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HYGIENIC ASSESSMENT OF DAIRY COWS UNDER TIE-STALL HOUSING

Abstract.

In modern dairy farming, the microclimate parameters of livestock premises are considered one of the leading factors determining the physiological state, productivity and welfare of dairy cows. Air temperature, relative humidity, speed of its movement and concentration of harmful gases form a thermoregulatory load on the animal body and directly affect feed consumption, milk production, immune status and reproductive function. According to modern research, deviation of microclimate parameters from the thermoneutral zone causes heat or cold stress, which is accompanied by a decrease in milk yield, a change in the composition of milk and an increase in morbidity. The problem becomes particularly relevant in conditions of tethered and stalled housing, where the motor activity of cows is limited, and the animals are in direct contact with the litter and the stall microclimate for a long time. In such systems, it is the parameters of the air environment and the sanitary condition of the stalls that determine the level of body contamination, udder cleanliness and the risk of mastitis, which is considered an effective indicator of welfare outcome. Modern climate changes and the tendency to increase the ambient temperature lead to an increase in the frequency of heat stress in cowsheds, which requires systematic monitoring of the microclimate and assessment of its impact on

the productivity and health of cows.

The paper investigates the parameters of the microclimate of the premises for keeping dairy cows in different seasons of the year and their impact on the hygienic condition of the animals. A pronounced seasonal variability of temperature, humidity, air velocity and gas composition of the cowshed air with deviations from the standards of NTP-APK 01.05, most significant in the winter and summer periods, was established. In the winter period, the air temperature was 2 ± 1 °C with increased concentrations of NH_3 and CO_2 , which indicates insufficient efficiency of the ventilation system. In summer, the temperature reached a maximum value of +32 °C, forming a risk of heat stress, while the gas composition of the air improved. In the autumn-spring period, according to the results of the multi-zone assessment of cleanliness, 83% of cows had 3 points and 17% - 4 points, the hygiene assessment index was 3.17 points, which corresponds to an unsatisfactory sanitary condition. In the summer period, the index decreased to 2.88 points, which indicates a relative improvement in animal hygiene. It was established that the deterioration of microclimate parameters is accompanied by an increase in the contamination of the cows' bodies and microbial contamination of the air. The results obtained confirm the decisive role of the indoor microclimate in the formation of the hygienic status of the dairy herd and the need to optimize ventilation systems, manure removal and management of maintenance.

Keywords: *temperature, humidity, ammonia, gas pollution, microclimate, hygiene, stress.*

Introduction. In modern dairy farming, animal housing conditions are among the key factors determining productivity, reproductive performance, longevity, and milk quality. Increased stocking density, inadequate manure removal, and suboptimal microclimatic conditions in housing facilities lead to the accumulation of organic contaminants on the hair coat and skin of cows, which contributes to the development of pathological conditions [1]. Effective hygiene management is critically important for improving the sanitary and microbiological quality of milk and reducing the risk of mastitis [2].

Analysis of recent studies and publications.

The microclimate of the cowshed (temperature, relative humidity, air velocity, gas composition, and dust levels) is a determining factor in the welfare of dairy cows, as it affects their behavioral and physiological parameters [3] and creates risks of heat stress, mastitis, and reduced productivity [1].

Ensuring proper housing conditions for farm animals in Ukraine has a regulatory basis. The Laws of Ukraine “On the Protection of Animals from Cruelty” [4] and “General Requirements for the Welfare of Farm Animals during Keeping” [5] establish the obligation to provide conditions that do not harm animal health and meet their physiological needs. The EFSA report emphasizes that inadequate housing conditions and related environmental hazards cause a range of adverse consequences for the welfare of dairy cows, and that optimization of environmental parameters is a key prerequisite for reducing risks to animal health and behavior [6].

Modern monitoring approaches confirm the feasibility of continuous, real-time monitoring of microclimate parameters (temperature, NH_3 , CO_2 , etc.) throughout the day [7] as a tool for early detection of problems and optimization of housing conditions from a welfare and productivity perspective [8]. The gaseous composition of air in dairy housing, particularly the concentrations of NH_3 and CO_2 , has a significant impact on the physiological status of animals [9]. Toledo et al. (2022)

reported that housing conditions are directly reflected in behavioral and physiological indicators of dairy cow welfare, with heat stress and inadequate ventilation identified as key risk factors [3]. Guarnieri et al. (2023) demonstrated that disruption of the humidity regime affects not only productivity but also overall health status and immune function in dairy cows [10].

