doi.org/10.29295/2311-7257-2021-104-2-305-310
UDK 697.92

Spodyniuk N.[1], Shepitchak V.[2]
[1]National University of Life and Environmental Sciences of Ukraine
(Heroiv Oborony Str., 12, Kyiv, 03041, Ukraine; e-mail: n_spoduniuk@meta.ua, https://orcid.org/0000-0002-2865-9320)
[2]Lviv Polytechnic National University
(S. Bandery Str., Lviv, 79013, Ukraine, e-mail: shepitchak@gmail.com, https://orcid.org/0000-0001-5883-548X)

INCREASING BROILER FEED CONVERSION AT INFRARED HEATING IN POULTRY HOUSES

The cost of feed for a broiler company is 60-70% of the total cost of its production. Therefore, the effective conversion of feed into live weight is the most important condition for profitability, when even a very small difference in the value of FCR at a given cost of feed can have a significant effect on the profitability of the enterprise. Therefore, the article proposes the use of an effective infrared heating system in poultry house, which will increase the performance of finished products, and as a result, the profitability of production. An economic comparison of the traditional air heating system of the broiler house and the infrared heating system was carried out and the influence of the microclimate system on feed costs and weight gain of the poultry was studied. The efficiency of feed conversion of broiler chickens was increased due to the positive effects of infrared radiation on the body of chicken. This has led to a reduction in poultry feed consumption, and as a result, to a reduction in feed purchase costs by 10% per technological cycle. The overall weight gain of poultry increased and improved the main conservation rates by 6.45%. The introduction of an energy-efficient infrared heating system has reduced operating costs in the broiler house by a total of 11.2%, which has improved the main indicators of profitability of the poultry enterprise.
Key-words: feed conversion, infrared heating system, weight gain, microclimate, technological cycle.

Introduction. Among the systems for ensuring the microclimate of poultry houses that raise poultry of meat breeds, due attention is paid to highly efficient and energy-saving heating and ventilation systems in poultry houses [1]. An important factor is feed conversion (FCR), as an indicator of how effectively the conversion of used feed into live weight of poultry occurs as well as production and economic indicators at a given cost of feed [2].

If the ambient temperature drops below comfortable (ie the poultry becomes cold), the feed intake increases [3]. The extra energy derived from this supplemental feed is expended to maintain a normal body temperature, not to grow, leading to an increase in feed conversion (FCR). If the ambient temperature rises above comfortable (ie the poultry becomes hot), then feed consumption decreases, poultry growth slows down and feed conversion of poultry will be higher than the norm [4]. If the relative humidity is too high, the high ambient temperature becomes an even bigger problem as the poultry find it harder to emit excess heat. To compensate for this, it is necessary to reduce the temperature on a dry bulb thermometer. If the relative humidity is too low, the temperature of the dry bulb thermometer should be increased to create a comfortable environment for the poultry. Observing the behavior of poultry is the most effective way to control the conditioned environment [2].

As we can see, an important condition for effective feed conversion is to ensure a dynamic microclimate in the poultry house, therefore, one of the best types of heating system for such premises is an infrared heating system. The use of such a system will provide the necessary zooveterinary conditions directly in the poultry`s location area.

It is a known fact that infrared radiation has a positive effect on the body of the poultry [5, 6]. Infrared rays penetrate and are absorbed by tissues, resulting in thermal effects on the body. Therefore, infrared emitters are widely used for heating of young poultry in the cold season. At long stay of a bird under an infrared heater biological processes in an organism increase, a metabolism improves, the tone of the autonomic nervous system normalizes. Also increases the preservation, growth and productivity of poultry, which has a positive effect on feed conversion, and subsequently on weight gain of the birds [7].

In addition, direct radiant heating of the lower zone and the ability to provide local heating give a significant economic effect. Due to the use of infrared heating systems, it is possible to reduce the temperature in the room by several degrees, which is an important reserve of thermal energy. When using such systems, energy savings can reach 40 - 50%, compared to other heating systems [8, 9].

Materials and methods of research

Because the cost of feed is 60-70% of the total cost of broiler production, efficient conversion of feed into live weight is the most important condition for profitability, when even a very small difference in the value of FCR at a given cost of feed can have a significant effect on the profitability of the enterprise [2, 10].

Conversion of feed to broiler live weight is a complex process and the correction of FCR requires an interdisciplinary approach, including the choice of microclimate system (Fig.1).

