STUDY RESULTS OF THE AIR VELOCITY INSIDE THE TECHNOLOGICAL MODULE FOR BROILER CHICKENS FATTENING

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Abstract. Air velocity in the poultry house is one of the most important factors in creating the optimal environment for broiler raising. This indicator affects the stress level and the number of respiratory diseases of broilers, and, consequently, their performance. The study was conducted in the technological module, which was a block container with the dimensions of 6x2.5x3 m, designed for the one-time fattening of up to 310 broilers in cages. To ensure the optimum air velocity, the module was equipped with the tunnel ventilation system with three inlets and six exhaust fans arranged in pairs at each level of the cage battery.To determine the air velocity in the module, an active experiment method was applied, which involved measuring the airflow rate on all tiers of the cage battery while operating one, two or three pairs of exhaust fans.The air velocity was measured on the reference points at the height of birds' places and near the ventilation inlets of each tier of the cage battery. According to the measurements, the air velocity inside the module varied in the range from 0.01 $m \cdot s^{-1}$ with one operating pair of fans to 0.97 $m \cdot s^{-1}$ with the three pairs of fans working. The minimum values of air velocity (from 0.01 to 0.1 $m \cdot s^{-1}$) were in line with the regulatory indicators for broiler growing from zero to fourteen days of age; the average experimental values from 0.1 to 0.5 $m \cdot s^{-1}$ corresponded to regulatory indicators for growing broilers from fifteen to twenty-one days of age; and the maximum values of air velocity from 0.5 to 0.97 $m \cdot s^{-1}$ corresponded to the regulatory indicators for the birds older than twenty-two days. The study proved the tunnel ventilation system installed in the module to provide the required air exchange without exceeding the permissible air velocity values inside the production premises.

Key words: agriculture, poultry farming, broiler, technological module, air velocity.

Introduction

Poultry farming in Russia is one of the leading branches of meat production. The years from 2001 to 2018 witnessed a steady increase in the poultry meat production, with the overall growth being above 5.5 times, or 4204 thousand tons in slaughter weight [1]. Figure 1 shows the dynamics of changes in poultry meat production in Russia in all farm categories.

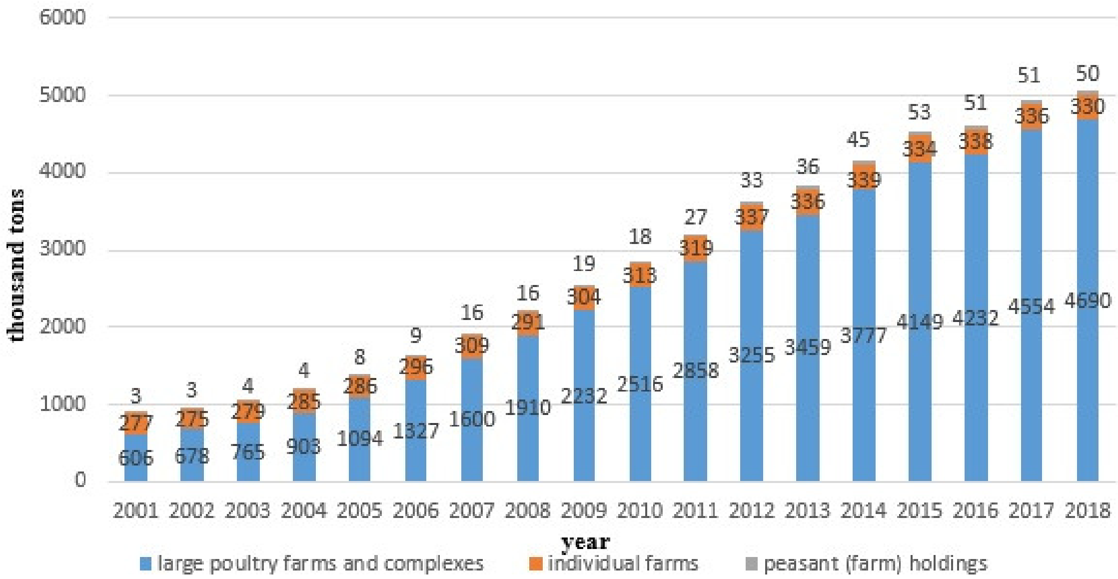

Fig. 1. **Poultry meat production in Russia by farm categories (slaughter weight, thousand tons)**

This increase is motivated by the rapid reproduction rates, intensive growth, high productivity and liveability of birds. In addition, the poultry meat is a leader in the per capita consumption of all types of meat in Russia, with the indicator of 33.5 $kg \cdot yr^{-1}$.