An important integrative indicator in welfare assessment is the hygiene assessment index (IGO), which is considered a welfare outcome measure — a performance indicator reflecting the actual impact of housing conditions on animal status [11]. According to the international Welfare Quality® assessment protocols, IGO is evaluated using a multifactorial approach that includes the cleanliness of the udder, lower limbs, thighs, and flanks, thereby reflecting the overall level of animal welfare and the quality of housing management [12]. An increased IGO score indicates excessive accumulation of organic contaminants within the housing environment and is associated with a higher risk of mastitis and dermatological lesions [13–14].

Therefore, the investigation of cowshed microclimate parameters and their influence on the hygienic status of dairy cows is not only scientifically justified but also represents a normatively regulated area of contemporary research. The IGO can thus be used as an objective indicator of the effectiveness of microclimate management in dairy farming systems.

The aim of this study was to evaluate seasonal variation in cowshed microclimate and its relationship with the hygienic status of dairy cows housed in tie-stall systems.

Materials and Methods. The study was conducted at the Agricultural Limited Liability Company “Peremoha” (Khrushchivka village, Zolotonosha district, Cherkasy region, Ukraine) and at the Department of Infectious Pathology, Biosafety and Veterinary Sanitary Inspection named after Prof. V.Ya. Atamas, Faculty of Veterinary Medicine, Odesa State Agrarian University. The experimental cowshed had a rectangular layout (75 m × 21 m) and was designed as a four-row tie-stall facility. The experimental herd (n = 150) consisted of Ukrainian Red-and-White and Black-and-White dairy cows with partial Holstein improvement.

Microclimate parameters were determined in accordance with NTP-APK 01.05 requirements [15] and methodological guidelines on veterinary hygiene [16]. Measurements were performed at three control locations within the cowshed: at the center of the building and at a distance of 1.5–2.0 m from the external walls, at a height of 1.2–1.5 m above the floor corresponding to the animal breathing zone.

Air temperature was measured using a smart air meter with integrated CO₂, temperature, and humidity sensors (GM8804, Benetech, China); relative humidity was measured with an August psychrometer; air velocity with a digital vane anemometer (GM8908, Benetech, China); CO₂ concentration with a portable gas analyzer (UG-2) and the GM8804 sensor; NH₃ concentration with a UG-2 gas analyzer. Air exchange rate was calculated from the ventilation rate or supplied air volume. The daylight factor was determined using a Yu-116 luxmeter. Airborne microbial contamination was assessed by the sedimentation method on Petri dishes.

The cow hygiene index (CHI) was calculated as the mean cleanliness score across individual anatomical regions (udder, lower limbs, thighs, and flanks). Scoring and index calculation were performed according to the Welfare Quality® protocol [12].

$$CHI = \Sigma (n_i \times b_i) / N$$

where,

n_i — the number of animals with the corresponding score;

b_i — the purity score;

N — the total number of animals examined.

Comparison of measured cowshed microclimate parameters (Table 1) with the normative values of VNTP-APK 01.05 [15] demonstrated marked seasonal variability and deviations from recommended hygienic standards, particularly during winter (December–February) and, to a lesser extent, in summer (June–August).

Table 1

**Microclimate parameters in the cowshed during tethered and stalled housing,
 (M±m, n=3)**

Microclimate indicators	Season			
	winter	spring	summer	autumn
Air temperature, 0C	+2±0,5	+18±3,5	+31,3±4	+18±3,5
Relative air humidity, %	70±1,15	71,7±2	85±1,7	75±1,7
Concentration of CO2 in the air, %	0,5±0,05	0,3±0,01	0,1±0,005	0,3±0,01
Concentration of NH3 in the air, mg/m3	35±1,73	27±2,88	20±1,15	27±1,72
Air velocity, m/sec	0,3±0,02	0,6±0,06	0,2±0,03	0,6±0,06
Concentration of H2S in the air, mg/m3	15±0,6	12±1,15	10±0,6	12±0,6
Coefficient of natural light, %	1,2±0,21	1,3±0,41	1,6±0,02	1,6±1,4

The table data – the results of the authors' research.

