Use of brooders in growing piglets to enhance their growth and preservation

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Abstract. A method of heat localization in the resting area of piglets is proposed. It has been established that the combined use of brooder and radiation or contact heating makes it possible to provide a temperature of 30.0 ± 0.17 … 30.4 ± 0.26 °С for the up to three-weeks-old aged young stock, and 26.6 ± 0.26 … 26.5 ± 0.27 °С without heating means for the seven-week-old aged animals, a reduction of air velocity by 40-50%. The installation of brooders for weaners at rearing allows creating a temperature of 23.4 ± 0.32 … 26.2 ± 0.28 °С, reducing its speed by 26.7…35.7% (P≤0.001) in comparison with the control. The use of brooders for heating contributes (P≤0.001) to an increase in the growth of live weight of young animals by the end of growing period by 8.6…9.6%, the livability – by 2…3%, and the improvement of hematopoiesis, in comparison with radiation heating by infrared lamps.

1. Introduction

The most important condition for increasing the growth and livability of animals along with complex feeding is the creation of an optimal microclimate in livestock buildings, the temperature regime in the resting area of piglets, which is due to the specific physiology of thermoregulation of young pigs [1]. The optimal temperature for newborn piglets should be 30-35 °C, and for weaners – 23-26 °C [2], however, it has a depressing effect on nursing sows, causing overheating of the body and agalactia [3]. Therefore, the creation of local radiation, contact, brooder or combined heating has a beneficial effect on the body of piglets [4]. Keeping piglets warm is critical to maintaining health and achieving early growth. It is less convenient to use than hanging heat lamp because the heat requires mounting into
piglet nest cover flaps or the lid of creep feed areas. A large warming box for weak or newborn piglets with outside dimensions of 105 × 45 × 45 cm. The lidded box has an internal capacity of 150 L, providing enough space for 20 newborn piglets [5]. The aim of this study was to analyze the thermal comfort of piglets in nursery phase, maintained in systems with EVA waste plates floor, used to reduce the animal heat transfer to the contact surface, using 24 weaned piglets, average age 23±2 days, distributed in 8 bays, using two types of floors: treatment 1: EVA plates + leaked plastic floor and treatment 2: leaked plastic floor. The experimental design was completely randomized (CRD) and the means were compared using Tukey’s test (P<0.05). The characterization of the thermal environment was performed by recording the air temperature, relative humidity, black globe temperature, luminosity and wind speed. Thermal comfort indices (black globe temperature and humidity and thermal radiation load), thermal mapping (floors and piglets) and the productive performance of animals were used to analyze the thermal comfort provided by the floors. The results indicated that the boards on the floor were shown to be efficient in reducing the transfer of sensible heat between the floor-piglet, which made heating more effective for the animals [6]. The aim of this work was to evaluate the effect of different shelter heating system types on thermal comfort and piglets’ behavior. A solar prototype water heater was built using alternative materials - SASA, which was compared to three other heating systems (conventional solar water heater - SASC, infrared lamps - SALI and concrete floor heating by means of electrical resistance (SAEL). Based on the results, it was concluded that the four tested heating systems in the shelters were deficient in the adequate temperature for the three weeks of piglets’ life and about the behavior inside the shelter the one that presented highest frequency was “walking” [7, 8]. Polypropylene fabrics may be an interesting tool to provide optimal environmental conditions for weaned piglets in winter, especially during the first two weeks after weaning. Their transmittance properties allow trapping infrared emission produced by the piglets and heating, avoiding heat losses through the roof, and therefore saving heating energy [9]. The objective of study was to evaluate the relationship between birth weight and vitality with the thermographic temperatures in piglets born to different parity sows. The vitality of piglets was determined using a numerical score based on respiratory latency, heartbeats, skin color, latency to stand up, and meconium staining of the skin. Temperatures were taken at birth, drying, and initial ingestion of colostrum and 24 h after birth. It was concluded that independently of parity, piglets with low birthweights and low vitality scores at birth are unable to increase ocular temperature even after ingesting colostrums [10].

