Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 1, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

INFLUENCE OF VENTILATION SYSTEM TYPE ON MICROCLIMATE PARAMETERS IN FARROWING ROOM AND REPRODUCTIVE QUALITIES OF PIGS

Oleksandr MYKHALKO[1], Mykola POVOD[1], Bogdan GUTYJ[2], Iminjon LUMEDZE[3], Artem IOVENKO[3], Alla BONDAR[3]

[1]Sumy National Agrarian University, *Department of Feed Technology and Animal Feeding, 160, H. Kondratiiev Street, Sumy, Ukraine, Phones: +38(095)5488087, +38(066)2871386, E-mails: Oleksandr.Mykhalko@snau.edu.ua, nic.pov@ukr.net
[2]Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnologies, Department of Pharmacology and Toxicology Employment, Pekarska Street, 50 Lviv, Ukraine, Phone: +38(068)1362054, E-mail: bvh@ukr.net
[3]Mykolayiv National Agrarian University, Department of Veterinary Medicine and Hygiene, Georgia Gongadze Str., 9. Mylolayiv, Ukraine, Phones: +380967130575, +380681953950, +380666122638, E-mails: iminhalidovich@gmail.com, iovenkoartyom@gmail.com, aobondar@mnau.edu.ua

Corresponding author: snau.cz@ukr.net

Abstract

The article studied the influence of temperature and humidity in the room for farrowing sows with different types of ventilation system on other microclimatic parameters and their relationship and dependence of the reproductive qualities of sows, the health of suckling piglets and the intensity of their growth on the method of room ventilation. An experiment was conducted in two separate groups of breeders (120 farrowing sows each), which were equipped with valve and geothermal systems for creating a microclimate. It was established that the valve ventilation system provides 2.12 mg/m^3 ($p < 0.01$) lower NH_3 content and 0.40 mg/m^3 ($p < 0.001$) lower H_2S content. At the same time, using the geothermal ventilation system, the weight of the piglets' nest at weaning was higher by 3.90 kg or 5.38% compared to the counterparts that were kept using valve ventilation. The level of morbidity and mortality of piglets, as well as the veterinary component of the cost of their growth, were lower when using the geothermal ventilation system. All indicators of the microclimate were in a reliable correlation relationship. In particular, as the internal temperature in the farrowing room increased, the content of CO_2 and H_2S also increased, but the content of NH_3 and relative humidity decreased. When the relative humidity increased, the content of hydrogen sulfide decreased, but the content of ammonia and carbon dioxide also increased. The contents of NH_3, CO_2 and H_2S were also correlated, but the relationship between them was weak.

Key words: *NH_3 content, CO_2 content, H_2S content, relative humidity, internal temperature*

INTRODUCTION

The productivity of pigs grown in industrial complexes depends on various factors, one of which is the microclimate of the farm premises [25]. Permanent global climate changes, combined with the use of pig genetics sensitive to stress factors, creates significant obstacles for efficient and cheap pork production. Since the parameters of the microclimatic environment in the farrowing room significantly affect the productivity of animals. This especially applies to suckling piglets, which are born with a limited supply of vital resources and are very sensitive to environmental factors in the first days of their lives. Therefore, there is an increased requirement to create the appropriate temperature, humidity and gas composition of the air in rooms for farrowing sows [1, 36].

The microclimate consists of a list of aggregated and interrelated parameters: temperature, humidity, air movement, chemical composition of the air, the content of dust, microbes, and harmful gases in it. It depends on various factors, such as the applicable care technologies, the number of animals, the systems for providing the animals with feed and water, the removal of manure, the use of waste, as well as the season and the external climate [13, 35]. Maintaining the microclimate is quite a difficult task at all times of the year, and especially during transitional seasonal periods, where there are frequent changes in external climatic parameters both during the day and during the calendar days. This task in the farrowing room is also complicated by the fact that the optimal microclimate parameters for the sow are mostly unacceptable for newborn piglets and vice versa [7, 30]. However, technological progress offers enough new engineering solutions and strategies for their application that will help mitigate the effects of stressors by modeling a healthy physical environment for the most efficient keeping of pigs [12, 13, 32].

The degree of humidity is one of the important parameters of the microclimate in the premises for keeping pigs and directly affects the metabolic processes in their bodies. When the air temperature in the middle of the room drops excessively, the concentration of moisture automatically increases, which leads to condensation settling on the surfaces and, as a result, to an increase in humidity and hypothermia of animals, the development of fungi and the spread of pathogenic microflora. At elevated temperatures, humidity critically decreases and the air becomes dry, as a result of which pigs overheat, which also negatively affects their general condition [6, 17].

Another, no less important parameter of the microclimate of a room for keeping pigs is the internal temperature of this space [14]. An increase in temperature leads to heat stress in animals. In previously published studies, heat stress has been reported to adversely affect health and growth in adult pigs [10, 11, 31] and especially in piglets [26]. In addition, the increase in temperature in the pig house is a complex problem and can not only worsen the productivity of pigs, but also affect other indicators of the microclimate, such as gassing with harmful gases [40].

The speed of air exchange has a direct effect on both humidity and temperature, as well as on the level of air contamination with harmful gases. Slowed and insufficient air exchange can result in the growth of the mentioned indicators above the critical level. Excessively accelerated air exchange in the farrowing room can cause heat loss and hypothermia of animals in the cold season and overheating in the warm season [2].

It is known that the intensity of the release of ammonia, hydrogen sulfide, and carbon dioxide produced by pigs depends on their weight, average daily growth, animal activity, the composition of their diet, and the type of bedding [3, 5, 18, 24, 27]. However, according to widespread data, it became known that the temperature and speed of air movement in the pigsty room also reliably affected the content of hydrogen sulfide, ammonia and carbon dioxide in it [33, 15, 16].