In the structure of poultry meat production the broiler meat is in the first place (89.7 %), followed by the layer meat (4.83 %) and turkey meat (4.67 %); other types of poultry meat account for 0.8 %.

Broiler chicken raising is popular owing to the low conversion rate (1.7), up to 8 fattening cycles per year, and no need for butchering and primary processing.

The share of small-scale poultry enterprises, such as smallholdings and private (peasant) farms, today does not exceed 7.5 % due to the lack of modern knowledge-intensive technological and space-planning solutions for poultry houses, which would envisage the use of mechanic, automatic and robotic equipment in the production processes to cut the labor inputs, to improve the sanitary and hygienic conditions for poultry, and to reduce the rate of stress situations.

Recently the number of small-scale pig farms has fallen dramatically due to the spread of African swine fever (ASF). In this regard, some measures have been introduced to switch the pig farmers to alternative agricultural activities. Considering the trend towards an annual increase in demand for poultry meat and a large number of small-scale pig farms, which have to change their profile, there is an urgent need to develop the space-planning solutions for the production premises for small poultry farms, which would specialise in broiler raising.

The Federal Scientific Agroengineering Center VIM (branch IEEP in Saint Petersburg) designed and manufactured a prototype of a technological module for broiler fattening. This is a block container with the dimensions of 6x2.5x3 m, equipped with the multi-tier cage battery with hopper feeders, nipple drinkers, heating devices, an air-exhaust ventilation system, LED lamps, and the trays for collecting and removing poultry manure [2]. The general view of the technological module and its main components are shown on Figure 2.

Fig. 2. **Technological module for broiler fattening**

The production capacity of the technological module is 2480 head per year, with the possibility of the one-time housing of up to 310 head. Broiler density is 18 head.m^{-2}. Under such a density, the main problem is to ensure the optimal air exchange inside the poultry house. According to Recommended Practice for Engineering Designing of Poultry Farms, the amount of fresh air required by poultry in cold season is 0.7-1 m^3·h^{-1} ·kg^{-1} LW and in warm season – 7 m^3·h^{-1} ·kg^{-1} LW [3]. These requirements can be fulfilled only with the forced ventilation system.

The technological module is equipped with a tunnel ventilation system with three inlets, the cases for incoming air heating and six BO-2.5 exhaust fans arranged in pairs on each tier of the cage battery. The air exchange capacity of the ventilation system is 5400 m^3·h^{-1} in warm season, when all the fans are switched on. Considering this characteristic and a relatively small inside volume of the technological module of 40.02 m^3, the inside air velocity needs to be examined as it affects some respiratory diseases of birds and, consequently, their performance.

To date, a number of studies considered the use of tunnel ventilation for growing broilers. It was proved in practice that for housing broilers aged from 0 to 14 days, the air velocity should not exceed 0.3 m·s^{-1}; for broilers aged 15 to 21 days, the air velocity should be from 0.3 to 0.5 m·s^{-1}, and for broilers older than 22 days and before slaughter, the air velocity indicator should not exceed 4 m·s^{-1} [4;5]. These air velocity indicators allow to achieve maximum productivity of broilers through utilization of harmful gases from the poultry house, as well as to reduce the risk of respiratory diseases. Based on a comparison of these air velocity indicators with the experimental data, the feasibility of a tunnel ventilation system use in the technological module will be estimated.

Materials and methods

The aim of the study was to test the installed ventilation system in the production conditions of the technological module for broiler fattening in terms of air velocity variation depending on the number of operating exhaust fans.

With this aim in view, the testing program and methodology were developed, providing for instrumental measurements. The methodology complied with the Industry Standard OST-10.31.2-86 [6]. To determine the air velocity in the module, an active experiment method was applied, which involved its measuring on all tiers of the cage battery while operating one, two or three pairs of exhaust fans. The air velocity was measured on the reference points at the height of birds' places and near the ventilation inlets on each tier of the cage battery.

The following data was recorded: cage tier A, B, C; various options for switching on Pair I, Pair II, and Pair III of fans; air flow measurement points No. 1-3, the level of measurements: U_{vi} – the level of ventilation inlets and U_{bp} – the level of birds' places, and the air velocity V.

The location of cage tiers, pairs of exhaust fans, measurement levels and reference points are shown on Figure 3.