The use of heating systems for new-born piglets can prevent major losses in the first 5 weeks of life. The present study had the objective of evaluating three heating systems in creeps for new-born piglets, being: floor-heated floor with circulating water (HF), incandescent lamp type SPOT 40 W (L) and incandescent lamp type SPOT 40 W plus black metal plate (LP). The variables evaluated were piglet performance (total weight gain and mortality), bioclimatic data (temperature and relative air humidity), animal behavior and economic revenue. Bioclimatic data were recorded in the external environment, in the maternity and in the interior of each shelter/creep for 21 days, three times a day, as well as the capture of photographic images for analysis of the animals’ disposal. The mean temperature of the retractors, the weight at weaning and the weight gain were higher in the HF treatment. Treatment HF improved the percentage of dispersed animals and provided the best thermal environment and the highest revenue at the time of the commercialization of the piglets [11].

The objective of this research was to evaluate the behavior of piglets at different heating systems using the image analysis and electronic identification devices. This research was developed in the farrowing house, with 80 piglets from birth to weaning. The results indicated for winter time the use of the standard heat lamp and electric resistance were recommended under the thermal point of view, for first and second week, however, considering the reflex of the heating in the behavior of the piglets in the third week, the heat mat was what provided better comfort condition to the animals [12].

The thermo-neutral zone of newborn piglets is around 34–36 °C and the most critical period for the survival of piglets is during the first two days of life. It has been suggested that sows may have a higher thermo-preference – closer to thermo-neutrality of the newborn piglets – around parturition. Studies in loose-housed sows have shown that sows do not avoid high temperatures at farrowing and may even
prefer to rest in areas with high temperatures (34–36 °C) during the first days after farrowing when given a choice. Moreover, since floor heating (33.5 °C) around farrowing resulted in earlier onset of suckling and improved the survival of piglets born into a heated environment, floor heating may be considered a mean of improving the pen climate during the critical early period in which the piglets only randomly use a heated piglet area provided in the pen of loose-housed sows [13].

The aim of this work is to increased growth and preservation of piglets by improving microclimate parameters in the den using brooders.

2. Material and methods

Our work envisaged the development of a method for optimizing the microclimate in the piglets’ lair in order to activate their growth processes and increase their livability. Scientific and industrial experience was conducted under the conditions of the Agricultural Production Cooperative “Ovsyanka” in the Goretsky district of the Republic of Belarus. The experimental design is shown in table 1.

### Table 1. Scientific and economic experiment design.

| Group            | Heating means, heat localization | Duration, days | Number of animals, heads |
|------------------|----------------------------------|----------------|--------------------------|
|                  | heat localization                 |                |                          |
| Control          | IR                               | 35             | 10                       | 103                       | 100                        |
| 1 experimental   | HF                               | 35             | 10                       | 104                       |
| (1st)            |                                  |                |                          |                           |
| 2 experimental   | IL+ B                            | 21             | 80                       | 101                       | 100                        |
| (2nd)            |                                  |                |                          |                           |
| 3 experimental   | HF+B                             | 21             | 80                       | 102                       |
| (3rd)            |                                  |                |                          |                           |

The material obtained in the course of a scientific experiment was processed under the conditions of the Educational Institution Belarusian State Agricultural Academy.

Experiments were carried out on sows and piglets of Belarusian large white breed. Pigs of this breed are large, the head is medium in size of a non-standard shape, the forehead is wide, and the snout is quite small, although the neck is thick and long. The back of the animals was wide, curved up. Their ears were small, resilient, not hanging, but pointing upwards. The torso and chest were long and quite wide. The length of the body in males reached 2 m, and in females – 1.7 m. The lower back of pigs was also wide with a transition to the sacrum, and the ribs were rounded. The sides and abdomen did not hang. The hooves of the breed were even and very strong. On the skin of pigs, the bristles were soft; there were no folds on the body. In general, the breed was very different, and it was difficult to confuse it with another. The most important difference was the large size of the animal. The character of the animals was calm, without aggression; also, females are good mothers and carefully care for the offspring. The weight of a small piglet at the age of 2 months was about 25 kg, at 6 months – 100, and adult animals weigh 270 and 400 kg for female and males, respectively.