In particular, the increase in the internal temperature in the room for farrowing led to an increase in the concentration of NH_3. The daily content of NH_3 was directly correlated with the air temperature in the premises of the pig complex (r = 0.86-0.91). The increase in ammonia content occurred together with the increase in internal temperature [9]. According to scientists, the effect of ammonia on pigs is harmful and leads to a decrease in productivity and a decrease in their live weight gain and to a decrease in feed consumption [28, 38]. Exposure to ammonia may be the reason of pathological changes in many tissues and organs of pigs [39].

In recently published works, it was indicated that the increase in temperature in the room for keeping pigs with the simultaneous decrease in air movement speed led to an reduction in the concentration of H_2S there [23]. Exposure to hydrogen sulfide reduces average daily growth, average daily feed consumption and increases the frequency of diarrhea in piglets. Increasing the content of hydrogen sulfide in sow pens can increase the number and diversity of intestinal microbiota, which is a common cause of diarrhea [5].

Similarly, according to other data [9], the CO_2 content increased with an increase in the internal temperature of the pig house, which was explained by the presence of an average direct correlation between these indicators of the microclimate (r = 0.42-0.83). Exposure to carbon dioxide has a negative effect on pigs and their offspring, in particular, it increases the frequency of stillborn piglets and abortions in sows with confirmed farrowing [8].

However, no matter which technological group of pigs releases harmful gases into the room at different internal temperatures and humidity, the task of the microclimate management system in the pig house is to remove them outside and replace them with fresh, clean air. Ensuring a healthy microclimate in the production premises that meets the physiological needs of pigs is carried out with the help of ventilation of various designs and methods of preparation and supply of external air, among which the most common are valve and geothermal systems [19].

The geothermal ventilation system provides more stable air temperature and humidity indicators and the temperature of the piglets' and sow's den throughout all seasons of the year, compared to the valve system. At the same time, it creates worse air pollution indicators [20]. The valve ventilation system better removes gassed air from the farrowing room, minimizing the negative impact of harmful gases on the reproductive qualities of sows and the growth intensity of piglets [22]. It was also found that when pigs were kept in farrowing rooms equipped with a geothermal microclimate system, indicators such as the number of piglets at weaning and the nest weight of piglets at weaning were significantly higher than in animals kept under a microclimate valve system [21].

The relationship between the humidity and air temperature in the room for keeping pigs on the one hand and the indicators of gassing on the other is considered a confirmed phenomenon, however, its strength and characteristics are manifested in different ways with the use of different ventilation systems and, as a result, it has different effects on pigs and on the formation of microclimate parameters. The study of the dependence of the content of harmful gases on the temperature and humidity of the air in a pig house with various ventilation systems is still relevant, taking into account their constant modernization and noticeable climatic changes in the natural environment, especially in transitional seasons such as autumn and spring.

The purpose of our work is to study the dependence of the content of ammonia, hydrogen sulfide and carbon dioxide on temperature and humidity in the room for keeping pigs using different systems for creating a microclimate in them in the autumn season and their effect on the reproductive qualities of sows.

MATERIALS AND METHODS

In order to carry out the research on the basis of the commercial breeder of the LLC "Globynsky Pig Complex" of the Globinsky district of the Poltava region, Ukraine, two groups of 120 sows were formed according to the principle of groups of analogues, the farrowing of which fell on one calendar week and began on November 8 (Table 1).

Table 1. Scheme of the experiment to study the influence of the type of microclimate system on the gas composition of the air and the productivity of sows

Indicator	**Valve ventilation**	**Geothermal ventilation**
Method of intake of outside air	Air intake directly from the outside environment	Air intake through underground buried air ducts
The method of air distribution inside the farrowing room	Valve distribution of air flow from the walls	Air distribution through perforated air ducts above the main part of the farrowing pens
Method of exhaust air removal	Output through exhaust shaft	Output through exhaust shaft
A group of sows	Group I	Group II
The number of sows in the farrowing section	120	120
Breed features of sows	♀L×♂LW	♀L×♂LW
Number of boars	4	4
Genotype of boars	PIC-337	PIC-337

Source: own calculations.

All sows were presented two-breed crossbreeds, whose mothers belonged to the Landrace breed and whose fathers belonged to the Large White breed of origin from the English company PIC. All sows were inseminated with mixed sperm of four terminal boars of the synthetic parental line PIC-337 breeding of the same genetic company.

During the idle and farrowing period, all experimental sows were kept under identical conditions and had the same type of background of feeding with complete balanced feed for farrowing sows. In 3-5 days before the expected farrowing on November 8, they were transferred to the premises of the reproduction section. The animals of the control group were placed for farrowing and subsequent lactation in housing No. 6 under negative pressure valve ventilation manufactured and installed by specialists of the German company Big Dutchman. In this air exchange system, the outside air was supplied via supply air valves located on the walls perpendicular to the farrowing pens.

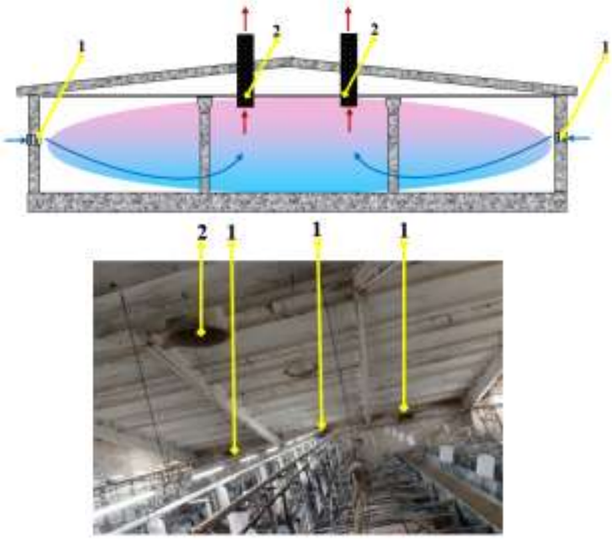

Fig. 1. Scheme of the valve system of ventilation at farrowing section in group I
1 - supply valve; 2 - exhaust shaft.
Source: Own determination.

