enterprises have been included in the list consisting of 37 agroecological indicators to determine the environmental situation. The effectiveness coefficient of the use of the nutritional value, according to the calculation, is considered to be a generalized ecological indicator. The higher the coefficient, the smaller the loss of the organic fertilizer and pollution of the environment, water, and air. The main drawback of this method is the inability to analyzing some processes, especially when it results in large nitrogen losses. In many cases, it is difficult to evaluate nitrogen spreading to the environment and many expensive experiments are needed. For the assessment of the nitrogen preservation during the utilization of droppings, the method of the formation of expert knowledge as a logico-linguistic model in the multidimensional systems was used.

The experiment showed a fundamental difference in the processing of solid and liquid droppings. In the first and second cases, aerobic and anaerobic processes occur in the processed material, respectively. Different nitrogen losses were observed due to differences in the characters of the processes. Therefore, two separate models (Y_1 and Y_2) were used for the calculation of nitrogen preservation during the processing of droppings with a moisture content of over 92 % and below 92 %.

The list of the factors affecting the objective function was determined based on the information model:

X_1 – nitrogen preservation level at the processing stage, %;

X_2 – nitrogen preservation level at the storage stage, %;

X_3 – nitrogen preservation level at the stage of the application as a fertilizer, %;

X_4 – humidity of the processed material, %;

X_5 – *N/C* ratio in the processed material;

X_6 – activity quality of the workers.

It is important to note that the given factor space has been selected taking into account the systematic approach to the studied object from the quality of the raw material used for the entire technological chain to the method of the fertilizer application to the soil. Here, the variables X_4 and X_5 characterize raw materials (input factors). X_1 and X_2 - processing and storage technology of raw materials; X_6 is a foreign factor that affects the whole technological chain of the processing.

The dependent variables of the factor space (Y_1 and Y_2) and the oppositely located individual scale for each variable have been developed. They were compared with the linguistic scale (upper part of the ordinate axis) and the numerical (lower part of the ordinate axis) scale. A standardized form in the interval [-1, + 1] was determined for using it in the survey matrix, and in the experiment planning method.

The following symbols were used on the linguistic scale:

A – low level of preservation;

OA – pre-intermediate level of preservation;

O – intermediate level of preservation;

OY – upper intermediate level of preservation;

Y – upper level of preservation;

Sometimes, intermediate values (for example, "*A*-*OA*" is located between *A* and *OA*) are used to increase the accuracy of the assessment. The axis has values in the corresponding unit of measure. Here the scale has a whole range of values and can accept factor variables. The direction of the axis is chosen so that the outermost left value corresponding to “-1” on the standard scale would correspond to the least favorable value of the factor for the target function. Similarly, the standardized value of “-1” for the target function corresponds to the worst nitrogen preservation and “+1” (maximum possible value) to the best preservation.

Figure 6 shows the scale for the dependent variables (Y_1 and Y_2). The minimum preservation level was 25 % and 19 % and corresponds to the A - linguistic value (low level of preservation).

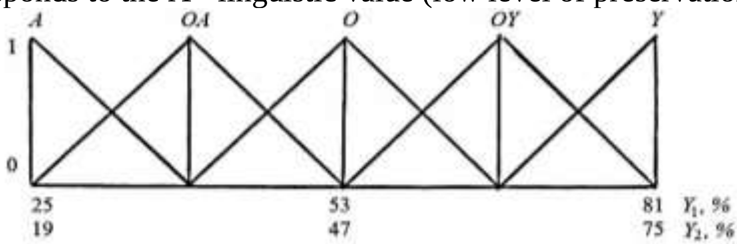

Figure 6. Scale for Y_1 and Y_2 target functions

The maximum values are 81 % and 75 % and correspond to the

"*Y*" linguistic (upper level) value. Similar scales were also developed for free variables (variable factors).