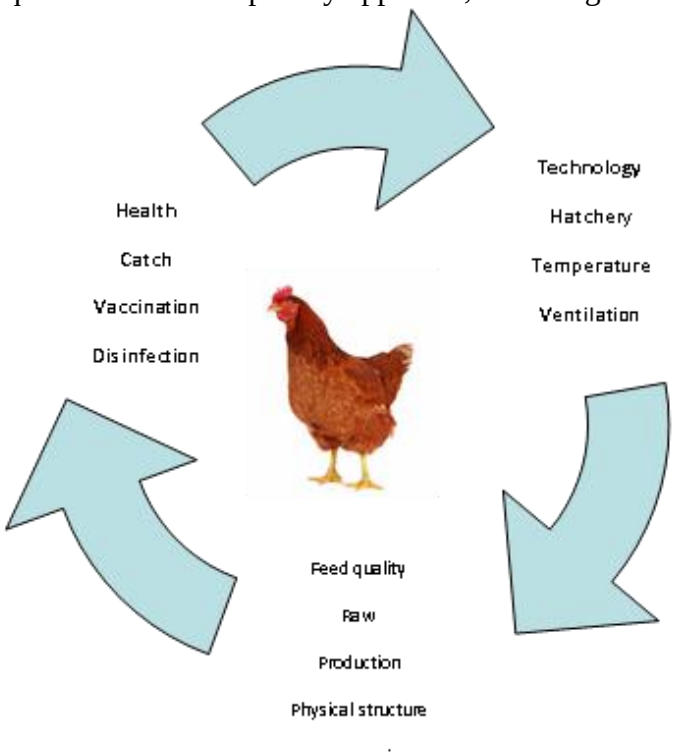

Fig. 1. Factors affecting feed conversion of broiler livestock

Therefore, the use of an efficient infrared heating system will increase the performance of finished products, and as a result, the profitability of production.

An economic comparison of the traditional air heating system of the broiler house and the infrared heating system was carried out and the influence of the microclimate system on feed costs and weight gain of the poultry was studied.

The broiler house for 34 thousand chickens with a cage arrangement of poultry was taken as a basis (Fig. 2). In a poultry house measuring 96x18 m, 3 m high, the room temperature is maintained t_{in} = 16… 35ºC and relative humidity φ_{in} = 70%. The supply air is heated in the heater of the supply unit to a temperature of t_{sup}, ºC and supplied to the upper area of the room through air ducts of uniform distribution. Air with temperature t_{in}, ºC is removed from the room through exhaust air ducts by means of roof fans. For humidification of air in the warm period of the year the cartridges for air humidification which are established in wall apertures of external protections are provided. The technological process of keeping poultry lasts 60 days when raising young animals for meat. At the end of the production cycle, the average live weight of broilers is 1.2… 1.4 kg.

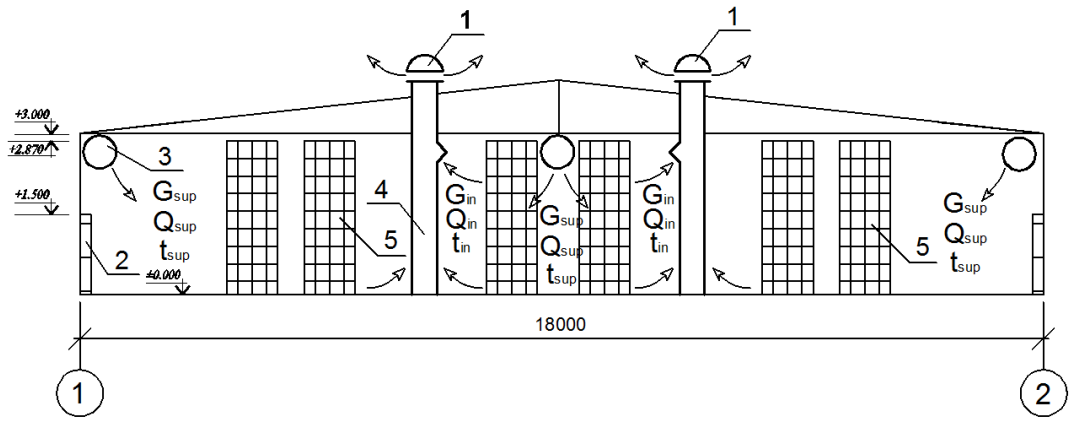

Fig. 2. Poultry house for caged broiler chickens
1 - roof fans; 2 - cartridges for air humidification; 3 - air duct of uniform distribution; 4 - exhaust air duct; 5 - cellular batteries