On the same day, the animals of the experimental group were placed in an adjacent reconstructed farrowing room with an identical layout, also equipped with a negative pressure ventilation system of the same Big Dutchman company, but with a modified method of air intake, transportation and distribution. Air, under the influence of negative pressure created by the exhaust fans, enters through the air intake holes in the underground galleries located at a depth of 120 cm from the soil surface. These galleries along their entire length are filled with granite stones of large size. When passing through the galleries, the air stabilizes its temperature parameters relative to the soil temperature at this depth. Stabilized air enters the air ducts, which are located in the front part of the farrowing pens perpendicular to its location in the section, and due to the holes in its lower part, it is evenly distributed among the animals (Fig. 2).

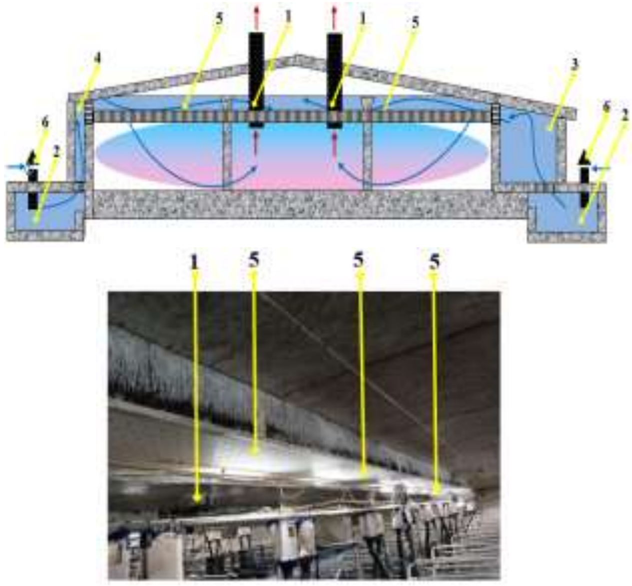

Fig. 2. Scheme of the geothermal system of ventilation at farrowing section in group II
1 - exhaust shafts; 2 - underground gallery; 3 - internal corridor; 4 - wall air duct; 5 - under-ceiling dispersive air ducts; 6 - inlet shafts.
Source: Own determination.

Coordination of the supply and exhaust elements of ventilation in both farrowing rooms was carried out by the same microclimate system control processor, based on temperature and air humidity.

During the research period, every Tuesday and Friday, the air temperature was determined using a Testo 425 thermal anemometer (Testo AG, Lenzkirch, Germany). The content of ammonia (NH_3), hydrogen sulfide (H_2S) and carbon dioxide (CO_2) was determined using a DOZOR-S-M gas analyzer (Testo AG, Lenzkirch, Germany). Air humidity was determined using a Testo 605 thermo-hygrometer (Testo

AG, Lenzkirch, Germany). All measurements were made at the level of the piglets lying 15 cm and the sow standing at 70 cm. Measurements were carried out in 8 pens of each section diagonally, in the morning from 7 to 9 o'clock and in the evening from 6 to 8 o'clock, each time in reverse order. In the experiment, the reproductive qualities of sows were studied according to generally accepted methods. The number of piglets born, fertility, weight of piglets at birth, nest weight of piglets at birth and at weaning were studied. The number of piglets in the nest when weaned at 21 days of age and their average weight, intensity of growth, percentage of morbidity in the weaning period and costs of funds for the prevention and treatment of animals during this period and the share of these costs in the total cost of raising one piglet.

For a comprehensive evaluation of the reproductive qualities of sows under different housing conditions, an evaluation index with a limited number of signs [34] was calculated according to the formula:

$$I = B + 2W + 35G \text{ ....(1)}$$

where:

I – index of reproduction qualities, points;
B – the number of piglets at birth, head;
W – number of weaned piglets, head;
G – average daily gain of piglets at weaning, kg.

For the same purpose, the selection index of reproductive qualities of sows was used according to the method [37]:

$$(SIRQS) = 6X_1 + 9.34\left(\frac{X_2}{X_3}\right) \text{..........(2)}$$

where: $SIRQS$ – selection index of reproductive qualities of sows;
X_1 – fertility, heads;
X_2 – weight of the nest at weaning, kg;
X_3 – weaning period, days.

During the experiment, all participants strictly followed the generally accepted rules of humane treatment of animals.

Statistical analysis of the results of the experiment was carried out in Microsoft Excel 2016. Values were considered statistically significant at the first – $p < 0.05$, the second – $p < 0.01$, the third – $p < 0.001$ thresholds of the Student's t-test.

RESULTS AND DISCUSSIONS

The analysis of microclimate parameters in the room for keeping suckling piglets showed that the ammonia content when using the geothermal type microclimate system was higher by 2.12 mg/m^3 ($p < 0.01$) compared to the room where the valve type of the microclimate maintenance system was used. It was also found that the hydrogen sulfide content in the brooder with experimental ventilation was 0.40 mg/m^3 ($p < 0.001$) (Table 2).

Table 2. Parameters of the microclimate in the premises at different ventilation system during the autumn season, (n = 90)

Indicator	Air temperature at the level of the pig's respiratory tract (60 cm), ºC	Relative humidity, % vol	Ammonia (NH_3) content, mg/m^3	Carbon dioxide (CO_2) content, % vol	Hydrogen sulfide (H_2S) content, mg/m^3
Group 1	19.43±0.24	67.20±0.72	13.30±0.59	0.23±0.01	2.16±0.07
Group 2	19.24±0.28	66.35±1.19	15.42±0.32**	0.25±0.01	2.56±0.15*

* – $P < 0.05$; ** – $P < 0.01$;
Source: own calculations.