In the scientific and economic experiment, four groups of nursing sows with an animal yield of ten animals each were selected, and at the age of seven weeks from each experimental group, fifty piglets were selected and transferred to the nursery group by the principle of analogues taking into account the clinical-physiological state and living mass. The experiment lasted from the birth of piglets until the young stock reached 110 days of age, i.e. before transferring to the stagnation group. The suckling pigs of the control group were kept under the IKZK 220-250 (IR) lamps, installed depending on the age of animals at a height of 0.6-1 m from the floor level for five weeks of the suckling period, of the first experimental one - on the heated floor (HF). For the piglets of the 2nd experimental group aged up to three weeks, radiation heating was created (incandescent lamps (IL) with a power of 100 W), and for the third experimental - contact (FH) heating. In addition, from the birth to the age of 80 days old, brooders were installed in the quarters for young animals of the 2nd and 3rd experimental groups (B) [14].

The following microclimate parameters were recorded. Temperature and relative air humidity were determined with a combined device TKA-PKM, model 42 (Scientific and Technical Enterprise TKA,
St. Petersburg, Russia), consisting of a signal processing unit and a measuring head with a probe, interconnected by a communication cable. The principle of instrument operation consists in conversion of light and climatic parameters of microclimate into electrical signals by sensors.

Air velocity was estimated with an anemometer TKA-PKM, model 50 (Scientific and Technical Enterprise TKA, St. Petersburg, Russia). The preservation of piglets was determined by the ratio of the number of piglets at removal from sows to the number of live piglets in the nest at birth (in %).

The number of red blood cells, leukocytes, hemoglobin concentration in the blood of piglets was determined with an Abacus junior Vet automatic blood analyzer, the protein content (total) was determined by agar gel electrophoresis, the concentration of aspartate aminotransferase (AsAT) and alanine aminotransferase – with the Multiskan Ascent photometer.

Abacus junior vet (Diatron, Austria) – is a fully automatic desktop hematology analyzer, was applied to estimate red blood cells and white blood cells, as well as hemoglobin levels in the blood of pigs. At the same time, the calculation is provided by the so-called Cullter method, or by the conductometric method, in which blood cells pass through the small aperture, as well as for measuring hemoglobin by the photometric method. The analyzer needs 25 μl of whole blood as a sample. Test tubes with samples shall be filled with blood to a height of not less than 7-8 mm. Before starting the analysis, you need to turn over the closed test tube with a sample 11 times.

A spectrophotometer CF-46 (LOMO-Spectrum, St. Petersburg, Russia) was used to measure spectral transmission coefficient (±1%) at 190-110 nm during 30 min. A multiskan Ascent photometer (Labsystems Oy, Finland) was used to examine optical density of 9-20 sec at 340-850 nm (light source – tungsten-halogen lamp 6B/10 W; half-width of filters transmission – 3-9 nm; measuring range – 0-6 Abs) at heating during 40 min.

3. Results and discussion

The dynamics of air temperature condition in the room and resting area for piglets is presented in table 2.

| Period, days | Indoors | Group of animals | Control | 1st | 2nd | 3rd |
|--------------|---------|------------------|---------|-----|-----|-----|
|              |         |                  | In the sow house |     |     |     |
| 1–2          | 18.7±0.18 | 32.7±0.18 | 22.1±0.33 | 25.8±0.22 | 26.2±0.23 |
|              |         | 34.2±0.20 | 25.1±0.53 | 30.0±0.16 | 29.8±0.16 |
| 6–7          | 19.3±0.16 | 32.7±0.12 | 22.5±0.30 | 25.9±0.17 | 26.7±0.29 |
|              |         | 34.6±0.16 | 25.6±0.55 | 30.9±0.20 | 30.2±0.17 |
| 13–14        | 20.0±0.19 | 24.1±0.13 | 23.2±0.19 | 25.6±0.19 | 26.4±0.31 |
|              |         | 26.2±0.19 | 26.2±0.56 | 29.6±0.2 | 30.2±0.26 |
| 20–21        | 20.3±0.16 | 24.2±0.19 | 23.5±0.24 | 25.3±0.18 | 26.6±0.29 |
|              |         | 26.8±0.14 | 26.3±0.48 | 30.0±0.17 | 30.4±0.26 |
| 34–35        | 21.0±0.17 | 23.0±0.16 | 24.2±0.30 | 22.8±0.14 | 22.9±0.13 |
|              |         | 26.2±0.18 | 26.8±0.50 | 27.1±0.30 | 26.3±0.24 |
| 49–50        | 20.3±0.15 | 20.5±0.15 | 20.4±0.15 | 21.4±0.20 | 21.5±0.17 |
|              |         | 23.3±0.26 | 23.5±0.36 | 26.6±0.26 | 26.5±0.27 |