During winter, indoor air temperature ranged from +1 to +3 °C, which is below the recommended range of 8–10 °C. This indicates insufficient thermal insulation and/or inadequate ventilation balance and poses a risk of cold stress in dairy cows. Relative humidity remained within 68–72%, corresponding to the permissible range (65–75%). Air velocity (0.25–0.35 m/s) was close to the recommended winter values (0.3–0.5 m/s). However, NH₃ concentrations (35–38 mg/m³) and CO₂ levels (0.5–0.6%) exceeded recommended limits approximately twofold, indicating insufficient air

exchange during the cold season.

During spring, air temperature (+12 to +24 °C) approached the physiologically comfortable range; however, in August it exceeded optimal values by approximately 10%. NH₃ concentrations decreased to 22–32 mg/m³ but still exceeded the maximum permissible level (≤ 20 mg/m³): by 10% in March, 22.7% in April, and 60% in May. CO₂ concentrations exceeded the maximum permissible concentration by 12–28%, although they were 1.5-fold lower than in winter.

The most critical deviations in microclimate parameters were recorded in summer. Air temperature reached +32 °C, substantially exceeding the thermoneutral zone for dairy cows (–5 to +25 °C) and posing a risk of heat stress. Air velocity increased to 0.8–1.0 m/s, corresponding to recommended summer values and partially compensating for heat load. NH₃ concentrations remained within permissible limits in June–July and exceeded the norm by only 10% in August. CO₂ levels decreased threefold compared to spring and were approximately twofold lower than the maximum permissible limit ($\leq 0.25\%$). In autumn, microclimate parameters gradually stabilized: temperature ranged from +14 to +22 °C, relative humidity from 72 to 78%, and air velocity from 0.5 to 0.7 m/s. During September–November, air temperature corresponded to the thermoneutral zone for dairy cows. In September, however, NH₃ concentration sharply increased to 30 mg/m³, representing a 36% rise compared to August. Elevated ammonia levels during autumn may indicate insufficient efficiency of manure removal systems and ventilation within the housing facility. In addition, CO₂ concentrations increased threefold compared to summer values.

Airborne microbial contamination in the cowshed exceeded recommended hygienic limits throughout the year, with exceedances of $2\text{--}3 \times 10^3$ CFU/m³ in winter and $4.0\text{--}4.5 \times 10^3$ CFU/m³ during transitional seasons (spring–autumn), indicating an elevated risk of infectious disease transmission.

According to the hygiene assessment of dairy cows using a four-point, multi-zone cleanliness scoring system (udder, lower limbs, thighs, and flanks) during the autumn–spring period, 83% of the animals received a score of 3. In these cows, the udder was moderately soiled (12...21% of the surface), the skin above the coronary band and on the thighs and flanks was covered with dried manure plaques, although the hair coat remained visible. The remaining 17% of cows received a score of 4, indicating severe contamination: the udder was covered with dried manure plaques over 30...34% of the surface, the skin above the coronary band was covered with dense plaques extending to the upper limb, and the thighs and flanks were heavily soiled. The cow hygiene index (CHI) averaged 3.17 points, exceeding the threshold value of 3.0 and characterizing the hygienic status of the animals as unsatisfactory.

During summer, hygiene assessment showed that 76% of cows received a cleanliness score of 3, 18% a score of 2, and 6% a score of 4. The mean cow hygiene index (CHI) was 2.88.

The CHI value observed in summer indicates an improvement in herd hygienic status compared with the autumn–spring period by 0.29 points and corresponds to a satisfactory hygiene level. However, from June through August this indicator remained

above the optimal recommended threshold (≤ 2.0), suggesting the need for further improvement of housing and sanitary management practices to achieve a high level of animal hygiene.

Conclusions and future research perspectives.

1. The microclimate of the tie-stall cowshed demonstrated pronounced seasonal variability, with the most critical deviations from hygienic standards observed in winter and summer. Winter conditions were characterized by low air temperature and elevated NH_3 and CO_2 concentrations, indicating insufficient ventilation efficiency, whereas summer was marked by excessive heat load and risk of heat stress.