No difference was found between the control and experimental rooms of the farrowing house in terms of carbon dioxide content, indoor temperature and relative humidity.

The evaluation of the correlations between the indicators of the microclimate in the room for keeping sows with suckling piglets in the autumn season showed a statistically confirmed weak interdependence between the temperature and the gas content. At the same time, the correlation of temperature with the content of NH_3 was inverse (r = -0.23; p <0.001), and with the content of CO_2 (r = 0.06; p <0.001) and the content of H_2S (r = 0.03; p <0.001) was direct. Indicators of temperature and relative air humidity were weakly correlated and had an inverse relationship (r = -0.03; p <0.001).

An inverse and weak but reliable relationship was found between relative humidity and hydrogen sulfide content (r = -020; p <0.001). Instead, relative humidity was directly correlated with both ammonia content (r = 0.29; p <0.001) and carbon dioxide content (r = 0.22; p <0.001) (Table 3).

Table 3. Correlation between microclimate indicators during the autumn season

	Temperature	**Relative humidity**	**NH_3 content**	**CO_2 content**	**H_2S content**
	r	**R**	**r**	**r**	**r**
Temperature	1.00	-0.03	-0.23	0.06	0.03
P-value	1.00	<0.001	<0.001	<0.001	<0.001
Relative humidity		1.00	0.29	0.22	-0.20
P-value		1.00	<0.001	<0.001	<0.001
NH_3 content			1.00	0.18	-0.21
P-value			1.00	<0.001	<0.001
CO_2 content				1.00	0.28
P-value				1.00	<0.001
H_2S content					1.00
P-value					1.00

Source: Own calculations.

At the same time, the gas content also correlated with each other, showing a weak dependence. The correlation relationship between NH_3 content and CO_2 content was direct (r = 0.18; p <0.001), and between NH_3 content and H_2S content, on the contrary, it was inverse (r = -0.21; p <0.001). Carbon dioxide and hydrogen sulfide were also weakly correlated (r = 0.28; p <0.001).

Regression analysis of the interdependence of indoor microclimate indicators showed that a 1.0 ^oC increase in internal temperature was due to a decrease in the content of NH_3 by 0.56 mg/m^3, an increase in the content of CO_2 by 0.001% vol (p <0.001) and an increase in the content of H_2S by 0.009 mg/m^3 (p <0.001) under the influence of the factor characteristic by 0.54%, 0.003% and 0.001%, respectively.

It was established that when the temperature increased by 1.0 ^oC, the relative humidity decreased by 0.10% vol (p <0.001), which was caused by the specified increase in the temperature index by 0.001% (Table 4).

Table 4. The regression analysis between air temperature at the level of the pig's respiratory tract (60 cm) and gases content and relative humidity during the autumn season

Indicator	**Regression equations**	**R²**	**Prob.**
NH_3 content	y = -0.5699x + 24.378	0.0543	<0.001
CO_2 content	y = 0.0018x + 0.192	0.0039	<0.001
H_2S content	y = 0.0093x + 1.981	0.0010	<0.001
Relative humidity	y = -0.1024x + 75.188	0.0012	<0.001

Source: Own calculations.

Based on the results of the regression analysis, it was proved that when the relative humidity increased, the gas content also increased. In particular, the NH_3 content also increased by 0.009 mg/m^3 (p <0.001) for every 1.0% vol increase in relative humidity (under the influence of fluctuations in the humidity index with a strength of 0.001%).

At the same time, if the relative humidity in the farrowing room increased by 1.0% vol, then the CO_2 content there also increased by 0.23% vol (p <0.001) (under the influence of fluctuations in the humidity indicator with a force of 0.08%).

When the humidity increased by 1.0% vol, the H_2S content decreased by 0.002 mg/m^3 (p <0.001) (under the influence of fluctuations in the humidity index with a strength of 0.04%) (Table 5).

Table 5. The regression analysis between relative humidity and gases content during the autumn season

Indicator	Regression equations	R²	Prob.
NH_3 content	y = 0.0093x + 1.981	0.0010	<0.001
CO_2 content	y = 0.2353x – 3.9161	0.0835	<0.001
H_2S content	y = -0.0021x + 0.0734	0.0467	<0.001

Source: Own calculations.

Part of the reproductive performance of sows also depended on the system of creating and maintaining a microclimate in their farrowing rooms. Under different microclimate creation systems, domestic sows of English origin had high indicators of reproductive qualities (Table 6). There was no significant difference between sows of the experimental and control groups in terms of the total number of piglets born, multifertility, weight of piglets at birth and litter weight of piglets at birth.

Table 6. Productive indicators of sows kept in rooms with different ventilation systems

Indicator	Group 1	Group 2
The number of sows at the end of the experiment, head	117	119
Total piglets per farrowing, head	16.4±0.43	16.4±0.46
Multifertility, head	15.0±0.36	15.1±0.41
Weight of piglets at birth, kg	1.33±0.014	1.31±0.019
Nest weight of piglets at birth, kg	20.0±0.68	19.8±0.73
The number of piglets at weaning per 1 sow, head	12.5±0.22	12.9±0.17
The number of piglets that died during the suckling period, head	2.5	2.16
Share of piglets that were treated, %	26.3	17.2
Preservation of piglets, %	83.2	85.7
Average weight of 1 piglet at weaning, kg	5.8±0.17	5.9±0.14
Weight of the nest of piglets at weaning, kg	72.5±1.17	76.4±1.04*
Absolute growth, kg	4.48±0.13	4.59±0.11
Average daily increase, g	211±3.04	217±2.97
Average costs for the treatment of 1 head, EUR	1.16	0.88
Veterinary cost of 1 kg of gain, EUR	0.26	0.19
The share of veterinary costs in the cost of one piglet, %	9.19	7.54
I, points	47.36	48.56
SIRQS, points	122.25	124.56