The results of these studies provide an opportunity to analyze the dynamics of nitrogen preservation depending on the utilization technology and the impact factors. The obtained data related to nitrogen preservation are used to determine the effectiveness criteria of the technology.

Adequacy of only regression equations having coefficients with a significance degree was examined by assessing the correlation of expert and calculated values.

Correlation coefficients of expert and calculated values were 0.93 and 0.95, respectively. This indicates a high degree of conformity as well as a high level of expert qualification.

Comparison of calculated and actual values of nitrogen preservation for specific poultry factories on the example of the technology of developing fertilizers using poultry droppings (Table 6) demonstrates the high adequacy of the developed model.

Thus, the knowledge gained about the regularity of poultry processing developed methods, and models capable of determining the level of nitrogen preservation will enable the utilization technologies to be evaluated for specific farms in terms of economic efficiency and environmental adequacy.

Computer research is of particular importance in the study of agricultural processes. Using this method, computer studies of illumination and evaluation of optimal parameters were performed for the LED lighting technological systems of two poultry factories.

Table 6. Comparison of factual and modeled values for nitrogen preservation

Enterprises	**Factors**						**Nitrogen preservation**	
	X_1	X_2	X_3	X_4	X_5	X_6	Factual, %	Calculated, %
Samukh poultry factory	-0.50	-0.25	-0.75	0.69	-0.50	0.00	38.40	39.86
Samukh poultry factory	-0.50	-0.25	-0.75	1.00	0.20	0.00	39.76	41.89
Ismayilli quş fabriki	-0.50	-1.00	-1.00	0.81	0.00	-0.50	39.10	39.33

Selection of input parameters: in both objects, j=7 lines were taken with γ=150 intervals. The chosen angle (γ) does not violate the dazzling light effect at 40-50^o, and therefore the starting angle was β_0 = 45^o.

Circular symmetric LEDs with a diameter below 5 mm were selected for the use of a large number of low-power (p_1) LEDs. Studies have been conducted at the opening angles of the LEDs from α 15^o to 30^o. Selected LEDs do not require cooling and they function at U=3 V and I=0.02 A when I_0=20 kd, and the power of a LED is p_1=0.06 W. The computer experiment is as follows when the opening angle of light flux for each bird building is α=20^o.

1. In a bird building with dimensions of a=66 m, b=12 m, 72 pieces of LED-19.2 (LED p_1=0.08 W, η=62.5 lm/W) were used for technological lighting. They were located along the line N_L=3. The illuminators were fixed at a height of H=3.5 m.

The total energy consumption was P_0=1382.4W when the power of each lamp was 19.2W. The measurement of the lighting revealed Z interval of the unequal illumination coefficient on the transverse surface ranged from 1.146 to 1.430.

In accordance with the physical modeling, we take the distance between the lighting lines, L_0=8 m, when N_L=2. If the length of the illuminatior is 1m and the distance is 1m, then the number of illuminators in a line is a/2=33, then

$$S_0=(a/2)\cdot N=66.$$

Then, we apply the algorithm for the opening angle of α=20^o of the light flux. When the number of LEDs is N_0=18018 and Z_0=1.086 the unequal illumination coefficient is L_0=8 m. After evaluating the optimal distance between the lines, we obtain L_{opt}=8.11 m. At this distance, the best number of LEDs and the best unequal illumination coefficients are obtained: N_{opt}=18,018 and Z_{opt}=1.081 (Figure 7).

The power of the lighting system for the chosen LEDs is $W_{opt}=W_1\cdot N_{opt}$=0.06W.18018=1081.1W, which is less by 27.9 % compared with illuminators produced by OOO “Rezerv”.

