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OPTIMIZATION OF MICROCLIMATE IN LIVESTOCK BUILDINGS AS A KEY FACTOR IN PREVENTING DISEASES IN CALVES

Kolechko A.V.
PhD of Veterinary Medicine
Vinnytsia National Agrarian University, Vinnytsia, Ukraine
ORCID: 0000-0002-8644-3616
VNAU, Faculty of Veterinary Medicine, Vinnytsia, Ukraine
Pikula O.A.
Candidate of Agricultural Sciences
Vinnytsia National Agrarian University, Vinnytsia, Ukraine
ORCID: 0000-0001-8950-6099
VNAU, Faculty of Veterinary Medicine, Vinnytsia, Ukraine

Abstract. *The article analyzes the impact of microclimatic conditions in calf housing on their health, with a particular focus on the prevention diseases. Key microclimate parameters (temperature, relative humidity, air velocity, concentration of harmful gases, dustiness) and their normative values for calves of different age groups are highlighted. The results of the author's own research on the relationship between microclimate deviations and increased morbidity in young animals are presented. The necessity of a comprehensive approach to optimizing housing conditions, including effective ventilation, heating, proper lighting, and timely waste removal, is substantiated. Practical recommendations for implementing effective measures to improve the microclimate in calf houses are proposed to reduce economic losses in cattle breeding.*

Key words: *calves, microclimate, veterinary hygiene, disease prevention, respiratory diseases, livestock buildings.*

Introduction.

Modern livestock farming requires high standards of animal husbandry and feeding to ensure their health, productivity and economic efficiency. This issue is especially acute in dairy and beef cattle breeding, where the growth and preservation of young animals is the key to the success of the farm. Diseases of young animals, especially respiratory and gastrointestinal diseases, lead to significant economic losses due to reduced live weight gain, increased treatment costs and mortality.

One of the key factors that significantly affects the health of calves is the microclimate of livestock facilities. Suboptimal indicators of temperature, humidity, air velocity, as well as high concentrations of harmful gases (ammonia, hydrogen sulfide, carbon dioxide) and dust negatively affect the immune system of young animals, making them more vulnerable to pathogens [3, 5]. The National Standard of Ukraine DSTU 4123:2006 is important for assessing air quality [2]. In addition, an unfavorable microclimate can directly affect digestion and metabolism, reducing the digestibility and absorption of nutrients from feed, and cause protein metabolism disorders.

The problems of microclimate impact on animal health have been the subject of research by many domestic and foreign scientists. Among the leading Ukrainian researchers in this field, it is worth noting the works of such scientists as *Protopopov* M.M. [3] and Khomenko V.M. [5], who emphasized the importance of housing hygiene in their textbooks on veterinary hygiene. Kovalenko V.O. [1] studied the effect of microclimate on the productivity and morbidity of cattle. Stepanenko S.V. [4] devoted his work to the sanitary and hygienic assessment of the air environment of livestock premises.

Foreign scientists also paid considerable attention to the study of the relationship between environmental conditions and animal health and productivity. In particular, M.M. Smith and T.J. Divers [14] in their works consider the impact of the environment on internal diseases of large animals. The issue of animal welfare and the impact of the environment on it is comprehensively covered by J. Webster [19]. Studies of the influence of housing conditions on the welfare of dairy cows were conducted by Cook N.B. and Nordlund K.V. [8], Tucker K.B. and Viri D.M. [16], as well as a group of scientists von Keiserling M.A.G. et al. The relationship between housing conditions and lameness of dairy cows was studied by Smith I. et al. [13]. Fricke R. and colleagues [11] reviewed environmental monitoring to assess the welfare of dairy cattle. Environmental management practices on dairy farms were studied by Barkema G.V. et al. [6].

The impact of microclimate on the health and welfare of other animal species is also the subject of active research. For example, Yanchuk O. et al [20] consider technologies for regulating microclimate in organic livestock. Pradhan S. et al. [12] reviewed the impact of microclimate on the growth and behavior of buffaloes. For pigs, the study by Choi G. et al. [7] studied the correlation between animal parameters and environmental parameters. Chykhovska M. et al [9] reviewed the impact of environmental enrichment on pig welfare. Toma N. et al. [15] investigated the effect of environmental conditions on the health of weaned piglets. The issue of air quality in livestock facilities and its risks to animal and human health were reviewed by Watson K.M. [18]. A general review of the scientific literature on animal welfare and the environment was carried out by Dawkins M.S. [10].