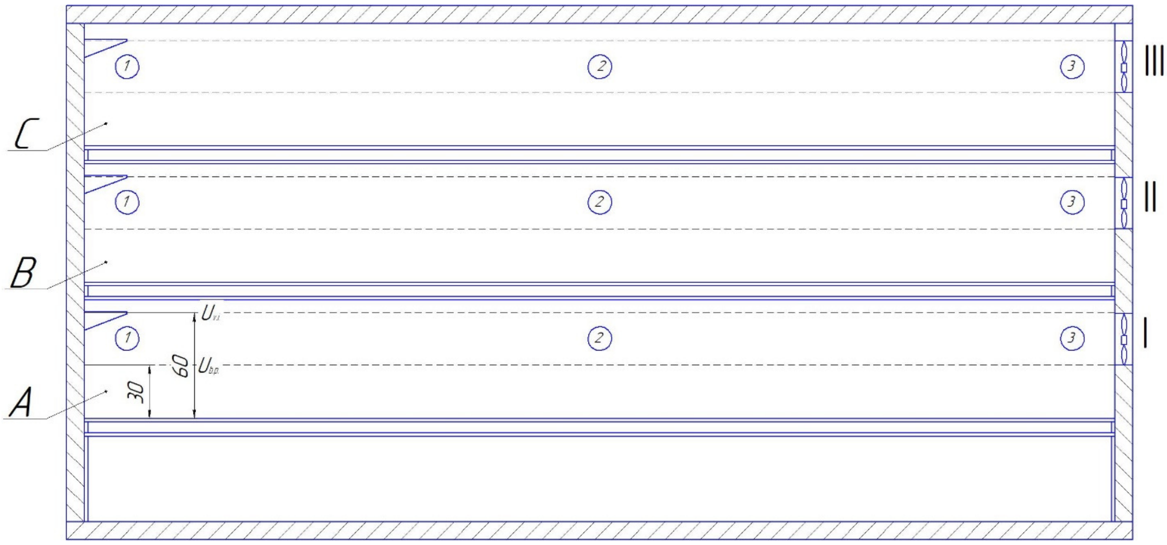

Fig .3. **Arrangement of measurement points of the air velocity in the technological module for broiler fattening**

The air velocity at the reference points was measured by TKA-PKM thermohygrometer-anemometer with the limit of permissible basic absolute measurement error for the air velocity in the range from 0.1 to 1 m·s^{-1} ± (0.045 + 0.05V) and in the range from 1 to 20 m·s^{-1} ± (0.1 + 0.05V) [7]. At each reference point, the air velosity was measured twice at each measurement level.

TKA-PKM thermohygrometer-anemometer and the method for air velocity determining are shown in Figure 4.

Fig. 4. **Method for determining the air velocity in the technological module using TKA-PKM thermohygrometer-anemometer**

The measurement results were processed by the well-known methods of mathematical statistics determining the mean values, standard deviation of the variables under study within the established time periods.

Results and discussion

The air velocity values need to be observed in poultry raising. For the birds younger than 21 days, the air velocity should be 0.01 - 0.5 $m \cdot s^{-1}$, for the birds older than 21 days – 0.5 - 4.0 $m \cdot s^{-1}$. The air velocity increases with the lower outdoor temperature [8].

The airflow in poultry houses is of great importance for metabolism, health status of birds and the sanitary-hygienic characteristics of the air environment.

The first phase of the study was to measure the air velocity in the measurement points on all cage battery tiers, with one pair of fans operating on one of the tiers.

Graphs of air velocity during the first phase of the study are shown in Figure 5.