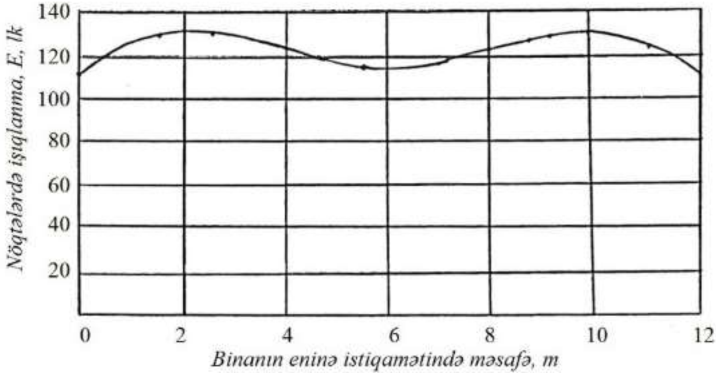

Figure 7. Cross lighting of the poultry building (66x12 m)

E_{min}=112.2 lk; E_{max}=130.35 lux; Z_{opt}=1. 081; L_{opt}=8.11 m.

The results of the study corresponding to lighting flux ranged from 15^o to 30^o, in the poultry building with dimensions of 66 m x12m are presented in Figure 7.

As seen in Table 7, when the beam angle of luminous flux is 30^o, the LEDs increase the energy use efficiency of the poultry building by 2.6 times. In this case, Z increases only by 3 % (Z=1.1). It should be noted that the difference between L_{opt} and the value obtained by physical modeling - L_0 (8.0 m) was very slight (2.5 %).

Table 7. Optimum values of *N, Z,* and L_0, at various α and energy consumption of 1382.4W in the poultry building of 66m x12 m dimensions

α, degree	η, lm/W	E_{or}, lk	L_{opt}, m	Z	N_{opt}	W_{opt}, W	W_0/W_{opt}
15	18	120.2	8.04	1.080	30594	1835.6	0.753
20	31.83	121.3	8.11	1.081	18018	1081.1	1.279
25	49.67	125.5	7.94	1.105	12012	720.7	1.918
30	71.33	130.4	7.84	1.130	8778	526.7	2.625

Thus, in a poultry building with dimensions of a=66 m, b=12 m, it is recommended to place 66 LED lamps on 2 lines (N_L=2) (a distance between the lines is 7.84 m). The number of LEDs in an illuminator (beam angle 30^0) is 133, and the power is 7.98 W. This variant is 2.4 times more efficient than the base variant (LED - 19.2). The lighting quality is Z=1.1 (Table 8).

Table 8. Comparison of lighting systems in the building with dimensions of 66 m x12m

Object	**Available lighting system**					
Poultry building 66x12m	Type of the illuminator (l=2m)	The number of LEDs in the illuminator	Power of a lamp, W	The number of illuminators	The number of illuminator lines	luminous flux lm
	LED-19.2	240	19.2	72	3	1200
Object	**Modernized lighting system**					
Poultry building 66x12m	Proposed illuminator (l=1m)	133	7.98	66	2	569.24

2. In the second poultry building (dimensions a=78 m, b=18 m), 160 pieces of GL036-D016.ON (LED W1=1W; η=112.5 lm/W) were used. They were placed along the building and N_L=4. The power of each illuminator was 16W and the total energy consumption was W_0=2,560W.

According to the physical modeling, the distance between lines (L_0) of illuminators was 8 m and the number of lines (N_L) was assumed to be 3. Considering that the length of the illuminator was l=1 m, and the distance between them-1m, the number of the illuminators in one line was a/2=39, and then $S_0=(a/2)N_L$=117.

Using a computer program (also when α=200), Z was found to be equal to 1.071, when N_0=31,122 and L_0=8.0 m. By estimating the optimal distance between the lines, Z=1.046 was obtained, provided N_{opt}=30,303 and L_{opt}=7.83 m (Figure. 8).