Despite a significant number of studies, the issue of comprehensive microclimate optimization in modern conditions of intensive livestock production remains relevant and requires further study and implementation of practical recommendations, which was the purpose of this study.

The aim of the study was to investigate the effect of various microclimate parameters in calf housing on their physiological parameters, health status and feed intake efficiency, as well as to develop practical recommendations for disease prevention by optimizing hygienic conditions.

Materials and methods of research.

The research was carried out on the basis of the Shcherbych farm in the period 2023-2025. The object of the study was calves of the dairy period of cultivation (from 10 to 90 days) in the amount of 100 heads, and the premises in which they were kept.

Two groups of calves were formed. Control group (n=50): kept in standard farm conditions. Experimental group (n=50): for which measures to optimize the microclimate were implemented.

Microclimate monitoring: measurement of microclimate indicators was carried out monthly, three times a day (morning, afternoon, evening), throughout the study period. The following devices were used: digital thermo-hygrometer (air temperature and relative humidity), anemometer (air velocity), gas analyzers (ammonia (NH_3) and hydrogen sulfide (H_2S) concentration), portable CO_2 meter (carbon dioxide (CO_2) concentration), dust content was determined by gravimetric method using an aspirator.

Assessment of calves' health and productivity: clinical examination included daily inspection of calves for signs of respiratory (coughing, sneezing, nasal discharge, shortness of breath) and gastrointestinal (diarrhea, refusal to feed) diseases. The morbidity was recorded by keeping individual records of morbidity, duration of illness, and mortality. Average daily live weight gain was determined by monthly weighing of calves.

Assessment of feed digestibility and protein metabolism: Determination of feed digestibility and assimilation (a balance experiment was conducted on 5 calves from each group at the age of 60 days using generally accepted methods). Biochemical blood test (blood samples were taken from calves from each group at the age of 30 and 60 days to determine the level of total protein, albumin, globulins, urea and creatinine using standard laboratory kits).

Measures to optimize the microclimate (for the experimental group): Installation of supply and exhaust ventilation with automatic regulation of air exchange intensity depending on temperature and concentration of harmful gases. Use of additional heating in winter (infrared lamps/heat guns) to create localized comfort zones. Regularly adding dry adsorbents (e.g. limestone, zeolite) to the bedding to bind ammonia and reduce moisture. Optimization of the manure removal and litter replacement regime.

The data obtained were processed using MS Excel. The methods of analysis of variance, Student's t-test for comparing mean values, and correlation analysis were used. The difference was considered significant at $p < 0.05$.

Research results and discussion. The conducted studies revealed significant differences in microclimate indicators between the control and experimental groups, as well as their impact on calf health, feed efficiency and protein metabolism.

Analysis of microclimate indicators. In the control group, frequent deviations of microclimate indicators from zoohygienic standards were observed. In particular, in winter, the air temperature often dropped below optimal values (up to +5°C), and the relative humidity exceeded 85%. Ammonia concentration reached 25-30 mg/m^3 (with a limit of 20 mg/m^3 for calves), and carbon dioxide - 0.35-0.4% (with a limit of 0.25%). Dustiness was also higher than normal, which is typical for calf houses with low thermal protection qualities of structures and inefficient ventilation. In the experimental group, due to the implemented optimization measures, which, in particular, included the use of infrared emitters for local heating of calf rest areas, the microclimate indicators were much more stable and met zoohygienic standards. The temperature was maintained within +15...+22°C (up to +28°C in the local heating zone), and the relative humidity was 60-75%. The ammonia concentration did not exceed 10-15 mg/m^3, carbon dioxide - 0.15-0.2%. The dust level was minimal. This confirms the data of Buyarov V.S. and co-authors [4], who emphasize the effectiveness of infrared radiation for creating comfortable conditions and reducing the concentration of harmful gases in the area of young animals.

Influence of microclimate optimization on the health and productivity of calves (during the study period). Table 1 analyzes the microclimatic indicators in the calf housing, including air temperature, humidity, and the concentration of harmful gases - ammonia and carbon dioxide - in the control and experimental groups.