* – P <0.05
Source: Own calculations

At the same time, in a farrowing room with a traditional valve ventilation system, a 9.1% higher share of piglets requiring veterinary intervention was found. Also, 0.36 heads (14.3%) more piglets died from this group during the suckling period compared to animals kept under geothermal ventilation. This caused a 2.5% deterioration in the survival of piglets in sows of the control group compared to the experimental group. This, in turn, led to a decrease of 0.46 heads or 3.7% in the number of weaned piglets in the nests of these sows. Then, as for the weight of one piglet at weaning, there was no practical difference between the animals of both experimental groups. At the same time, the greater number of piglets in the nest contributed to a probable (p <0.05) increase of 3.8 kg (5.3%) in the animals of the experimental group over the control weight of the nest of piglets at weaning. Whereas, according to the intensity of growth of piglets in the post-weaning period, no significant difference was found between the animals of both groups. More frequent manifestations of diseases of piglets in a farrowing room with a traditional microclimate system caused a 24.4% (EUR 0.28) increase in the cost of treatment of one average head of piglets. This caused an increase of EUR 0.07 or 26.2% of the veterinary component of the cost of one kilogram of suckling piglet growth. Which, in turn, led to a 1.61% increase in the share of veterinary costs in the total cost of raising one piglet until weaning. According to comprehensive indicators of reproductive qualities, sows that farrowed and raised their offspring in a farrowing room with a geothermal microclimate maintenance system had an advantage of 1.9-2.5% compared to animals whose farrowing took place in a farrowing room with classical valve ventilation. Thus, piglets that were kept during the suckling period in a farrowing room with a geothermal ventilation system were 9.1% less likely to be treated, had 2.5% better survival until weaning and 3.7% more of them during this period. This, in turn, contributed to a probable increase of 5.3% in the weight of their nest at weaning, a decrease of 24.4% of the funds spent on the treatment of one piglet, a decrease of 26.2% of the veterinary component of the cost of one kilogram of growth of suckling piglets and 1.61% share of costs for prevention and treatment in the cost of rearing one piglet until weaning compared to analogues that were kept in the room under the classical valve ventilation system. At the same time, in terms of the total number of piglets at birth, multifertility, weight of piglets at birth, weight of the litter of piglets at birth, the intensity of their growth during the suckling period and the weight of one piglet at weaning, no significant difference was found between sows kept under different microclimate maintenance systems.

The significantly higher value of the ammonia content indicator found by us in the farrowing room, where the geothermal microclimate system was used, did not have a significant effect on the indicators of piglet growth intensity, as other researchers [28, 38] claimed. In our experiment, the absolute and average daily increases were equal for both valve and geothermal ventilation despite the higher NH_3 level in the experimental room.

The increased content of hydrogen sulfide in the experimental brooder with underground preparation of outside air also had no confirmed effect on piglet gains, which were almost equal in both groups, which did not coincide with reports [5].

According to the results of the assessment of the relationship between the temperature indicator and the ammonia content in our experiment, the mentioned indicators had an inverse correlation dependence, the presence of which was not confirmed in other scientific works [9], which spoke of a direct correlation between the mentioned microclimate indicators. We assume that for the growth of the temperature index, we did not get an increase, but, on the contrary, a decrease in the content of ammonia in the farrowing room due to the automatic activation of the ventilation system, which, in order to lower the internal temperature, started the process of accelerated air exchange. Accelerated air exchange immediately removed NH_3 faster than other gases, since ammonia is twice as light as air, so it concentrated in the subceiling space in the immediate vicinity of the exhaust shafts. Carbon dioxide and hydrogen sulfide, on the contrary, are heavier than air and concentrated in the lower part of the interior space of the farrowing room due to these properties. In this regard, when the internal temperature increased and the ventilation was activated, extracting ammonia that was immediately near the exhaust shafts, the available CO_2 and H_2S required longer operation of the microclimate system in order to reduce their concentrations near the floor in the living area of the piglets. An increase in the temperature in the farrowing room leads to a more intense release of CO_2 by the animals, which begin to breathe more often, and to a more intense evaporation of H_2S from underground manure pits and channels, where the circulation of exhaust air is difficult and cleaning occurs with some delay [29]. This contributes to the increase in the content of carbon dioxide and hydrogen sulfide when the internal temperature increases, even despite the automatic forced increase of air exchange by the microclimate control system, which is consistent with other reports [33, 15, 23]. However, such an increase in the concentration of the specified gases in the specified space of the brooder room is not long-lasting, because despite a temporary increase in the accumulation of their volumes at the initial stage of ventilation, their further accumulation decreases as the intensity of air exchange increases to a level sufficient to remove CO_2 and H_2S and reduce their content to a safe level [22]. However, in the process of increasing air exchange when the exhaust ventilation system is activated in manure pits and channels, the intensity of air movement also increases, which accelerates not only the removal of hydrogen sulfide, but also its diffusion from the manure surface. At an elevated temperature in the farrowing room, the surface temperature of manure in manure pits and channels also increases, which comprehensively contributes to evaporation and the simultaneous accumulation of additional hydrogen sulfide for some time, until a sufficient decrease in its surface temperature occurs [4]. This explains the temporary increase in the content of hydrogen sulfide and carbon dioxide due to the increase in internal temperature and the increase in the intensity of air exchange when forced to accelerate it by the microclimate control system.