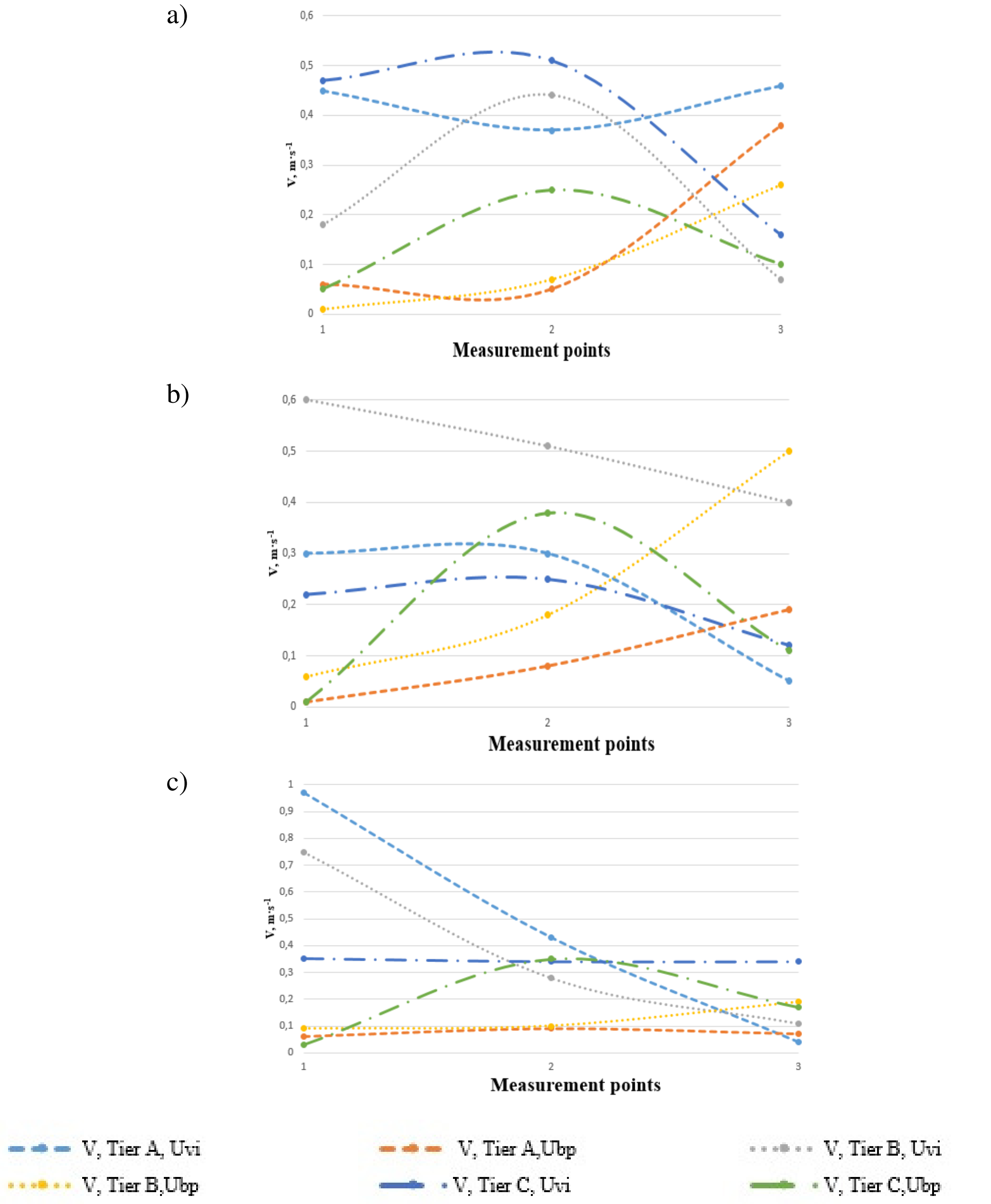

Fig. 5. **Variation of air velocity in the technological module for broiler fattening when one pair of fans works:** a – Pair I of fans; b – Pair II of fans; c – Pair III of fans

When one of the three pairs of exhaust fans was switched on, the minimum air velocity was 0.01 $m \cdot s^{-1}$ recorded at the level of birds' places; the maximum air velocity was 0.97 $m \cdot s^{-1}$ observed at the ventilation inlet. The air velocity at the level of birds' places varied in the range from 0.01 to 0.38 $m \cdot s^{-1}$; the air velocity at the level of the ventilation inlet was in the interval from 0.04 to

0.97 m·s^{-1}. The most uniform air velocity values at the level of birds' places were observed, when Pair III of fans was switched on. Therefore, if operation of only one pair of installed exhaust fans is required, Pair III is advisable.

The second phase of the study was to measure the air velocity in the reference points on all tiers of the cage, when two pairs of fans were switched on.

Graphs of air velocity during the second phase of the study are shown on Figure 6.