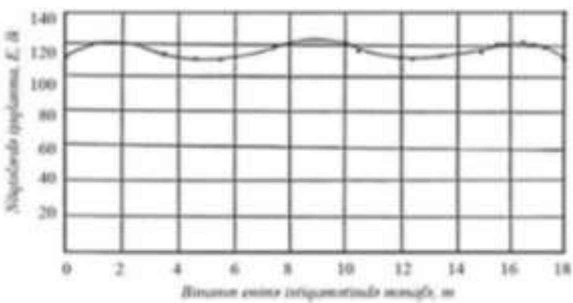

Figure 8. Lighting of the poultry building (78m x18 m) in the transverse direction

E_{min}=125.44 lux, Z=1.046, L_{op}=7.83 m.

The calculated values for the variation of x with 5 m steps from 9 m to 69 m are the same as those obtained at x=39 m. The lighting power of the system for the chosen LEDs was $W=W_1.N_{opt}=$ $=0.06\cdot30303=1818.2$W. This value is less by 40.8% compared with illuminators produced by OOO “Qelan” (Table 9).

As seen in Table 9, when the opening angle of the used LED ranged from 15^o to 25^o, the energy use efficiency increased from 13.3 % to 117.1 %. Thus, the lighting quality was high (coefficient of inequal lighting Z<1.1).

Table 9. The main parameters for the poultry building with the dimensions of 78m x18m at various values of α and when the energy consumption W_0 equals to 2560W

α, degree	η, lm/W	E_{or}, lk	L_{opt}, m	Z_{opt}	N_{opt}	W_{opt}, W	W_0/W_{opt}
15	18	120.2	7.94	1.078	54054	3243.2	0.789
20	31.83	120.2	7.83	1.046	30303	1818.2	1.408
25	49.67	124.7	7.60	1.078	19656	1179.4	2.171
30	71.33	120.4	7.46	1.108	13104	786.2	3.256

As seen in the table, the W_0/W_{opt} ratio decreases slightly (less than 0.8 %) and the use efficiency of light energy increases more the 3 times in such a poultry building.

The optimum distance between lighting lines (L_{opt}) differs from the value of the physical modeling (L_0=8.00) by less than 7.2 %.

Thus, 117 pieces of LEDs located along the line (N_L=3) in the poultry building with the dimensions of 78 m x 18 m can be recommended. The distance between the lines is assumed to be 7.46 m (Table 10).

Table 10. Comparison of lighting systems in the building with dimensions of 78mx18 m

Object	Available lighting system					
Poultry building 78x18m	Type of the illuminator	The number of LEDs in the illuminator	Power of a lamp, W	The number of illuminators	The number of illuminator lines	luminous flux lm
	GL036-D016.ON	16	16	160	4	1800
Object	**Proposed lighting system**					
Poultry building 78x18m	Proposed illuminator	112	6.72	117	3	479.36

The number of LEDs in one illuminator is 112, the opening degree - 30^{o}, the power of the illuminator - 6.72W, which is 2.4 times more efficient compared with the illuminator GL036-D016.ON. In this case, the illumination quality *Z* is almost 1.1.

The seventh chapter is entitled "Economic Evaluation of the Research Results". Annual profit due to the reconstruction of the ventilation system of the poultry building during the summer period, economic efficiency of the utilization technology of poultry droppings, and lighting system have been evaluated. The economic impact assessment is not only related to the availability and operation of the cooling system but also to the increase in productivity as a result of decreasing energy costs and improving the keeping conditions of birds. The specification of the latter is very complex. According to the recommendations of experts, the equipment purchase and the evaluation of the economic benefit of its operation should be carried out in comparison with the base object. We used the micro-climatic unit “Klimat-2000”, designed for the storage of 30,000 laying hens for the summer period in the village of Suliddinoghlu of Samukh district as a base variant. It has a nominal air consumption of 180,000 m^3 / h with Multifan-130-V4D15-5 axis ventilation for removing harmful impurities from the building during the hot period. As an application for air cooling, a nested humidifier with a surface area of 50 m^2 is used.

