Scientific Papers. Series D. Animal Science. Vol. LXVIII, No. 2, 2025
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

STUDY OF DIFFERENT PARAMETERS OF THE MICROCLIMATE OF DAIRY COWS FREE-RANGE INDOOR IN THE TOWN OF TROYAN

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Abstract

The study investigated 16 microclimatic parameters in a steel-concrete building for rearing Simmental dairy cattle in the Troyan region. The analyses were carried out with an electronic device "Air Environment Analyzer", electronic environment patent №. 127047, of the Cherkassy Experimental Station of Bioresources of the National Academy of Agrarian Sciences of Ukraine. Measurements were made in the following seasons: spring, summer and winter. Air exchange and heat balance of the building were evaluated. Rectal and body temperature, pulse and respiratory rate of 10 lactating Simmental cows were measured. The comfort indices were monitored and recorded according to Grant, 2009 and the relationship between the studied parameters and the milk production of the animals was analysed.

Key words: *air exchange, comfort index, humidity, microclimate, temperature.*

INTRODUCTION

The dairy industry is at the crossroads of two critical global challenges: the need to meet increasing demand for high quality dairy products and the imperative to reduce environmental impact. Dairy managers need to combine historical principles with modern technology (Krawzel & Grant, 2009; Gheorghe-Irimia et al., 2023).

According to Trifonov (2016), indoor climate is expressed by the complex action of physical, chemical and biological factors: temperature and humidity, air movement, light rays, radiation, gaseous composition of the air - mainly the presence of harmful gases - carbon monoxide, ammonia, hydrogen sulphide, etc., air ionisation, noise level, presence of particulate matter and microorganisms. Failure to comply with microclimate requirements results in: a 10-15% reduction in milk production, an increase in cow fattening, an increase in feed consumption and the development of pathogenic microorganisms and infections.

Slavov et al. (2016) emphasize that it is of sanitary and hygienic importance to control the concentration of polluting gases in the air of livestock premises. Harmful gases, exceeding the maximum permissible zoohygienic standards, entering the blood, interact with hemoglobin and block its transport function of transferring oxygen to cells and carbon dioxide from cells. As a result of the interaction of hemoglobin with ammonia, alkaline hematin is formed, with hydrogen sulfide - iron sulfide, with carbon dioxide - carbohemoglobin, with carbon monoxide - carboxyhemoglobin.

Modern dairy farms need to provide optimal environmental conditions with consistent parameters for productivity and competition, to achieve milk and meat production in terms of quantity and quality, and to maintain animal health and welfare (Strateanu et al., 2022).

Building parameters are a reliable criterion for assessing the production environment and the appropriateness and cost-effectiveness of the choice of a particular housing technology when cows are kept indoors and the microclimate is dominant (Krastev, 2012, 2015; Yovovic et al., 2015).

The aim of the present study was to determine the necessary parameters for the assessment of the main microclimatic factors and to compare the obtained results with the existing norms in a steel-concrete building for the rearing of dairy cows of the Simmental breed, located in the area of the town of Troyan, Middle Balkan Mountains.

MATERIALS AND METHODS

The building under investigation is constructed of 0.21 mm thick multi-layered steel concrete elements, the joints of which are plasterless. Inside, the walls are sprayed with thick mortar. The windows are on the south side of the building and the doors are on the east-west side. The roof is double-pitched and covered with double T-shaped thermal panels with hydro-insulating and thermal insulation properties. This type of building has the following dimensions: length 42 m, width 15 m and height 5.5 m. It provides each cow with 6.43 m^2, with a minimum floor area of 6.00 m^2. The building is designed for one hundred milking cows, divided into four pens of 25 cows each. In the middle of the room is a milking parlour with a 1 x 6 Bavaria-type staircase. The type of ventilation is mixed (natural and mechanical). There is one feed alley and two manure alleys in the building. The beds are separated and lined with synthetic rubber fabric with a slope of 3° and the dimensions of the metal box enclosures are 1.60 m wide and 195 m long, while the two manure paths are located between the cribs and the beds and are cleaned by a mini tractor with a bulldozer shovel. The dimensions of each building element and animal pen were measured using a Parkside electronic tape measure. Manure was collected in two external pits, which were pumped out once a month by a Spartacus tanker. The cows were free-range during the summer, housed in the building for resting and milking, and indoors during the autumn and winter, with access to the constructed yards in front of the building. During the trial, 98 cows were housed in the building. The microclimate parameters were studied by traditional zoohygienic methods: temperature, relative humidity, periodic air velocity, carbon monoxide, carbon dioxide, ammonia, hydrogen sulphide, etc. using the electronic device "Air Environment Analyzer", patent No. 127047, of the Cherkasy Experimental Station for Bioresources of the National Academy of Agrarian Sciences of Ukraine.