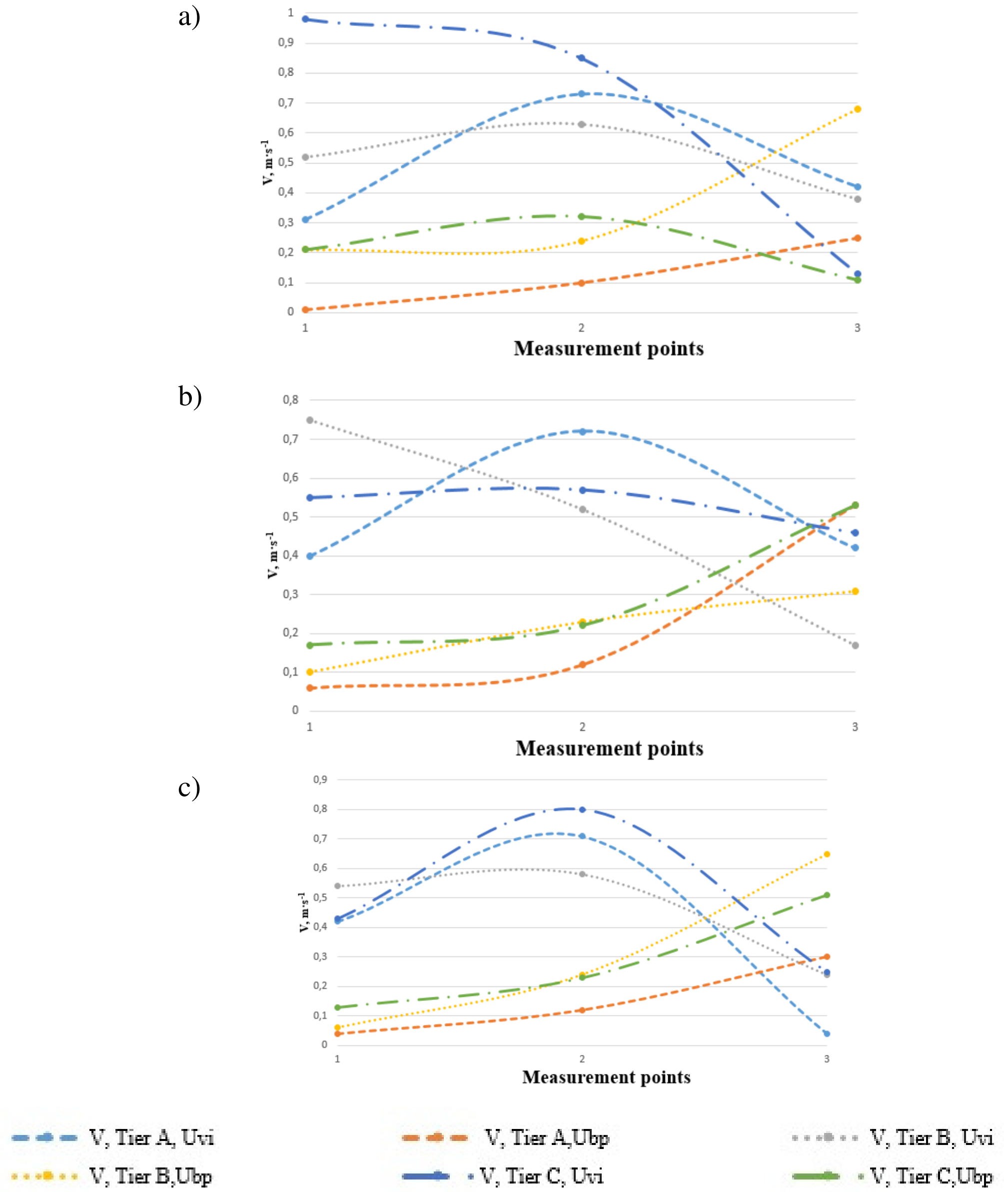

Fig. 6. **Variation of air velocity in the technological module for broiler fattening when two pairs of fans work:** a – Pair I and Pair II of fans; b – Pair I and Pair III of fans; c – Pair II and Pair III of fans

On the second phase of the study with two pairs of exhaust fans operating, the minimum air velocity was found equal to the air velocity in the first phase of the study – 0.01 m·s^{-1} recorded at the level of birds' places. The maximum air velocity at the level of the ventilation inlet also coincided with the air velocity in the first phase of the study – 0.97 m·s^{-1}. The range of air velocity at the level of birds' places was from 0.01 to 0.68 m·s^{-1}; the range of air velocity at the level of the ventilation inlet was from 0.04 to 0.97 m·s^{-1}. The most uniform air velocity at the level of birds' places was recorded when Pair II and Pair III of fans were switched on. Therefore, if two pairs of installed exhaust fans are required to operate simultaneously, Pair II and Pair III are advisable.

The third phase of the study was to measure the air velocity in the reference points on all tiers of the cage with the three pairs of fans operating.

Graphs of the air velocity during the third phase of the study are shown in Figure 7.