CONCLUSIONS

The geothermal ventilation system of the room for farrowing sows contributed to the reduction of the morbidity and mortality of piglets, funds for the prevention and treatment of piglets, the reduction of the veterinary component of the cost of growth and its share in the total cost of growth, the improvement of the survival of piglets and the increase of their nest weight at weaning.

The gassing level of the sow pig house depends reliably on fluctuations in internal temperature and relative humidity. As the internal temperature increased, the content of carbon dioxide and hydrogen sulfide increased, while the content of ammonia and relative humidity decreased slightly. When the relative humidity in the farrowing room increased, the content of NH_3 and CO_2 increased, while the content of H_2S, on the contrary, decreased slightly.

The valve ventilation system provided better cleaning of the farrowing room from the content of harmful gases compared to the geothermal ventilation, however, it did not affect the indicators of sows' reproductive characteristics and the intensity of piglets' growth.

REFERENCES

[1]Baxter, E.M., Jarvis S., D'Eath, R.B., Ross, D.W., Robson, S.K., Farish, M., Nevison I.M., Lawrence, A.B., Edwards S.A., 2008, Investigating the behavioural and physiological indicators of neonatal survival in pigs. Theriogenology, Vol. 69: 773–783. https://doi.org/10.1016/j.theriogenology.2007.12.007

[2]Blanes-Vidal, V., Hansen, M., Pedersen, S., Rom, H., 2008, Emissions of ammonia, methane and nitrous oxide from pig houses and slurry: Eff ects of rooting material, animal activity and ventilation flow. Agriculture, Ecosystems & Environment, Vol. 124(3): 237–244. https://doi.org/10.1016/j.agee.2007.10.002 Accessed on 03.01.2022.

[3]Calvet S., Estellés F., Cambra-López M., Torres A.G., Van den Weghe H.F.A., 2011, The influence of broiler activity, growth rate, and litter on carbon dioxide balances for the determination of ventilation flow rates in broiler production. Poult. Sci., Vol. 90: 2449–2458. https://doi.org/10.3382/ps.2011-01580.

[4]Chowdhury, A., Rong, L., Feilberg, A., Adamsen, A., 2014, Review of ammonia emissions from a pig house slurry pit and outside storage: Effects of emitting surface and slurry depth. The Danish Environmental Protection Agency. Environmental project No. 1611. https://www.researchgate.net/profile/Md-Albarune-Chowdhury-2/publication/279255353_Review_of_ammonia_emissions_from_a_pig_house_slurry_pit_and_outside_storage_Effects_of_emitting_surface_and_slurry_depth/links/55925b2208ae15962d8e5cf0/Review-of-ammonia-emissions-from-a-pig-house-slurry-pit-and-outside-storage-Effects-of-emitting-surface-and-slurry-depth.pdf Accessed on 03.01.2022.

[5]Cui, J., Wu, F., Yang, X., Liu, T., Xia, X., Chang, X., Wang, H., Sun, L., Wei, Y., Jia, Z., Liu, S., Han, S., Chen, B., 2021, Effect of gaseous hydrogen sulphide on growth performance and cecal microbial diversity of weaning pigs. Veterinary Medicine and Science, Vol. 7(2): 424–431. https://doi.org/10.1002/vms3.324

[6]Dourmad, J.Y., Garcia-Launay, F., Narcy, A., 2013, Pig nutrition: Impact on nitrogen, phosphorus, Cu and Zn in pig manure and on emissions of ammonia,

greenhouse gas and odours. In Proceedings of the Batfarm European Workshop Reconciling Livestock Management to the Environment, Rennes, France. https://hal.archives-ouvertes.fr/hal-01594359/document Accessed on 03.01.2022.

[7]Hörtenhuber, S.J., Schauberger, G., Mikovits, C., Schönhart, M., Baumgartner, J., Niebuhr, K., Piringer, M., Anders, I., Andre, K., Hennig-Pauka, I., Zollitsch, W., 2020, The Effect of Climate Change-Induced Temperature Increase on Performance and Environmental Impact of Intensive Pig Production Systems. Sustainability, Vol. 12: 9442. https://doi.org/10.3390/su12229442

[8]Huynh, T.T.T., Aarnink, A.J.A., Spoolder, H.A.M., Verstegen, M.W.A., Kemp, B., 2004, Effects of floor cooling during high ambient temperatures on the lying behavior and productivity of growing finishing pigs. Transactions American Society of Agricultural Engineers, Vol. 47: 1773–1782. https://doi.org/10.13031/2013.17620

[9]Jeppsson, K.H., 2002, SE–Structures and Environment: Diurnal Variation in Ammonia, Carbon Dioxide and Water Vapour Emission from an Uninsulated, Deep Litter Building for Growing/Finishing Pigs, Biosystems Engineering, Vol. 81(2): 213–223. https://doi.org/10.1006/bioe.2001.0025.

[10]Johnson, J.S., Abuajamieh M., Sanz Fernandez M.V., Seibert J. T., Stoakes S. K., Nteeba J., Keating A. F., Ross, Rhoads R. P., Baumgard L., 2015, Thermal stress alters postabsorptive metabolism during pre- and postnatal development. Climate change impact on livestock: adaptation and mitigation. New Delhi (India): Springer India. 61–79. https://doi.org/10.1007/978-81-322-2265-1_5

[11]Kerr, B.J., Yen J.T., Nienaber J.A., Easter R.A., 2003, Influences of dietary protein level, amino acid supplementation and environmental temperature on performance, body composition, organ weights and total heat production of growing pigs. J. Anim. Sci., Vol. 81: 1998–2007. https:// doi.org/10.2527/2003.8181998x

[12]Li, R., 2020, Effect of partial pit exhaust ventilation system on ammonia removal ratio and mass transfer coefficients from different emission sources in pig houses, Energy and Built Environment, Vol. 1(4): 343–350. https://doi.org/10.1016/j.enbenv.2020.04.006

[13]Mader, T.L., Davis, M.S., Brown-Brandl, T., 2006, Environmental factors influencing heat stress in feedlot cattle. J. Anim. Sci., Vol. 84: 712–719 https://doi.org/10.2527/2006.843712x.