To calibrate the CO_2, H_2S, NH_3 and CH_4 sensors, certified calibration gas mixtures in 2-liter high-pressure cylinders manufactured by the State Enterprise "Ukrmetrteststandart" and a UTR-1 valve with a pressure gauge were used. The device was located at the level of the cows' living area (1.5 m from the floor) using a tripod for the FD-150 laser level (Stepanovich et al., 2017).

Measurements were taken at four opposite points in the building. Air speed was measured with a vane anemometer and illuminance with a luxmeter. The data were averaged for each season. The air exchange and heat balance of the building were estimated according to (Hristev, 2008). The temperature of the inner surface of the walls and of the floor in the area of the beds was measured with a compact infrared thermometer EYUSALL at a height of 1.20 m at five points. Physiological studies were performed twice in each month of the study seasons, at 11am and 5pm. Rectal temperature (°C) was measured with a Conttoly-01 electronic thermometer and body temperature (°C) with an EYUSALL Compact infrared thermometer with a range of 30 to 45°C, arterial pulse rate (ppm) with a stopwatch and respiratory rate (ppm) with a stopwatch, on a group of 10 lactating Simmental cows, separated by the method of analogs.

The observation and recording of the data necessary for the calculation of the indices of conformity according to Grant, 2009 were carried out in duplicate, each month of the seasons studied, at the hours of 11 h, 13 h, 15 h, 17 h.

The indices were calculated using the following formulas:

Cow Conformity Index (CCI) = Number of cows lying down in stalls/Number of cows standing upright or lying down x 100

Stall Utilisation Index (SUI) = Number of cows lying down in stalls/number of cows not eating x 100

Index of Standing in Stalls (ISS) = Number of cows standing in stalls and cows standing with their forelimbs in stalls/number of cows in stalls x 100.

The values were processed with the methods of variance statistics using MS Excel and presented in tables.

RESULTS AND DISCUSSIONS

From the data in Table 1 it can be seen that during the study period the average daily temperature outside the building varies from +4.5^{0}C in winter to +23^{0}C in summer. The winters are mild and the summers relatively cool. Given these climatic temperature conditions during the winter season, the average indoor air temperature is +7.4°C. The established temperature of +7.4°C in winter, according to the Regulation № 44/2006 on Veterinary Requirements for Animal Breeding Establishments, etc., adopted in our country, is higher than the stated norm-minimum of +5°C.

The biological heat released from the bodies of the 98 housed cows is sufficient to maintain normal air temperature parameters in the production building. During the summer season, the average building air temperature measured for 100 cows was +27.2°C, and on 11 production days the building temperature was above the norm at +28°C, or 8.18% of the time studied.

Since humidity is an important component of the microclimate, it is necessary to ensure optimal humidity in livestock buildings to meet the physiological requirements of the species and category of animals (Nenov, 1983; Trifonov, 2016). During the experimental period, the average relative humidity in the farm area varied from 71.70% to 79.30%. In the middle, the average relative humidity ranged from 67.4% in summer to 82.20% in winter. These relative humidity values are within the upper limit of 85%.

The air velocity in the building for 100 cows ranged from 0.28 m/s to 0.42 m/s at different times of the year and was within the acceptable norm (0.3-1 m/s).

Table 1. Average values of temperature, relative humidity and air movement in the area of the farm and the building during different periods of the year

Indicators	Building	Outside the building
	X±SE	X±SE
Spring		
Temperature, °C	11.30±0.30	10.40±0.20
Relative humidity, %	82.00±1.24	74.00±1.90
Wind velocity, m/s	0.41±0.03	0.63±0.02
Summer		
Temperature, °C	27.2±1.17	23.00±1.02
Relative humidity, %	67.4±0.31	71.70±0.27
Wind velocity, m/s	0.34±0.04	0.47±0.05
Winter		
Temperature, °C	7.40±0.40	4.50±0.25
Relative humidity, %	80.20±1.12	79.30±1.60
Wind velocity, m/s	0.28±0.03	0.53±0.01

$P<0.05$

The ventilation of the building for 100 milking cows is mixed. The heat balance in winter is positive (Hristev, 2008).

The level of toxic gases found in the building for 100 dairy cows throughout the lactation period was within the accepted norms (Table 2). The following values were found: ammonia from 8.11 mg/m² to 11.4 mg/m², carbon dioxide from 0.04% to 0.1%, hydrogen sulphide from 0.09 mg/m² to 2.1 mg/m², methane from 0.00029 mg/m² to 0.0013 mg/m².