The most favorable range of relative humidity is 60-70 %. In the absence of the required ventilation within 2-3 hours, the building is filled with 10-20 % carbon dioxide, resulting in oxygen deficiency and paralysis in the respiratory organs of the birds. Thus, the best mode of keeping birds in the summer period is as follows: temperature-12 ^oC, relative humidity-65 %, air speed in the zone of birds-1.5 m/sec, air exchange rate in the building -4.0 m^3/h per 1 kg of a bird.

When determining the annual benefit, the costs of purchased equipment and operating costs are taken into account.

The base variant was compared with the evaporative cooling block. This block, along with the base ventilation system, provides a cooling depth of 8-12 ^oC. This increases the cooling capacity of the proposed cooling system to 400-900 kW. The technical characteristics of the compared objects are given in Table 11

Table 11. Technical characteristics of cooling systems

No	Indicators	Base "Klimat-2000"	Plate-type cooling system
1	Nominal air consumption, m^3 / hour	180,000	180,000
2	Cold efficiency, W	198,000	400,000
3	Cooling depth, ^oC	3	8
4	Air temperature in the poultry building (when the outdoor air temperature is 30 ^oC) ^oC	29	25
5	Number of Multifan-130-V4D15-5 fans	6	6
6	Performance of a fan, m^3 / hour	31,500	31,500
7	Power of an electric motor, kW	0.6	0.6
8	Area of irrigation unit/ plate, m^2	50	20

Expected results with the use of evaporative cooler: using plate-type evaporative cassettes and reducing energy consumption by optimizing geometric parameters, increasing poultry productivity by improving temperature-humidity parameters indoors.

Economic efficiency as a result of the application of the plate-type evaporative cooler during hot periods is 84,187.1. This value is achieved by reducing the specific costs of purchasing a product unit and increasing the productivity of birds in the new variant by 10%.

The technical and economic indicators of the evaporative cooler are given in Table 12. The improvement of the conditions for keeping birds, as well as decreasing losses, contributes to the enhancement of productivity.

Table 12. The technical and economic indicators of the plate-type evaporative cooler

№	Indicators	Unit of measurement	Base "Klimat-2000"	Plate-type cooler system
1	Balance price	AZN	111,000	129,000
2	Special energy capacity	W_{en}/ W_{soy}	0.0008	0.0007
3	Operating costs for the summer	AZN	29,978.51	16,377.15
4	Saving costs for the summer	AZN	-	1,720.2
5	Economic efficiency	AZN	-	84,187.1

The economic evaluation of the utilization technology of bird droppings was conducted in the "Suliddinoglu" farm of the Samukh region. The main activity of the farm is bird breeding and producing eggs, bird meat and sub-products. The collected bird droppings are utilized as organic fertilizer and have the potential to be used in agricultural farming. The advisability of the applying biofermentation designed on the basis of the investigations and expert system of the utilization technology has been demonstrated.

According to the existing technology, the processing of bird droppings for further utilization was performed by keeping them in a stack on the concrete ground for 3 months. The organic fertilizer was realized in own sowing areas as well as in other farms by request. The choice of bioferment technology is related to the acquisition of high-quality organic fertilizers. Considering the application of this technology requires great investment, a staged plan has been developed. The object at the poultry factory is planned to reach its full potential in the 2020 year. Currently, the first stage has been completed and 20 % of the collected bird droppings can be utilized. Although the private investment is slightly larger compared to base technologies, it was found that Z=0.078 AZN/tonne versus Z=75 AZN/tonne. The economic benefit compared to the base technology is $Э_y$=7945.58 AZN versus $Э_b$=1642.5 AZN.

The effectiveness indices of the proposed technology are given in Table 13.