[14]Mayorga, E.J, Renaudeau, D., Ramirez, B.C, Ross, J.W., Baumgard, L.H., 2019, Heat stress adaptations in pigs. Animal Frontiers, Vol. 9(1): 54–61. https://doi.org/10.1093/af/vfy035

[15]Mielcarek-Bocheńska P., Rzeźnik W., 2019, The impact of microclimate parameters on odour emissions from pig production in spring. Ecol Chem Eng S., Vol. 26(4): 697–707. https:// doi.org/10.1515/eces-2019-0050

[16]Mihina, Š., Sauter, M., Palkovičová, Z., Karandušovská, I., Brouček, J., 2012, Concentration of harmful gases in poultry and pig houses. Animal Science Papers and Reports, Vol. 30(4): 395–406. https://www.igbzpan.pl/uploaded/FSiBundleContentBlockBundleEntityTranslatableBlockTranslatableFilesElement/filePath/419/pp395-406.pdf, Accessed on 03.01.2022.

[17]Min, L., Cheng, J.-bo, Shi, B.I., Yang, H.J., Zheng, N., Wang, J.Q., 2015, Effects of heat stress on serum insulin, adipokines, AMP-activated protein kinase, and heat shock signal molecules in dairy cows. Journal of Zheijang University Science B – Biomedicine & Biotechnology, Vol. 16: 541–548. https://doi.org/10.1631/jzus.B1400341

[18]Montalvo, G., Morales, J., Piñeiro, C., Godbout, S., Bigeriego, M., 2013, Effect of different dietary strategies on gas emissions and growth performance in post-weaned piglets. Span. J. Agric. Res., Vol. 11: 1016–1027. https://doi.org/10.5424/sjar/2013114-3185.

[19]Mykhalko, O.G., Povod, M.G., 2020a, Richna dynamika parametriv mikroklimatu tsekhu oporosu za riznykh system ventyliatsii [Annual dynamics of microclimate parameters of the farrowing shop under different ventilation systems]. Visnyk Sumskoho natsionalnoho ahrarnoho universytetu. Seriia "Tvarynnytstvo" [Bulletin of Sumy National Agrarian University. "Livestock" series], Vol. 2: 44–57. [in Ukrainian]. https://doi.org/10.33245/2310-9270-2020-158-2-44-57 Accessed on 03.01.2022.

[20]Mykhalko, O.G., Povod, M.G., 2020b, Produktyvnist svynomatok ta richna dynamika intensyvnosti rostu porosiat zalezhno vid konstruktyvnykh osoblyvostei systemy pidtrymannia mikroklimatu [The productivity of sows and the annual dynamics of growth intensity of piglets depending on the design features of the microclimate maintenance system]. Zbirnyk naukovykh prats «Tekhnolohiia vyrobnytstva i pererobky produktsii tvarynnytstva» [Collection of scientific works "Technology of production and processing of animal husbandry products"], Vol. 1: 84–95. [in Ukrainian]. https:// doi.org/10.33245/2310-9270-2020-157-1-84-95 Accessed on 03.01.2022.

[21]Mykhalko, O., Povod, M., Korzh, O., Verbelchuk, T., Verbelchuk, S., Shcherbyna, O., 2022, Seasonal dependence of the productivity of Irish origins sows from the type of microclimate systems in the farrowing room. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 22(2): 523–533. http://managementjournal.usamv.ro/pdf/vol.22_2/volume_22_2_2022.pdf, Accessed on 03.01.2022.

[22]Mykhalko, O., Povod, M., Korzh, O., Verbelchuk, T., Verbelchuk, S., Shcherbyna, O., Kalynychenko, H., Onishenko, L., 2022, Annual dynamics of microclimate parameters of farrowing room in pigsty using two different ventilation systems. Agraarteadus, Vol. 33(2): 425–434. https://doi.org/10.15159/jas.22.26.

[23]Ni, J.Q., Heber, A., Lim, T., Diehl, C., Duggirala, R.K., Haymore, B., 2002, Hydrogen sulphide emission from two large pig-finishing buildings with long-term high-frequency measurements. The Journal of

Agricultural Science, Vol. 138: 227–237. https://doi.org/10.1017/S0021859601001824

[24]Nicks, B., Laitat, M., Vandenheede, M., Désiron, A., Verhaeghe C., 2033, Emissions of ammonia, nitrous oxide, methane, carbon dioxide and water vapor in the raising of weaned pigs on straw-based and sawdust-based deep litters. Animal Research, Vol. 52(3): 299–308. https://doi.org/10.1051/animres:2003017

[25]Parker, M., O'Connor, E., McLeman, M., Demmers, T., Lowe, J., Owen, R., Abeyesinghe, S., 2010, The impact of chronic environmental stressors on growing pigs, Sus scrofa (Part 2): Social behaviour. Animal, Vol. 4(11): 1910–1921. https://doi.org/10.1017/S1751731110001084

[26]Pearce, S.C., Mani V., Boddicker R.L., Johnson J.S., Weber T.E., Ross J.W., Baumgard L.H., Gabler N.K., 2012, Heat stress reduces barrier function and alters intestinal metabolism in growing pigs. J. Anim. Sci., Vol. 90(4): 257–259. https:// doi.org/10.2527/jas.52339

[27]Pedersen, S., Blanes-Vidal, V., Joergensen, H., Chwalibog, A., Haeussermann, A., Heetkamp, M.J.W., Aarnink, A.J.A., 2008, Carbon dioxide production in animal houses: A literature review. Agric. Eng. Int. CGIR E J., Vol. 5: 19. https://www.researchgate.net/profile/Andre-Chwalibog/publication/37791707_Carbon_Dioxide_Production_in_Animal_Houses_A_literature_review/links/0046351836e759e395000000/Carbon-Dioxide-Production-in-Animal-Houses-A-literature-review.pdf, Accessed on 03.01.2022.