It was monitored and recorded the data necessary to calculate the comfort indices twice a month by season for one calendar year during daylight hours at 11.00, 13.00, 15.00, 17.00 (Grant, 2009). Based on the recorded and averaged data, the following indices are calculated in Table 3.

Table 2. Microclimatic indicators in the building by seasons

Indicatorss	Seasons			
	Spring	Summer	Winter	Standart
Temperature, °C	11.3±0.30	27.2±1.17	7.4±0.40	5.0-28.0
Relative humidity, %	82.00±1.24	64.7±0.31	80.20±1.12	50-85
Wind velocity, m/s	0.41±0.03	0.34±0.40	0.28±0.03	0.3-1
Atmospheric pressure, Hpa	968.2±0.01	1095±0.05	1005±0.03	800-1100
Illumination, lx	500±1.27	700±2.46	550±2.87	500-900
Noise, Db(A)	53±0.26	64±0.67	58±0.39	50-70
Level of cooling, mcal/cm²s	3.98±1.12	4.19±1.23	6.87±1.54	5-8
Fine dust particles, mg/m³	26±0.74	23±0.51	20±0..32	50
Ammonia, mg/m³	8.11±0.2	10.8±.43	11.4±0.62	0.001-20
Carbon dioxide, %	0.1±0.05	0.04±0.04	0.07±0.08	0.3
Hydrogen sulfide, mg/m³	1.4±0.74	0.09±0.98	2.1±1.07	10
Carbon monoxide, mg/m³	0±0	0±0	0±0	10-100
Nitric oxide, mg/m³	0±0	0±0	0±0	4-200
Nitrogen dioxide, mg/m³	0±0	0±0	0±0	40-200
Methane, mg/m³	0.00029±0.02	0.0013±0.04	0.00033±0.05	0.0017

P<0.05

Table 3. Values of the three comfort indices

FARM	Seasons	CCI,%	SUI,%	ISS,%
		X±SE	X±SE	X±SE
RIMSA	Spring	96±1.94	71.95±1.29	31.5±0.86
RIMSA	Summer	117±1.45	57.24±1.84	34.8±0.94
RIMSA	Winter	84.6±0.86	49.21±1.89	30.1±1.24

P<0.05

When monitoring the comfort level of cows classified according to (Armstrong, 1994), it is seen that the IKK and IIB indices are in the zone of light and moderate comfort, varying from 84.6% to 117% for IKK and from 49.21% to 71.95% for IIB. The quantification of comfort in dairy cows depends on the IKK. This index takes into account the behavior of the animal in the box. The higher this index, the better the comfort and the higher the welfare of the cattle (Tasheva, 2022).

Table 4. Pulse, body, rectal temperature and respiratory movements

Indicators	n	Seasons			Min.-max. Norma
		Spring	Summer	Winter	
		X±SE	X±SE	X±SE	
1. Pulse per 1 min	10	106±2.54	112±1.87	108±2.38	80-120
2. Body temperature °C	10	38.2±1.11	38.5±1.28	38.7±1.32	38.1-39.2
3 Rectal temperature °C	10	38.1±0.58	38.3±0.63	38.5±0.47	38.1-39.2
4. Breathing movements for 1 min	10	23±1.18	32±1.21	28±1.94	16-38

P<0.05

The studied results of pulse, body, rectal temperature and respiratory movements are presented in Table 4. It shows that the study animals were in good physiological condition for these parameters. No deviations from norms were observed. Pulse rate ranged from 106 to 112 beats per minute, body temperature from 38.2°C to 38.7°C and rectal temperature from 38.1°C to 38.5°C. Respiratory movements ranged from 23 to 32 movements per 1 min. The average milk yield of the cows studied was 6743 kg milk with 3.89% fat and 3.4% protein. The data we obtained are close in value and correspond to the results obtained by (Yovovic et al., 2015; Krastev, 2015; Strateanu et al., 2022).

CONCLUSIONS

A probable influence of the paratypical factor of the season on microclimate indicators and the values of comfort indices has been established.

The microclimatic dynamics in the studied steel-concrete building for one hundred cows show that a relatively optimal technological gradient of air temperature and humidity was ensured during the different seasons studied. Air cooling was higher in winter and lower in summer. The values of gas composition and air velocity were within the specified norms throughout the year, and the detected toxic gas content in the building for 100 cows was within the norms throughout the lambing period. The CCI and SUI indices were in the mild and moderate comfort zone, ranging from 84.6% to 117% for CCI and from 49.21% to 71.95% for SUI. No deviations from the norms were observed.

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