The air temperature in the room where the control group of calves was kept was lower than the recommended zoohygienic standards and amounted to 13.0 ± 0.8°C. Such a temperature regime is insufficient for the comfortable existence of young animals, as the optimal values range from 16-20 °C. Instead, in the experimental group, the temperature reached 19.0 ± 0.5 °C, which indicates the effectiveness of measures aimed at preserving heat. Such a microclimate helps to reduce heat loss and the need for additional energy expenditure for thermoregulation in calves, which generally has a positive effect on their growth and productivity.

Table 1 - Influence of microclimate optimization on the health and productivity of calves (M ± m, n=50)

Indicator	Control group	Experimental group
Microclimate (average values)		
Air temperature, °C	13.0 ± 0.8	19.0 ± 0.5
Relative humidity, %	89.0 ± 1.5	71.0 ± 1.0
NH_3 concentration, mg/m^3	28.0 ± 1.2	13.0 ± 0.7
CO_2 concentration, %	0.40 ± 0.02	0.18 ± 0.01
Disease incidence, %.		
Respiratory diseases	45.0	15.0
Gastrointestinal diseases	30.0	10.0
Total mortality	8.0	2.0
Productivity		
Average daily weight gain, g	682 ± 25	803 ± 20

Authoring: own research

The relative humidity in the control room was high and amounted to 89.0 ± 1.5%. Such conditions are unfavorable because they promote the active development of pathogenic microflora. In turn, in the experimental group, the air humidity decreased to 71.0 ± 1.0%, which corresponds to the optimal normative values (60-75%). This decrease may be due to improved ventilation or reduced moisture evaporation from the litter. This level of humidity ensures better environmental hygiene, reduces air pollution and minimizes the risk of respiratory diseases.

The concentration of ammonia (NH_3) in the air of the control room exceeded the permissible limits and reached 28.0 ± 1.2 mg/m³ with the recommended limit value of ≤20 mg/m³. This poses a threat to the health of calves, as ammonia irritates the respiratory tract and suppresses the epithelium. In the experimental group, the concentration of this gas was much lower - 13.0 ± 0.7 mg/m³, which indicates an effective air purification system and a positive effect on the general condition of the respiratory system of animals.

The level of carbon dioxide (CO_2) in the room where the calves of the control group were kept was 0.40 ± 0.02%, which indicates insufficient air exchange. In the experimental group, this indicator was at the level of 0.18 ± 0.01%, which fully complies with acceptable zoohygienic standards (no more than 0.25%). This indicator is evidence of effective ventilation, which ensures proper gas exchange, reduces the risk of hypoxia and general metabolic stress in animals.

In general, the conditions in the experimental group were much closer to optimal, which indicates the effectiveness of the implemented measures to improve the microclimate and their positive impact on the health and productivity of calves.

The results shown in Table 2 demonstrate a significant relationship between the microclimate parameters in calf housing and the digestibility and assimilation of fermented feed. Changes in microclimatic conditions in the experimental group provided a significant improvement in physiological processes associated with digestion and metabolic absorption of nutrients.

Table 2 - Influence of microclimate on the digestibility and assimilation of fermented feed in calves, %.

Indicator	Control group	Experimental group	Increase in the experimental group, %.
Digestibility of fermented feed	78.5 ± 1.2	87.6 ± 1.0	9.1 - 10.1
Digestibility of fermented feed	72.0 ± 1.0	78.2 ± 0.8	6.2 - 6.3

Authoring: own research

Digestibility of fermented feed. In calves of the control group, the level of digestibility of fermented feed was 78.5 ± 1.2%, which is within the permissible values, but does not reach the optimal level. In the experimental group, where measures were taken to stabilize the air temperature (within the zoohygienic norm), reduce relative humidity, and reduce ammonia and carbon dioxide concentrations, the digestibility rate increased to 87.6 ± 1.0%. The absolute increase of 9.1-10.1% is statistically significant and indicates an increase in the efficiency of the gastrointestinal tract.

The physiological rationale for such changes is that under conditions of thermal comfort and normalized gas composition of the air, calves reduce energy consumption for thermoregulation, which directs the body's resources to enhance digestive functions. In addition, improved housing conditions contribute to the formation of a stable rumen microflora, activation of enzymatic activity and optimization of the hydrolysis of feed components.

Digestibility of fermented feed. The digestibility of fermented feed in the control group was 72.0 ± 1.0%, while in calves of the experimental group it reached 78.2 ± 0.8%, which is 6.2-6.3% higher. This indicates not only improved digestion, but also more efficient transportation and absorption of nutrients into the systemic metabolism. This result can be explained by the effect of the improved microclimate on the functional state of the respiratory and circulatory organs, which provide oxygen supply to tissues necessary for cellular metabolism.