Table 13. Evaluation of the effectiveness of the utilization technology of bird droppings

No	Indices	Unit	Technology	
			Base technology	Designed technology
1	Collected bird droppings	tonne/year	4562.5	4562.5
2	Annual organic fertilizer	tonne/year	4562.5	8212.5
3	Investment	thou. AZN	2322	4603.5
4	Amortization, maintenance and technical service	thou. AZN /year	184.6	261.78
5	Energy costs	kW hour/year	-	436540
		thou. AZN	-	30557.8
6	Fuel costs	tonne/year	198.16	577.9
		Thou.AZN	178.35	404.53
7	Labor cost	person/hour	12140	26810
		thou. AZN	12.14	26.81
8	Added material	tonne	-	-
		thou. AZN	-	3650
9	Maintenance costs	thou. AZN	404.52	1418.1
10	Initial nitrogen amount	tonne	82.13	82.13
11	Coefficient of nitrogen preservation		0.37	0.77
12	Specific cost reduction	thou. AZN /tonne	0.075	0.0786
13	Ecological and economic effect	thou. AZN	1642.5	7945.58
14	Nitrogen loss	tonne	51.74	18.89
15	Effectiveness of the convenient technology	thou. AZN /tonne	-	143.9

Evaluation of LED lighting was performed in the “Ismayilli Zarat broiler” poultry farming with dimensions of 66mx12m (the illuminators were fixed at a height of 3.5 m, number of birds-50,000 hens, method of keeping-on the floor). The lighting mode was the same in both bird buildings with control and experimental facilities, switching on and off were implemented with a lighting controller “Rassvet-200”. Indicators for determining annual energy savings are given in Table 14.

We evaluate the economic efficiency of the application of LEDs for bird buildings based on lamps with a capacity of 16.4W. Lighting with ЛСП 2x36 type luminescent lamps was selected for comparison. Considering the unevenness of economic costs, we accept the following prerequisites: 1) Losses and feed costs are the same in both cases; 2) the number of hens is the same in an older brood.

Table 14. Determination of the annual electric energy savings

№	Parameters	Poultry building with a luminescence lamp	Poultry building with LED-19.2 type illuminator	Illuminators with GL036-D016ON type LEDs	Poultry building with designed illuminators
1	The number of illuminators	72	72	160	66
2	The power of one lamp, W	36.2=72	19.2	16	16.4
3	The total power of the lighting system, W	5.18	1.38	2.56	1.08
4	The specific total power of the lighting system, W/m^2	6.54	1.74	1.82	1.36
5	Working time of the illuminator in a year, hour	5100	5100	5100	5100
6	The cost of 1 kW/hour, AZN	0.07			
7	Specific price for electricity in a year, AZN/m^2	4.0	1.06	1.57	0.83

Considering the recommendations, when evaluating investment projects, the use of cash flow at various times can be implemented by discounting to the initial period t_0=0. Discounting means finding a sum corresponding to a certain moment (t), which can increase with further calculating percentage.

It is recommended to use the following indicators to evaluate the effectiveness of an investment project:

1) Net discounted income (NDI); 2) The profitability index coefficient (PIC); 3) Term of payment of investments; 4) Other indicators that reflect the project specificity or the interest of the participants.

The value found by discounting the increased value is a reduced value. Inflation processes, bank investments for loans, time factors associated with securities are considered in financial calculations.

Discount norm equal to income return on investment is used to reduce various expenses, outcomes and effects. This is measured by the share unit or percentage for a year.

Technically, bringing cash flow to the base is determined by multiplying it by the discount rate.

Net discounted income is the most important efficiency criterion. NDI values calculated for different years are given in Table 15.

Table 15. Final estimation results of NDI

Service period T, year	Discount coefficient	Income, AZN	Net discounted income, AZN
0	1.000	0	- 2,688.6
1	0.870	1,349.25	- 1,515.33
2	0.756	1,349.25	- 495.11
3	0.658	1,349.25	392.04
4	0.572	1,349.25	1,163.47
5	0.497	1,349.25	1,834.29
6	0.432	1,349.25	2417.61
7	0.376	1,349.25	2,924.84
8	0.327	1,349.25	3,365.92
9	0.284	1,349.25	3,749.46
10	0.247	1,349.25	4,082.97

When using private investment in the market economy, the discount rates are determined based on the deposit interest rate. In practice, it is higher due to inflation and risk. If all investments are debt, then the discount rate reflects the appropriate interest rate.