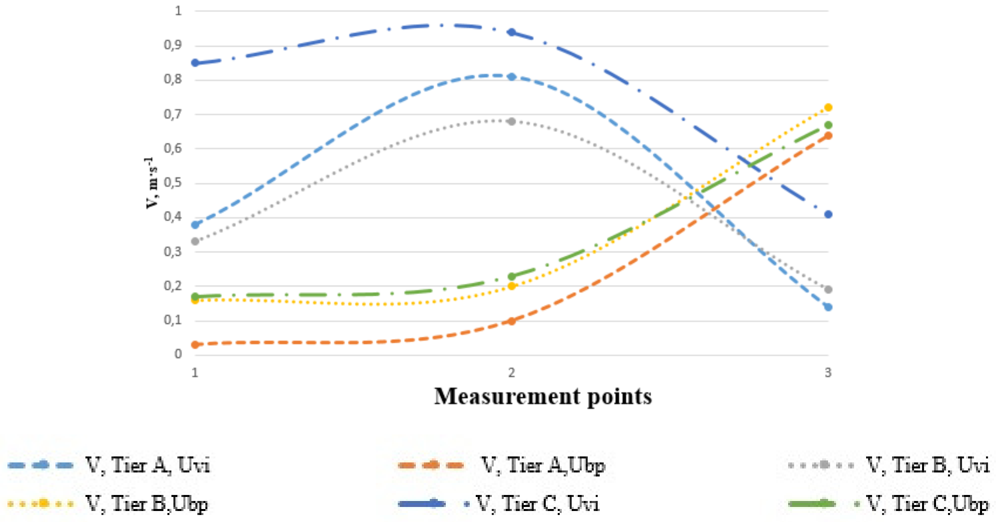

Fig. 6. **Air velocity variation in the technological module for broiler fattening when three pairs of fans are switched on**

During the third phase of the study, the three pairs of exhaust fans were switched on. The minimum air velocity of 0.03 $m \cdot s^{-1}$ was recorded at the level of birds' places; the maximum air velocity of 0.94 $m \cdot s^{-1}$ was recorded at the level of the ventilation inlet. The air velocity at the level of birds' places was in the range from 0.03 to 0.72 $m \cdot s^{-1}$; the range of air velocity at the level of the ventilation inlet was from 0.14 to 0.94 $m \cdot s^{-1}$.

The air velocity at the level of birds' places was noted to increase on all tiers of the cage in the direction from the ventilation inlets to the exhaust fans and reached the values from 0.64 to 0.72 $m \cdot s^{-1}$. This indicator does not exceed the allowable values, since the operation of the three pairs of fans is required only in the warm season at the end of the broiler fattening cycle, with the allowable air velocity being up to 2 $m \cdot s^{-1}$ [3].

Table 1 presents for comparison the experimentally obtained air velocity data in the technological module and the statistical data of this indicator.

Table 1

Comparison of experimental and statistical air velocity data

Age of broilers, days	**Experimental air velocity data, $m \cdot s^{-1}$**	**Statistical air velocity data, $m \cdot s^{-1}$**
0-14	0.01-0.38	≤ 0.3
15-21	0.01-0.65	0.3-0.5
22-45	0.03-0.72	≤ 4

A slight excess of air velocity is observed when one and two pairs of fans are operating, only in the third measurement point. This may be explained by the location of exhaust fans close to the measurement point. The average value of the air velocity inside the technological module is in line with the statistical data.

Conclusions

In the technological module for broiler fattening, a tunnel-type ventilation system was used, which provided for various options for exhaust fans operation.

The study demonstrated that in the initial period of the fattening cycle, before the broilers are 14 days old, the operation of one pair of fans was required regardless of the season. It was verified in practice that the airflow was most uniform when Pair III of fans was switched on, with the air velocity not exceeding 0.38 $m \cdot s^{-1}$. From the fourteenth to the twenty-first day of the fattening period, Pair III of fans was advisable in cold season, and two pairs of fans were to be switched on in warm season. In the latter case, the most uniform airflow was provided by Pair II and Pair III of fans, with the air velocity not exceeding 0.65 $m \cdot s^{-1}$. Three pairs of exhaust fans had to be switched on in warm season from the fortieth to the forty-fifth day of the broiler fattening cycle. The study showed that the air velocity in this case did not exceed 0.72 $m \cdot s^{-1}$ that corresponded to the standard values.

The study conducted proved the applicability of the ventilation system installed in the technological module for broiler fattening to provide the required air exchange without exceeding the permissible values of the air velocity.

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