In the pigsty for weaned piglets nursery

| Period, days | Indoors | Group of animals | Control | 1st | 2nd | 3rd |
|--------------|---------|------------------|---------|-----|-----|-----|
|              |         |                  |         |     |     |     |
| 50–51        | 16.8±0.17 | 17.6±0.19 | 20.3±0.22 | 19.7±0.63 | 23.4±0.32 |
| 57–58        | 17.1±0.15 | 18.0±0.10 | 20.6±0.19 | 20.4±0.71 | 24.3±0.35 |
| 64–65        | 17.5±0.18 | 18.2±0.15 | 20.8±0.12 | 20.9±0.53 | 25.0±0.19 |
| 71–72        | 18.2±0.25 | 19.0±0.13 | 21.6±0.22 | 21.2±0.50 | 25.3±0.24 |
| 79–80        | 19.2±0.19 | 19.8±0.23 | 22.4±0.28 | 22.0±0.50 | 26.2±0.28 |
| 109–110      | 20.8±0.16 | 21.9±0.14 | 25.5±0.21 | 21.8±0.25 | 25.5±0.28 |

*a*with no piglets; *b*with piglets; *c*P<0.05; *d*P<0.01; *e*P<0.001.
The air temperature in the resting area (lair) of the newborn piglets in the control group in the first two days after farrowing was 34.2 ± 0.20 °C, in the first experimental one – 25.1 ± 0.53 °C, and in brooders of the 2nd and the 3rd experimental groups – 30.0 ± 0.16 and 29.8 ± 0.16 °C, respectively. For animals of the control group, the lamps (infrared) suspension height was increased at the 2nd week from 0.6 to 0.8 m, and at the 4th week - up to 1 m above the floor, which contributed to a decrease in T in the piglets resting area to 26.2 ± 0.18 °C. The air temperature in quarters of the 1st experimental group on the 14th day of an experiment above the heated floor was 26.2 ± 0.56 °C, by the time of weaning – 26.8 ± 0.50 °C. In the 2nd and 3rd experimental groups, by the end of the 1st week of an experiment, the air temperature under the brooders increased to 30.9 ± 0.20 and 30.2 ± 0.17 °C, of the 2nd week to 29.6 ± 0.21 and 30.2 ± 0.26 °C. In the 3rd week of an experiment, we turned off the heating sources in order to reduce energy costs. Therefore, by the time of weaning under the brooders of indicated groups, the air temperature turned out to be equal to 27.1 ± 0.30 and 26.3 ± 0.24 °C. During the first month of growing in the lair of young animals of the control and 1st experimental groups, it varied within 20.3 ± 0.22 – 22.4 ± 0.28 °C, and of the 2nd and 3rd experimental groups - were higher 15.2…20.2% (P≤0.001) than in the control.

The dynamics of relative humidity and air flow rate indicators is shown in table 3.