Results

1. The study of the efficient use of energy shows that it may be more advisable to substantiate total energy consumption indicators to assess the energy efficiency of the production process in poultry enterprises.

2. It is possible to determine the air humidity, temperature and air components in the bird keeping area, as well as in the buffer zone using equations included in the developed methodology, managing parameters and external conditions for substantiation of the energy-saving ventilation variant.

3. The existing humidifying equipment set is often out of order. In the case of malfunction, there may be leakage and salt formation on the rotating disc. The obtained results allow determining the direction of the humidifier improvement.

4. A more rational method of normalizing the temperature and humidity parameters of the air in the poultry buildings under the local climatic conditions has been developed based on the plate-type evaporative refrigerator.

5. An analysis of the environmental impact of poultry factories shows that the main hazardous waste is poultry droppings. The aggravating factor is that they are rarely used and the technology is not perfect. The main environmental indicator of safe technology of the utilization of poultry droppings has been established to be the distribution of nitrogen to the environment.

6. The analysis of modern lighting systems for poultry buildings has shown that using improved LED lighting systems ensures energy-saving in this area.

7. The criterion for the efficient operation of heat exchangers in poultry buildings has been substantiated. Theoretically and experimentally, a more rational value of the cooling depth for air coolers, i.e. the cooling efficiency has been established as a special case. These values depend on the number, species and keeping methods of birds.

8. A mathematical model of energy balance has been developed for the evaporative air coolers. The main distinguishing feature of this model is the consideration of the specific evaporation properties of heat exchangers.

9. A mathematical model directed to *N* preservation during the utilization of poultry droppings based on the formation of the expert knowledge with a logical-linguistic method about the multidimensional fuzzy logic system has been developed. The main factors affecting nitrogen preservation are processing method - X_1, conservation method - X_2, application method - X_3, humidity of poultry droppings - X_4, C/N ratio in the processed mixture - X_5, and work quality - X_6.

10. A computer-based research method has been developed to improve the energy efficiency of the poultry building based on the mathematical model. Using the computer program, the number of LEDs (α=20^o, I_0=20 kd) was substantiated for the poultry buildings with the dimensions of 66mx12 m and 78mx18m, respectively, N=273 and N=259.

11. Economic efficiency due to the application of the improved cooling system in the poultry building with a capacity of 30,000 birds during the summer period was 84,187 manats. The economic benefit of the utilization of poultry droppings was 7,945.58 manats and energy saving in lighting was 20,910 kW.

Recommendations for producers

Based on the results of the research, the following recommendations were made:

- Application of the cooling device and thermal recuperators with improved and substantiated parameters for a building with a probability of generating stable heat around 322.6 kW and capacity of keeping 30,000 laying hens (average weight of one hen is 1.6 kg) in the cage; This allows maintaining the required temperature and humidity regimes inside the building throughout the year.
- Considering the environmental impact of production conditions,

application of machine technology for the utilization of poultry droppings to increase the economic efficiency and ensure ecological safety;

Application of the developed LED lighter and computer program in the poultry factories.

The main points of the dissertation are presented in the following articles:

1. Hajiyev, R.M. Features of the industrial poultry under hot climatic conditions // – Baku: Azerbaijan Agrarian Science, – 2012. No1, – pp.70-71.

2. Hajiyev, R.M. Assessment of light regimes as energy - and resourcesaving factor in industrial poultry// – Baku: Azerbaijan Agrarian Science, – 2012. No3, – pp.69-71.

3. Hajiyev, R.M. Study of air humidification system in the poultry building // – Baku: Azerbaijan Agrarian Science, – 2013. No4, – pp.76-78.

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5. Hajiyev, R.M. The study of the energy-saving ventilation regime of the poultry building // – Baku: Azerbaijan Agrarian Science, – 2014. No2, – pp.106-108.

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