Reducing the concentration of ammonia in the air helps to reduce irritation of the mucous membranes of the respiratory tract, and therefore reduce stress in animals. Improved ventilation, which has led to a decrease in CO_2 levels, promotes better gas exchange, increases tissue oxygenation and overall metabolic activity, including absorption processes in the small intestine. Reducing humidity, in turn, reduces the risk of bacterial overgrowth, which also has a positive effect on the overall condition of the gastrointestinal tract.

The experimental data obtained convincingly confirm that optimizing the microclimate in calf housing has a direct positive effect on the digestibility and assimilation of fermented feed. Ensuring an appropriate temperature regime, reducing air humidity and gas load (NH_3 and CO_2) creates a physiologically favorable environment for the normal functioning of the calves' digestive system. This, in turn, increases the efficiency of feed utilization, helps to accelerate growth, improve health indicators and reduce veterinary costs.

Thus, rational microclimate regulation should be considered as one of the leading factors in improving the efficiency of feeding and keeping young cattle, in particular when using high-quality fermented feed.

The data presented in Table 3 reflect the effect of microclimatic conditions on the main biochemical parameters of protein metabolism in the blood of calves. Comparison of the control group (suboptimal microclimate) with the experimental group (optimal microclimate parameters) reveals significant changes in both the concentration of protein fractions and the levels of nitrogen metabolites, which allows us to judge the general state of protein and energy metabolism in the body of young animals.

Table 3 - Indicators of protein metabolism in calves under different microclimatic conditions (M ± m, n =15)

Indicator	Control group *(suboptimal microclimate)*	Experimental group *(optimal microclimate)*
Total protein, g/l	68.5 ± 1.5	74.2 ± 1.0
Albumin, g/l	32.1 ± 0.8	36.5 ± 0.7
Globulins, g/l	36.4 ± 1.0	37.7 ± 0.9
Urea, mmol/l	5.8 ± 0.2	4.1 ± 0.1
Creatinine, μmol/L	95.3 ± 2.5	82.1 ± 2.0

Authoring: own research

As can be seen from Table 3, in the control group, the concentration of total protein was 68.5 ± 1.5 g/l, which is at the lower limit of the physiological norm for calves, while in the experimental group this figure increased to 74.2 ± 1.0 g/l. An increase in the level of total protein may indicate an improvement in the synthetic function of the liver and more active protein nutrition, which, in turn, is a consequence of better digestion and absorption of feed in an optimal microclimate. The positive dynamics also indicates a general increase in the metabolic activity of the calf's body.

The level of albumin in the experimental group was 36.5 ± 0.7 g/l against 32.1 ± 0.8 g/l in the control group. Albumin is the main plasma transport protein that also plays a key role in maintaining oncotic pressure. Their increase indicates a stable functional activity of the liver, improved detoxification and more efficient protein metabolism under normalized microclimate conditions. This indicates that not only quantitative but also qualitative changes in protein metabolism occurred in the experimental group. Globulin values in both groups remained relatively stable: 36.4 ± 1.0 g/l in the control group and 37.7 ± 0.9 g/l in the experimental group. A slight increase may indicate the activation of immunobiological processes in the body of calves due to a decrease in the impact of microclimate stressors. This is especially important during the period of intensive growth, when the immune system is still in the process of formation.

The concentration of urea in the experimental group was significantly lower (4.1 ± 0.1 mmol/L) compared to the control group (5.8 ± 0.2 mmol/L). The decrease in urea content indicates a decrease in the intensity of protein catabolism, which is typical for conditions of reduced stress load and improved energy supply. In combination with high levels of total protein and albumin, this indicates the predominance of anabolic processes in metabolism. The level of creatinine, a marker of protein metabolism and muscle activity, in calves of the control group was 95.3 ± 2.5 mmol/l, while in the experimental group it was 82.1 ± 2.0 mmol/l. A decrease in this indicator may indicate a decrease in muscle protein breakdown due to a decrease in metabolic stress. This is consistent with other indicators and confirms the positive effect of the optimal microclimate on the overall metabolism.