### Table 3. Relative humidity and air velocity in the piglets resting area.

| Period, days | Indoors | Group of animals |                   |                   |                   |
|--------------|---------|------------------|-------------------|-------------------|-------------------|
|              |         |                  | **Control**       | **1st**           | **2nd**           | **3rd**           |
|              |         |                  |                   |                   |                   |                   |
|              |         |                  | In the sow house  |                   |                   |                   |
|              |         |                  | Relative humidity, % |                   |                   |                   |
| 1–2          | 70.0 ± 0.31 | 61.8 ± 0.43 | 66.6 ± 0.40<sup>a</sup> | 62.2±0.43 | 62.8±0.43 |
| 6–7          | 69.3 ± 0.44 | 61.4 ± 0.37 | 65.4 ± 0.20<sup>a</sup> | 61.6±0.39 | 61.8±0.27 |
| 13–14        | 68.3 ± 0.37 | 64.4 ± 0.53 | 65.2 ± 0.27        | 62.6±0.37 | 62.4±0.52 |
| 20–21        | 69.7 ± 0.29 | 66.0 ± 0.17 | 67.0 ± 0.17        | 61.6±0.30<sup>a</sup> | 62.0±0.17<sup>a</sup> |
| 34–35        | 69.1 ± 0.30 | 66.2 ± 0.27 | 67.0 ± 0.50        | 65.0±0.50 | 64.6±0.37 |
| 49–50        | 68.0 ± 0.21 | 66.4 ± 0.20 | 66.4 ± 0.39        | 64.4±0.53 | 64.2±0.27 |
|              |         |                  | Air velocity, m/s  |                   |                   |                   |
| 1–2          | 0.09 ± 0.005 | 0.09 ± 0.003 | 0.10 ± 0.002        | 0.05±0.003<sup>a</sup> | 0.05±0.002<sup>a</sup> |
| 6–7          | 0.10 ± 0.004 | 0.09 ± 0.003 | 0.10 ± 0.002        | 0.05±0.001<sup>a</sup> | 0.05±0.002<sup>a</sup> |
| 13–14        | 0.11 ± 0.003 | 0.10 ± 0.003 | 0.11 ± 0.002        | 0.05±0.002<sup>a</sup> | 0.05±0.003<sup>a</sup> |
| 20–21        | 0.11 ± 0.003 | 0.10 ± 0.003 | 0.11 ± 0.003        | 0.06±0.001<sup>a</sup> | 0.05±0.003<sup>a</sup> |
| 34–35        | 0.12 ± 0.005 | 0.10 ± 0.003 | 0.12 ± 0.001        | 0.06±0.002<sup>a</sup> | 0.06±0.003<sup>a</sup> |
| 49–50        | 0.12 ± 0.005 | 0.10 ± 0.002 | 0.12 ± 0.002        | 0.06±0.003<sup>a</sup> | 0.06±0.003<sup>a</sup> |
|              |         |                  | In the pigsty for weaned piglets nursery |                   |                   |                   |
|              |         |                  | Relative humidity, % |                   |                   |                   |
| 50–51        | 70.8 ± 0.32 | 68.5 ± 0.20 | 64.4 ± 0.31<sup>a</sup> |                   |                   |
| 57–58        | 69.7 ± 0.31 | 68.9 ± 0.26 | 64.0 ± 0.33<sup>a</sup> |                   |                   |
| 64–65        | 70.0 ± 0.18 | 68.4 ± 0.23 | 63.4 ± 0.25<sup>a</sup> |                   |                   |
| 71–72        | 69.7 ± 0.23 | 68.2 ± 0.17 | 63.2 ± 0.30<sup>a</sup> |                   |                   |
| 79–80        | 69.4 ± 0.26 | 68.6 ± 0.17 | 64.2 ± 0.28<sup>a</sup> |                   |                   |
| 109–110      | 69.4 ± 0.25 | 68.4 ± 0.37 | 68.2 ± 0.52        |                   |                   |
|              |         |                  | Air velocity, m/s  |                   |                   |                   |
| 50–51        | 0.16 ± 0.007 | 0.14 ± 0.003 | 0.09 ± 0.003<sup>a</sup> |                   |                   |
| 57–58        | 0.17 ± 0.005 | 0.15 ± 0.004 | 0.09 ± 0.002<sup>a</sup> |                   |                   |
| 64–65        | 0.18 ± 0.005 | 0.15 ± 0.005 | 0.11 ± 0.003<sup>a</sup> |                   |                   |
| 71–72        | 0.18 ± 0.004 | 0.16 ± 0.005 | 0.11 ± 0.003<sup>a</sup> |                   |                   |
| 79–80        | 0.18 ± 0.005 | 0.18 ± 0.004 | 0.12 ± 0.003<sup>a</sup> |                   |                   |
| 109–110      | 0.19 ± 0.005 | 0.18 ± 0.005 | 0.19 ± 0.005        |                   |                   |

<sup>a</sup>P≤0.001.

In the lair of newborn piglets of the experimental groups, the relative humidity ranged from 61.8 ± 0.43
to 66.6 ± 0.40%. In the 2nd and 3rd experimental groups, it was below the control in the third week of the experiment by 6.1-9.7% (P≤0.001), in the seventh week by 6.0% (P≤0.001), before removal of the brooders - by 6.4-7.3% (P≤0.001).

The air velocity in the sucking pigs resting area of the control and the 1st experimental group ranged from 0.09 ± 0.003 to 0.12 ± 0.002, young stock at nursery - from 0.14 ± 0.003 to 0.19 ± 0.005 m/s, and the 2nd and 3rd experimental groups - from 0.05 ± 0.001 to 0.06 ± 0.003 and from 0.09 ± 0.003 to 0.12 ± 0.003 m/s, respectively, and was significantly (P≤0.001) lower than the control and the 1st group.