As an alternative, has proposed system of heat providing in the poultry house on the basis of infrared heaters and local ventilation with heat recovery at modular keeping of a poultry (Fig. 3). An infrared heating system was used to ensure the air temperature in the poultry breeding module in the range t_{in} = 16… 35ºC [11, 12]. Heated air with temperature t_{in}, ºC is removed from the module through an exhaust outlet with the amount of heat Q_{in}, W, used to heat the external supply air from the temperature t_{out}, ºC to the temperature $t_{sup} = t_{in}$, ºC in the recuperator by heat transfer. After that air is supplied to the module through the air distributor of uniform distribution and is used for assimilation of heat, damp excesses.

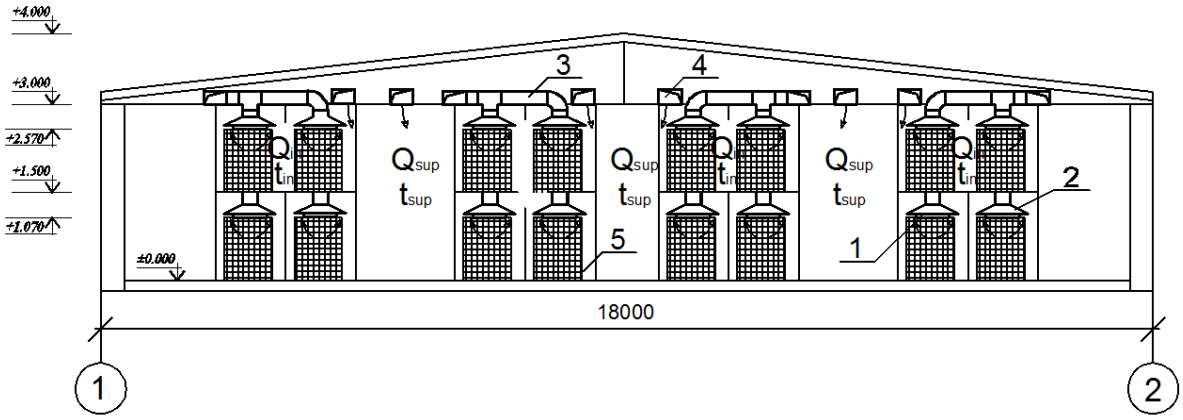

Fig. 3. Poultry house with modular keeping of broiler chickens
1 - infrared heater; 2 - exhaust outlet; 3 - exhaust air duct; 4 - supply air duct; 5 - air distributor of uniform distribution

The cost of purchasing feed and increasing the weight gain of poultry was determined by the method given in [13, 14].

For the air heating system of poultry house the cost of purchasing feed makes:

$$E_f^1 = C_f \cdot n \cdot j \cdot z, \text{ UAH / year}, \quad (1)$$

where C_f - the cost of feed per feed unit, UAH / t; n - the number of poultry, pcs.; j - daily feed consumption per 1 kg of live weight of poultry; z - duration of the period, days.

The cost of purchasing feed for the infrared heating system was determined:

$$E_f^2 = C_f \cdot n \cdot j \cdot z \cdot (1 - \frac{k_2}{100}), \text{ UAH / year}, \quad (2)$$

where k_2 – the coefficient of reduction of feed consumption for poultry is 3.9-5.1% [13].

Results of the research. Comparative analysis of poultry microclimate systems will allow to investigate their influence on poultry consumption of feed, and as a result on weight gain of poultry. This will justify the use of an efficient infrared heating system and its impact on increasing the profitability of the enterprise in terms of obtaining finished products.

The results of calculations of feed purchase costs for the compared options are summarized in the table (Table 1).

Table 1 – Comparison of heating system options by feed purchase costs

Age of the poultry, days	Live weight, kg	Feed consumption kg/kg of live weight	Air heating system, thousand UAH/year	Infrared heating system, thousand UAH/year
1 day 10 days	0.08	0.152	1292	1162
11 day 30 days	0.25	0.475	7267.5	6540.75
31 day 60 days	1.4	2.66	63308	56977.2
Total costs for the technological period, thousand UAH/period			71867.5	64680.75
Total costs for the year, thousand UAH/year			287470	258723

Discussion of results. When using the infrared heating system, the cost of purchasing feed decreased by 10% per year (Fig. 4). This indicates an increase in the profitability of the poultry farm as a whole.