The data obtained confirm that the optimal microclimate parameters (temperature, humidity, air gas composition) have a significant positive effect on protein metabolism in calves. The increase in total protein and albumin levels, combined with a decrease in urea and creatinine content, indicates the activation of anabolic processes and an overall improvement in metabolic functions. Such changes create prerequisites for intensive growth, increased immune resistance and reduced morbidity in young cattle.

Taking into account the results obtained, it was proved that the optimization of the microclimate in livestock facilities significantly affects the protein metabolism of calves. The calves of the experimental group, which were kept in optimal conditions, had significantly higher levels of total protein and albumin in the blood serum compared to the control group. This indicates more intensive protein synthesis and a better state of protein metabolism. At the same time, the levels of urea and creatinine, nitrogen metabolism products that are indicators of protein catabolism and kidney burden, were significantly lower in the experimental group. This indicates more efficient use of feed nitrogen and less protein degradation in the body under comfortable conditions. Improving the microclimate helps to stabilize the morphobiochemical composition of the blood and stimulate metabolic processes.

Summary and conclusions The results obtained convincingly confirm the important, even critical role of microclimatic parameters in ensuring the health, productivity and metabolic stability of young cattle. In particular, the use of infrared heating as an element of a comprehensive microclimate control system has demonstrated high efficiency in creating a favorable environment for calf growth.

The presence of elevated concentrations of toxic gases in the air, such as ammonia (NH_3), hydrogen sulfide (H_2S) and carbon dioxide (CO_2), combined with a violation of the optimal temperature and humidity conditions, creates chronic stress on the animal body. This effect is realized through a number of physiological mechanisms: damage to the mucous membranes of the upper respiratory tract, impaired mucociliary clearance, and suppression of local and systemic immunity. As a result, the risk of infection with bacterial and viral agents increases, leading to the development of respiratory diseases, stunted growth and reduced feed conversion.

Improving microclimate parameters has not only a local effect on respiratory function, but also a systemic effect, which is expressed in increased efficiency of digestion and absorption of nutrients. Creating a comfortable thermal environment, reducing the level of gas pollution and normalizing humidity help reduce energy costs for thermoregulation and detoxification, which in turn allows more resources to be allocated to synthetic and metabolic processes. This is confirmed by the positive dynamics of digestibility and assimilation of fermented feed, as well as an increase in the level of total protein and albumin in the blood serum of calves.

Thus, microclimatic conditions cannot be considered solely as a component of zoohygienic support - they are a full-fledged regulator of internal homeostasis, including metabolic processes, immune status and adaptive reactions of the body.

An integrated approach to microclimate optimization, which combines effective ventilation, spot infrared heating, hygienic replacement and dry bedding, has demonstrated its effectiveness in the study. These conclusions are in line with the results of numerous modern scientific publications, which also emphasize the importance of a stable microclimate for the normal functioning of the respiratory, digestive and immune systems of animals.

Compliance with the recommended zoohygienic standards has a direct economic effect: it reduces morbidity, reduces the cost of veterinary interventions, improves live weight gain, and increases the profitability of dairy and beef cattle breeding. Therefore, microclimate regulation should be considered as a strategic tool in the technology of growing young animals, which ensures high health, metabolism and productivity.

Conclusions.

1. Deviations in microclimate indicators (high humidity, concentration of harmful gases, dustiness, low temperature) in livestock facilities are a significant factor that leads to an increase in the incidence of respiratory and gastrointestinal diseases in calves, and also negatively affects metabolism.

2. The introduction of comprehensive measures to optimize the microclimate, including automated ventilation, heating (in particular, with infrared radiators) and the use of bedding absorbents, has significantly improved the microclimate to zoohygienic

standards.

3. Optimization of the microclimate provided a significant reduction in the incidence of calves with respiratory pathologies (by 30%) and gastrointestinal disorders (by 20%), as well as a decrease in mortality (by 6%) in the experimental group compared to the control group.

4. Improved housing conditions had a positive effect on calf productivity, providing an increase in average daily live weight gain by 15-20%.

5. Studies have shown that the optimal microclimate significantly increases the digestibility (by 9.1-10.1%) and digestibility (by 6.2-6.3%) of fermented feed, and also has a positive effect on protein metabolism (increase in total protein and albumin, decrease in urea and creatinine).

6. Comprehensive optimization of microclimate is a key and economically feasible factor in the system of preventive measures to maintain health, increase productivity and efficiency of feed resources use in young cattle.

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