The results of the piglets growth dynamics studies are presented in table 4.

The live weight of piglets contained under the combined heating exceeded the control at the age of three weeks by 6.5-6.6%, of five weeks – by 8.2-8.9% (P≤0.05).

When transferring to nursery, this indicator in piglets of the 2nd (15.7 ± 0.37kg) and 3rd (15.9 ± 0.28 kg) experimental groups (P≤0.05-0.001) exceeded the control by 8,8% and 10.0%, when removing brooders – by 11.8% (27.2 ± 0.28 kg) and 12.8% (27.5 ± 0.32 kg), when transferred to sagination - by 8.6% (44.4 ± 0.32 kg) and 9.6% (44.8 ± 0.39 kg), respectively (P≤0.001).

### Table 4. Piglet growth dynamics.

| Period, days | Piglet live weight, kg |
|--------------|------------------------|
|              | Group of animals       |
|              | Control | 1st      | 2nd      | 3rd      |
| at birth     | 1.28±0.04  | 1.33±0.04 | 1.31±0.05 | 1.29±0.05 |
| 21st         | 5.6±0.17   | 5.5±0.20  | 5.9±0.18  | 5.9±0.19  |
| 35th         | 9.0±0.20   | 8.9±0.20  | 9.7±0.27<sup>a</sup> | 9.8±0.30<sup>a</sup> |
| 50th         | 14.5±0.31  | 14.4±0.30 | 15.7±0.37<sup>a</sup> | 15.9±0.28<sup>b</sup> |
| 80th         | 24.4±0.30  | 24.1±0.24 | 27.2±0.28<sup>c</sup> | 27.5±0.32<sup>c</sup> |
| 110th        | 40.9±0.33  | 40.2±0.24 | 44.4±0.32<sup>c</sup> | 44.8±0.39<sup>c</sup> |

<sup>a</sup>P<0.05; <sup>b</sup>P<0.01; <sup>c</sup>P<0.001.

The piglets livability and causes of mortality are presented in table 5.

### Table 5. Piglets livability and causes of mortality.

| Indicator                      | Group of animals |
|--------------------------------|------------------|
|                                | Control | 1st | 2nd | 3rd |
| Number of piglets at the       | 103     | 104 | 101 | 102 |
| beginning of the experiment,    |         |     |     |     |
| heads                          |         |     |     |     |
| Mortality of piglets, heads    | 6       | 7   | 3   | 4   |
| including stepped on by a      |         |     |     |     |
| sow, heads                     |         |     |     |     |
| Livability, %                  | 94.2 ± 2.11 | 93.3 ± 1.62 | 97.0 ± 1.54 | 96.1 ± 1.34 |

In the 2nd and 3rd experimental groups, the livability of piglets was higher by 3.0 and 2.0%, respectively, compared with that in the control. The main reason for the mortality of piglets in the control and the 1st group is stepping them on by a sow in the 1st week of life. The cause of the remaining animals mortality in the experimental groups was gastroenteritis.

The dynamics of nursing sows litter weight is presented in table 6. If at the beginning of the experiment, it ranged between groups from 13.2 ± 0.24 to 13.8 ± 0.28 kg, then on the 21st day of lactation this indicator in sows of the 2nd and 3rd experimental groups exceeded the control by 7.6 and 7.7%, and for the period of piglets weaning - by 9.3 and 10.0% (P≤0.05).
Table 6. The dynamics of nursing sows litter weight, kg.

| Period, days | Group of animals | Control | 1st | 2nd | 3rd |
|--------------|------------------|---------|-----|-----|-----|
| 1st          |                  | 13.2±0.24 | 13.8±0.28 | 13.2±0.67 | 13.2±0.27 |
| 21st         |                  | 54.0±1.26 | 53.5±2.18 | 58.1±1.92 | 58.2±2.52 |
| 35th         |                  | 87.2±1.19 | 86.5±2.52 | 95.4±3.83 | 95.9±3.79<sup>a</sup> |
| 50<sup>th</sup> |                | 140.4±1.12 | 139.2±4.96 | 154.3±6.22<sup>a</sup> | 156.0±4.01<sup>b</sup> |

<sup>a</sup>P<0.05; <sup>b</sup>P<0.001.

Thus, the combined heating during 21 days of the suckling period, and brooding in the post-weaning and during the first month of keeping piglets at nursery, contributed to the growth and livability of animals.