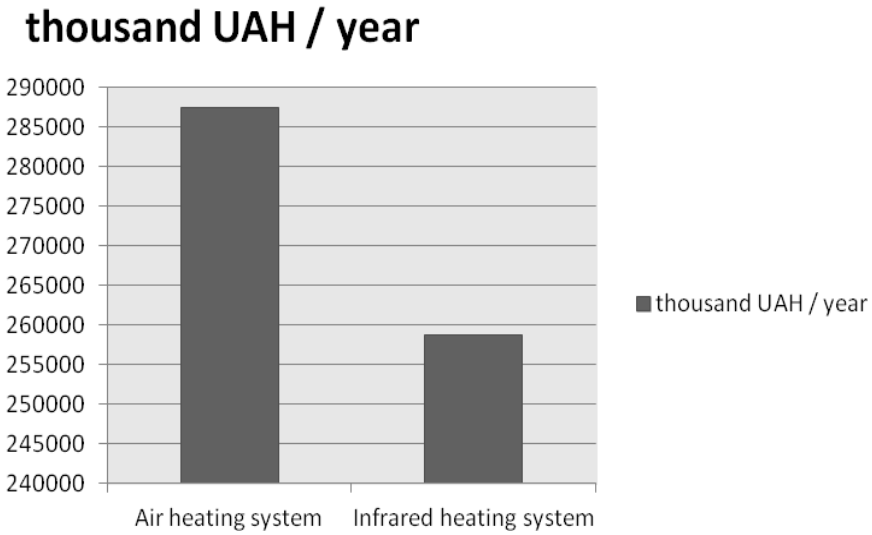

Fig. 4. Diagram of reducing the cost of purchasing feed for the proposed systems

Since FCR is calculated as the total amount of used feed divided by the live weight in the processing plant. It was advisable to investigate the increase in body weight gain of poultry using an effective infrared heating system and its positive effects on the body.

As the increase in poultry weight gain leads to an increase in finished products, the results were translated into price indicators. The calculation was performed for both variants of heating systems (Table 2).

Table 2 – Calculation of the growth of finished products for the compared options

	Air heating system, thousand UAH/year	Infrared heating system, thousand UAH/year
Total weight gain over the technological period, thousand UAH/period	4611.49	4929.77
Total weight gain per year, thousand UAH/year	18445.95	19719.08

Due to the use of infrared heating system, the microclimate in the broiler house was improved. This helped to further preserve the poultry population. As a result, the profit from the introduction of energy efficient heating system increased by 6.45%.

Conclusions. The feed conversion efficiency of broiler chickens was increased due to the positive effect of infrared radiation on the body of the poultry. This has led to a reduction in poultry consumption of feed, and, as a result, to reduce the cost of purchasing feed by 10% for one technological cycle.

The overall weight gain of the poultry increased and the overall conservation rate improved by 6.45%.

The introduction of an energy-efficient infrared heating system has reduced operating costs in the broiler house by a total of 11.2%, which contributed to the improvement of the main indicators of profitability of the poultry enterprise.

REFERENCES:

1. Vitt R., Weber L., Zollitsch W., Hortenhuber S.J., Baumgartner J., Niebuhr K., Piringer M., Anders I., Andre K., Hennig-Pauka I., Sch€onhart M., Schauberger G. Modelled performance of energy saving air treatment devices to mitigate heat stress for confined livestock buildings in Central Europe. Biosystems Engineering. 2017. Vol. 64. P. 85-97.
2. Ross Broiler Management Handbook. 2015. 127 p. URL: http://ru.aviagen.com/assets/Tech_Center/BB_Foreign_Language_Docs/RUS_TechDocs/Ross-Broiler-Handbook-2014-RU.pdf.
3. Spodyniuk N., Zhelykh V., Dzeryn O. Combined Heating Systems of Premises For Breeding of Young Pigs And Poultry. FME Transactions. 2018. Vol. 46. P. 651-657. https://doi.org/10.5937/fmet1804651S.
4. Spodyniuk N., Lis A. Research of temperature regime in the module for poultry growing. Lecture Notes in Civil Engineering, LNCE 100. 2020. P. 451-458. https://doi.org/10.1007/978-3-030-57340-9_55.
5. Spodyniuk N.A., Shepitchak V.B. Natural research of the thermal process on the surface of irradiation by infrared heater. Scientific Bulletin of UNFU. 2021. Vol. 31. No 1. P. 85-88. https://doi.org/10.36930/40310114.
6. Dudkiewicz E., Szałański P. Overview of exhaust gas heat recovery technologies for radiant heating systems in large halls. Thermal Science and Engineering Progress. 2020. Vol. 18. 10552. https://doi.org/10.1016/j.tsep.2020.100522.
7. Trokhaniak V.I., Rogovskii I.L., Titova L.L., Luzan P.H., Popyk P.S., Bannyi O.O. Computational fluid dynamics investigation of heat-exchangers for various air-cooling systems in poultry houses. Bulletin of the University of Karaganda-physics. 2020. Vol. 1. No 97. P. 125 - 134. https://doi.org/10.31489/2020PH1/125-134.
8. Sarbu I., Tokar A. Numerical modeling of high-temperature radiant panel heating system for an industrial hall. Int. J. Adv. Appl. Sci. 2018. Vol. 5. No 5. P. 1-9. https://doi.org/10.21833/ijaas.2018.05.001.
9. Kuznetsov G.V., Kurilenko N.I., Nee A.E. Mathematical modelling of conjugate heat transfer and fluid flow inside a domain with a radiant heating system. Int. J. Therm. Sci. 2018. Vol. 131. P. 27-39. https://doi.org/10.1016/j.ijthermalsci.2018.05.010.
10. Pinilla J.C., Williams A.M. Managing sow farms for high performance. Allen Leman Swine Conference Proceedings. 2010. P. 134-140.
11. Ermolaev A.N., Khaustova O.V., Turaev I.A. Simulating a convectional heat transfer in buildings with radiant gas heating. MATEC Web Conf., 2018. Vol. 194. P. 10-13. https://doi.org/10.1051/matecconf/201819401025.

12. Brown K.J., Farrelly R., O'shaughnessy S.M., Robinson A.J. Energy efficiency of electrical infrared heating elements. Applied Energy. 2016. Vol. 162. P. 581-588.
13. Lee E.H., Yang D.Y. Experimental and numerical analysis of a parabolic reflector with a radiant heat source. International Journal of Heat and Mass Transfer. 2015. Vol. 85. P. 860-864.
14. Guo-Jun Li, Jian Ma, Ben-Wen Li Collocation Spectral Method for the Transient Conduction. Radiation Heat Transfer with Variable Thermal Conductivity in Two-Dimensional Rectangular Enclosure. Journal of Heat Transfer. 2015. Vol. 137. No 3.

Сподинюк Н.А., Шепітчак В.Б. ПІДВИЩЕННЯ КОРМОКОНВЕРСІЇ БРОЙЛЕРІВ ПРИ ІНФРАЧЕРВОНОМУ ОПАЛЕННІ В ПТАШНИКАХ. Вартість корму для бройлерного господарства становить 60-70% від загальної вартості його виробництва. Тому ефективна конверсія кормів у живу масу є найважливішою умовою прибутковості, коли навіть дуже мала різниця у величині FCR при певних витратах корму може мати значний вплив на прибутковість підприємства. Тому в статті пропонується використовувати ефективну систему інфрачервоного опалення пташника, що підвищить продуктивність готової продукції, і як результат, рентабельність виробництва. Було проведено економічне порівняння традиційної системи повітряного опалення бройлерного господарства та інфрачервоної системи опалення та вивчено вплив системи мікроклімату на витрати корму та приріст маси птиці. Ефективність перетворення кормів курчат-бройлерів була підвищена за рахунок позитивного впливу інфрачервоного випромінювання на організм птиці. Це призвело до зменшення споживання кормів для птиці та, як результат, до зменшення витрат на придбання кормів на 10% за технологічний цикл. Загальний приріст маси птиці збільшився та покращив основні показники збереження на 6,45%. Впровадження енергоефективної системи інфрачервоного опалення дозволило знизити експлуатаційні витрати в бройлерному господарстві загалом на 11,2%, що покращило основні показники рентабельності птахофабрики.
Ключові слова: кормоконверсія, система інфрачервоного опалення, приріст маси, мікроклімат, технологічний цикл.