[28]Philippe, F.X., Cabaraux, J.F. Nicks, B., 2011, Ammonia emissions from pig houses: Influencing factors and mitigation techniques. Agric. Ecosyst. Environ, Vol. 141(3-4): 245–260. https://doi.org/10.1016/j.agee.2011.03.012

[29]Povod, M., Mykhalko, O., Korzh, O., Gutyj, B., Mironenko, O., Verbelchuk, S., Koberniuk, V., Tkachuk, O., 2022, Dependence of the microclimate parameters of the pig house on different frequency of manure pits emptying and outdoor temperature. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 22(4): 603–615. https://managementjournal.usamv.ro/pdf/vol.22_4/volume_22_4_2022.pdf, Accessed on 03.01.2022.

[30]Ramirez, B.C., Hayes, M.D., Condotta, I.C.F.S., Leonard, S.M., 2022, Impact of housing environment and management on pre-/post-weaning piglet productivity. J Anim Sci., Vol. 100(6): skac142. https:// doi.org/10.1093/jas/skac142.

[31]Renaudeau, D., Collin, A., Yahav, S., de Basilio, V., Gourdine, J.L., Collier, R.J., 2012, Adaptation to hot climate and strategies to alleviate heat stress in livestock production. Animal, Vol. 6: 707–728. https:// doi.org/10.1017/S1751731111002448

[32]Reshetnyk, A.O., Smoliak, V.V., Laiter–Moskaliuk S.V., 2016, Stan dobrobutu svynei u promyslovomu svynarstvi [The state of welfare of pigs in industrial pig breeding]. Naukovyi visnyk LNUVMBT imeni S.Z. Gzhytskoho [Scientific Bulletin of LNUVMBT named after SZ Gzhytsky], Vol. 18-4(72): 66–71. [in Ukrainian]. https://nvlvet.com.ua/index.php/journal/article/download/987/987, Accessed on 03.01.2022.

[33]Rodriguez, M.R., Losada, E., Besteiro, R., Arango, T., Velo, R., Ortega, J.A., Fernandez, M.D., 2020, Evolution of NH_3 Concentrations in Weaner Pig Buildings Based on Setpoint Temperature. Agronomy, Vol. 10(1): 107 https://doi.org/10.3390/agronomy10010107

[34]Rybalko, V.P., Berezovs'ky, M.D., Bohdanov, H.A., Kovalenko, V.F., 2005, Suchasni metodyky doslidzhen u svynarstvi [Modern methods of research in pig breeding]. Poltava: IS UAAN [Poltava: IS UAAN], 75–81. [in Ukrainian]. http://dspace.puet.edu.ua/bitstream/123456789/2057/1/%D0%9C%D0%BE%D0%BD%D0%BE%D0%B3%D1%80%D0%B0%D1%84%D1%96%D1%8F%20%20%D0%A0%D0%B8%D0%B1%D0%B0%D0%BB%D0%BA%D0%BE%2C%20%D0%A4%D0%BB%D0%BE%D0%BA%D0%B0.doc, Accessed on 16.12.2022.

[35]Sada, O., Reppo, B., 2009, Effect of animal keeping technologies on the pigsty inner climate in summer. International Scientific Conference: Engineering for Rural Development, 8, Jelgava (Latvia), 70–75. https://www.tf.llu.lv/conference/proceedings2009/Papers/12_Oliver_Sada.pdf, Accessed on 03.01.2022.

[36]Suriyasomboon, A., Lundeheim, N., Kunavongkrit, A., Einarsson, S., 2006, Effect of temperature and humidity on reproductive performance of crossbred sows in Thailand. Theriogenology, Vol. 65(3): 606–628. https://doi.org/10.1016/j.theriogenology.2005.06.005.

[37]Tsereniuk, O.M., Khvatov, A.I., Stryzhak, T.A., 2010, Otsinka efektyvnosti indeksiv materynskoi produktyvnosti svynei [Evaluation of the efficiency of indices of maternal productivity of pigs]. Suchasni problemy selektsii, rozvedennia ta hihiieny tvaryn. Zb. nauk. prats Vinnytskoho NAU [Modern problems of selection, breeding and hygiene of animals. Collection of science works of the Vinnytsia National University of Science and Technology], Vol. 3(42): 73–77. [in Ukrainian] http://socrates.vsau.org/repository/view_doc.php?filename=6689.pdf, Accessed on 03.01.2022.

[38]Wegner, K., Lambertz, C., Daş, G., Reiner, G., Gauly, M., 2014, Climatic effects on sow fertility and piglet survival under influence of a moderate climate. Animal, Vol. 8(9): 1526–33. http://doi.org/10.1017/S1751731114001219.

[39]Xia, C., Zhang, X., Zhang, Y., Li, J., Xing, H., 2021, Ammonia exposure causes the disruption of the solute carrier family gene network in pigs. Ecotoxicology and Environmental Safety, Vol. 210: 111870. https://doi.org/10.1016/j.ecoenv.2020.111870

[40]Xu, W., Zheng, K., Liu, X., Meng, L., Huaitalla, R.M., Shen, J., Hartung, E., Gallmann, E., Roelcke, M., Zhang, F., 2014, Atmospheric NH_3 dynamics at a typical pig farm in China and their implications. Atmospheric Pollution Research, Vol. 3(5): 455–463. https:// doi.org/10.5094/APR.2014.053.