Morphological indicators, plasma enzymes strength in experimental animals are presented in table 7. The combined heating of piglets of the 2nd and 3rd experimental groups contributed to an increase in the number of red blood cells by 27.5 (P≤0.001) and 23.9% (P≤0.001), and the concentration of hemoglobin by 10.7 (P≤0.05) and 15.1% (P≤0.01) for the period of weaning compared to control, respectively.

Table 7. Morphological indicators, plasma enzymes strength of piglets.

| Name of indicator | Observation period, days | Control | 1st | 2nd | 3rd |
|-------------------|--------------------------|---------|-----|-----|-----|
| Red blood cells, 10¹²/L |                          | 5.3±0.12 | 5.3±0.24 | 6.8±0.21<sup>c</sup> | 6.6±0.18<sup>c</sup> |
| White blood cells, 10⁹/L |                          | 9.0±0.25 | 9.3±0.15 | 8.9±0.17 | 9.2±0.12 |
| Hemoglobin, g/L       |                          | 117.6±3.05 | 113.8±3.10 | 130.2±2.60<sup>a</sup> | 135.4±2.45<sup>b</sup> |
| AsAT, nkat/L          | 35                       | 252.3±55.1 | 289.1±45.61 | 461.8±51.33<sup>a</sup> | 315.6±75.32 |
| AlAT, nkat/L          | 421.1±30.2               | 452.2±75.02 | 475.4±114.3 | 506.4±109.21 |
| Red blood cells, 10¹²/L | 50                       | 5.9±0.24 | 6.0±0.09 | 6.2±0.23 | 6.0±0.12 |
| White blood cells, 10⁹/L |                          | 9.3±0.11 | 9.3±0.16 | 9.3±0.17 | 9.1±0.14 |
| Hemoglobin, g/l       | 117.6±0.55               | 115.0±2.00 | 126.6±3.81<sup>a</sup> | 122.8±1.90<sup>a</sup> |
| AsAT, nkat/L          | 308.6±40.3               | 252.3±30.11 | 370.6±12.82 | 347.3±51.02 |
| AlAT, nkat/L          |                          | 456.0±45.1 | 393.9±29.81 | 426.9±14.93 | 351.2±45.14 |
| Red blood cells, 10¹²/L | 80                       | 5.2±0.20 | 5.6±0.43 | 6.2±0.25<sup>b</sup> | 6.3±0.17<sup>b</sup> |
| White blood cells, 10⁹/L |                          | 8.7±0.25 | 9.0±0.25 | 9.2±0.09 | 9.0±0.08 |
| Hemoglobin, g/l       | 115.0±2.50               | 122.8±6.61 | 133.8±2.91<sup>b</sup> | 132.6±2.96<sup>b</sup> |
| AsAT, nkat/L          | 461.2±63.9               | 475.1±31.12 | 459.6±27.62 | 395.3±45.12 |
| AlAT, nkat/L          |                          | 461.2±63.9 | 475.1±31.11 | 459.6±27.62 | 395.3±45.11 |

<sup>a</sup>P<0.05; <sup>b</sup>P<0.01; <sup>c</sup>P<0.001.

Continued use of brooders for weaned piglets of these groups contributed to a slight increase in the content of red blood cells by the age of 50 days and a significant (P≤0.05) increase in hemoglobin concentration by 7.6 and 4.4%, and by the age of 80 days (P≤0.01) - by 20.5 and 22.0% of red blood cells, by 16.3 and 15.3% of hemoglobin concentration.
During brood heating in piglets of the experimental groups, the AlAT strength was higher than the control at weaning by 7.4–20.1%, and AsAT by 14.6–83.1%, but a significant (P≤0.05) difference in the AsAT strength was only between the control and the 2nd experimental groups. By the 50th day of the experiment, this indicator was 12.6 and 20.1% higher than in the control group, but the difference was not significant. When removing brooders, dependencies in the concentration of AlAT and AsAT between the control and experimental groups were not established.

The dynamics of total protein and protein fractions is presented in table 8.