2. Airborne microbial contamination in the cowshed exceeded recommended hygienic limits throughout the year, particularly during transitional seasons, indicating unfavorable sanitary conditions and an increased risk of infectious disease transmission in the dairy herd.

3. Hygiene assessment of dairy cows revealed predominantly moderate to severe contamination of anatomical zones during the autumn–spring period (CHI = 3.17), corresponding to an unsatisfactory hygienic status. In summer, hygienic status improved (CHI = 2.88) but remained above the optimal recommended level (≤ 2.0).

4. Seasonal changes in microclimate parameters were associated with corresponding changes in cow cleanliness and hygienic status, confirming the impact of housing environmental conditions on animal welfare indicators.

5. The results substantiate the need to optimize ventilation, manure removal, and overall sanitary management in tie-stall dairy housing to improve microclimate conditions, reduce microbial load, and achieve a high level of animal hygiene and welfare.

Future research should aim to elucidate the relationships between microclimate conditions in tie-stall housing systems and the welfare, productivity, and physiological resilience of dairy cows.

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ВИЗНАЧЕННЯ ГІГІЄНІЧНОЇ ОЦІНКИ ДІЙНИХ КОРІВ ЗА ПРИВ'ЯЗНО-СТІЙЛОВОГО УТРИМАННЯ

Анотація.

У сучасному молочному скотарстві параметри мікроклімату тваринницьких приміщень розглядаються як один із провідних факторів, що визначає фізіологічний стан, продуктивність і добробут дійних корів. Температура, відносна вологість, швидкість руху повітря та концентрація шкідливих газів формують терморегуляційне навантаження на організм тварин і безпосередньо впливають на споживання корму, молочну продуктивність, імунний статус і репродуктивну функцію. За даними сучасних досліджень, відхилення параметрів мікроклімату від зони комфорту спричиняє тепловий або холодний стрес, що супроводжується зниженням надоїв, зміною складу молока та зростанням захворюваності. Особливої актуальності проблема набуває в умовах прив'язно-стійлового утримання, де рухова активність корів обмежена, а тварини тривалий час перебувають у безпосередньому контакті з підстилкою та мікрокліматом стійла. У таких системах саме параметри повітряного середовища та санітарний стан стійл визначають рівень забрудненості тіла, чистоту вимені та ризик виникнення маститу, що розглядається як результативний індикатор добробуту (welfare outcome). Кліматичні зміни та підвищення температури навколишнього середовища зумовлюють зростання частоти теплового стресу в корівниках. Саме тому, системний моніторинг мікроклімату та оцінка впливу-запорука здоров'я та продуктивності корів.

У роботі досліджено параметри мікроклімату приміщення для утримання дійних корів у різні сезони року та їх вплив на гігієнічний стан тварин. Встановлено виражену сезонну варіабельність температури, вологості, швидкості руху повітря та газового складу повітря корівника з відхиленнями від нормативів ВНТП-АПК 01.05, найбільш значимими у зимовий та літній періоди. У зимовий період температура повітря становила 2 ± 1 °C за підвищених концентрацій NH_3 і CO_2 , що свідчить про недостатню ефективність системи вентиляції. Влітку температура досягала максимального значення +32 °C, формуючи ризик теплового

стресу, тоді як газовий склад повітря покращувався. В осінньо-весняний період за результатами мультizonальної оцінки чистоти 83 % корів мали 3 бали та 17 % - 4 бали, індекс гігієнічної оцінки становив 3,17 бали, що відповідає незадовільному санітарному стану. У літній період індекс знизився до 2,88 бали, що свідчить про відносно покращення гігієни тварин. Встановлено, що погіршення параметрів мікроклімату супроводжується зростанням забрудненості тіла корів та мікробного обмінення повітря. Отримані результати підтверджують визначальну роль мікроклімату приміщення у формуванні гігієнічного статусу дійного стада та необхідність оптимізації систем вентиляції, видалення гною і менеджменту утримання.

Ключові слова: температура, вологість, аміак, загазованість, мікроклімат, гігієна, стрес.

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