### Table 8. The dynamics of serum protein assay of piglets.

| Group of animals | Observation period, days | Total protein, g/l | Protein fractions, % |
|------------------|--------------------------|--------------------|---------------------|
|                  |                          |                    | Alubmin             | α-     | β-     | γ-     |
|                  |                          |                    |                     | globulins | globulins | globulins |
| Control          | 35                       | 60.6 ± 2.38        | 32.3 ± 0.58         | 32.9 ± 1.62 | 17.4 ± 1.80 | 17.2 ± 0.58 |
| 1<sup>st</sup>   | 65.5 ± 0.65              | 31.9 ± 0.65        | 32.8 ± 2.32         | 17.4 ± 1.45 | 17.7 ± 2.70 |
| 2<sup>nd</sup>   | 67.4 ± 3.66              | 34.3 ± 1.26        | 30.9 ± 1.17         | 17.1 ± 0.41 | 17.5 ± 1.22 |
| 3<sup>rd</sup>   | 68.8 ± 1.39<sup>a</sup>  | 33.9 ± 0.91        | 31.0 ± 1.56         | 18.4 ± 2.14 | 16.5 ± 1.66 |
| Control          | 50                       | 66.0 ± 0.87        | 33.1 ± 1.45         | 31.6 ± 1.86 | 18.9 ± 1.60 | 16.3 ± 1.18 |
| 1<sup>st</sup>   | 65.3 ± 2.27              | 32.9 ± 0.53        | 30.0 ± 3.02         | 19.4 ± 2.26 | 17.6 ± 2.27 |
| 2<sup>nd</sup>   | 70.2 ± 4.88              | 34.5 ± 1.15        | 29.0 ± 1.71         | 17.4 ± 0.86 | 19.0 ± 0.82 |
| 3<sup>rd</sup>   | 72.3 ± 2.09<sup>a</sup>  | 34.4 ± 0.84        | 27.9 ± 1.31         | 20.3 ± 1.62 | 18.7 ± 0.79 |
| Control          | 80                       | 66.0 ± 4.36        | 34.0 ± 0.81         | 29.5 ± 2.11 | 18.9 ± 0.75 | 17.4 ± 2.37 |
| 1<sup>st</sup>   | 67.4 ± 5.26              | 31.9 ± 1.10        | 30.6 ± 1.84         | 19.4 ± 0.52 | 16.5 ± 2.07 |
| 2<sup>nd</sup>   | 67.4 ± 1.92              | 33.8 ± 1.44        | 30.4 ± 0.94         | 18.2 ± 1.08 | 17.3 ± 2.01 |
| 3<sup>rd</sup>   | 71.6 ± 2.76              | 32.6 ± 2.00        | 33.3 ± 3.80         | 17.3 ± 1.10 | 16.6 ± 2.75 |

<sup>a</sup>P<0.05.

When brooder heating, the piglets at weaning exceeded the control by 11.3 and 13.6% (P≤0.05) by the total protein content in the blood serum, and on the 50th day of the experiment, by 6.3 and 7.9% (P≤0.05). We did not establish a significant difference between groups.

The studied blood parameters of animals during the experiment were within the physiological norm.

Thus, the piglets keeping during the first three weeks of the suckling period during combined heating stimulates hematopoiesis: the number of red blood cells and the concentration of hemoglobin in blood, the level of total protein, aminotransferases strength increase compared to those in the control at the time of weaning. Such a pattern in the dynamics of specified blood indices in the 2nd and 3rd experimental groups was observed before the brooders were removed.

### 4. Conclusion

In order to localize heat in the den of piglets during the growing period, cylindrical brooders are proposed, limited from above by a truncated cone with a valve on the fasteners, which allows closing its hole to create a closed air space inside the brooders.

The combined heating for three weeks of the suckling period, and later, until the age of 80 days is only brooding, makes it possible to provide a temperature of 30.0-30.4 °C for the up to three-weeks-old aged young stock, and 26.6-26.5 °C without heating means for the seven-week-old aged animals, a reduction of air velocity by 40-50%. The installation of brooders for weaners at rearing allows creating a temperature of 23.4-26.2 °C, reducing its speed – by 26.7-35.7% (P≤0.001) in comparison with the control. The use of brooders for heating contributes (P≤0.001) to an increase in the growth of live weight of young animals by the end of growing period by 8.6-9.6%, the livability – by 2-3%, and the improvement of hematopoiesis, in comparison with radiation heating by infrared lamps, a hematopoiesis stimulation, an increase in the total protein concentration, an aminotransferases strength in serum compared to those in the control.
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