FACTORS INFLUENCING THE INDOOR CLIMATE OF A COWSHED AND THE RELIABILITY OF INDOOR CLIMATE PARAMETERS OF A MILKING PARLOUR

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ABSTRACT. *During various technological processes, inevitable changes in the chemical content and electrical characteristics of air occur. Thus, it is essential to research the influence of materials used in production and proceeding sideproducts upon micro-, para- and electroclimate in a cowshed.*

This article studies data regarding the provided norms of indoorclimate parameters, the indices of reliability of specific parameters and their subordinance to distribution laws.

Keywords: *indoor climate, microclimate, electroclimate, paraclimate, environment, technological processes, materials, reliability*

Introduction

Nowadays, the field of indoor climate reliability and its insurance methods are becoming more and more popular. Indoor climate includes a great number of different parameters that have also been frequently measured by different scientists, but as far as we know, indoor climate reliability and its insurance methods have not been studied before.

Ensuring the required indoor climate mainly involves heating, airing and ventilation. By valuing the indoor climate and striving for the established regulations, we create the premises for higher quality life and work environment. When the indoor climate parameters do not remain on normal level, their reliability changes in time, which is expressed in parameter failures.

The objective of the research was to control the possible influences of the used and produced materials on the cowshed indoor climate.

The purpose of this research was to determine the factors and norms influencing the indices of reliability of indoor parameters in order to assess the indoor climate reliability in a milking parlour of a bovine farm.

In order to achieve that goal, the following tasks were completed: 1) determination and systemization of factors influencing on indoor climate parameter norms in a cowshed; 2) treatment of indoor climate parameters and norms; 3) determining and assessing the indoor climate reliability indices in a milking parlour.

Material and Methods

As the research work has shown, the concept climate can be taken as *outdoor* and *indoor climate*. The latter can be grouped by its peculiarities as *micro-*, *para-* and *electroclimate*. The research method can be used for the further development of science and its results will be of much use in agriculture and industrial field (Tomson, 2001; Viljasoo, Tomson, 2003).

Each research on climate parameters can be developed as a separate field of science. Electronic precise measuring equipment has enabled such an approach. Climate parameters may be grouped as well. By the regulations of Occupational Safety and Health Care in Estonian Republic (Tööohutus…, 1998), the concept *microclimate, e.g.,* meant the following indices: air temperature ϑ_k, relative humidity W_s, air velocity v and thermal loading Q in one group. In addition, it is desirable to consider such indices as dew point ϑ_p, absolute humidity W_a (Tomson, 2001; Viljasoo, Tomson, 2003), heat Q_s and humidity W_l secreted from animal.

The other group may be formed by such indoor climate indices as noise $\overline{X}$, vibration, lightness E, pressure, radiation R, gases (O_2, CO_2, CO, NH_3, NO_2, SO_2, H_2S), dust T, bacteria, viruses, air necessity H, optimal volume of air per animal H_o, repetition of air exchange N, normative area per animal S_a and height of cowshed h_a (Tomson, 2001; Viljasoo, Tomson, 2003) and it can be called *paraclimate* (Viljasoo, Tomson, 2002). The term has been derived from the Greek "para", which, in this field, can be understood as side, by or coactive phenomena of various actions.

Electroclimate is an electrostatic state of inner and outer atmosphere connected with living, production and other activity. The study and research of electroclimate is based on such main concepts as ion, polarity, ionization, aerosol, mobility rate of ions, electric conductivity of atmosphere, electrostatic dispersion of ions, stability of ions, concentration and the factor of unipolarity (Viljasoo, Tomson, 2001).

Air ions are measured by the ion reader UT-8401, the measuring accuracy of the measurer is ±10%. Micro- and paraclimate parameters, such as temperature, the relative and absolute humidity of air, dew point and air velocity and content of air gases (O_2, CO_2, NH_3) were measured in cowshed. The equipment DATA LOGGER ALMEMO 8990-8, with O_2 sensor ZA9000-AK2K, with CO_2 sensor FYA6000-CO2, thermohydrosensor FHA646-1, (measuring accuracy ±1%), thermoanemosensor FHA645TH2 (measuring accuracy ±3%) and ammonia sensor ZA9601-FS2 (measuring accuracy ±2%) were used (Tomson, 2001; Viljasoo, Tomson, 2003; Viljasoo, Tomson, 2002).

According to the experiment planning theory for getting data (Melnikov *et al.*, 1980), the constant confidence probability (α=0,95) was chosen. For getting data with the constant confidence probability, the parameter values were measured 30 times in one experiment. Measurement results were registered by the online connection, Microsoft Excel program was used for the processing of statistical data.

The *relative predominance* of micro-, para- and electroclimate parameters were calculated from the statistical data list of measurement results, the *relative pollution* of air by electroclimate parameters and *relative freshness* by the following formulae:

$$A = \frac{B}{C} \cdot 100 - 100; \quad S = \frac{q_m}{q_a} \cdot 100 - 100; \quad V = 100 - \frac{q_m}{q_a} \cdot 100, \qquad (1, 2, 3)$$

$$\text{if} \quad \bar{q} > q_a, \quad \text{then} \quad K_{SV} = \left(\frac{\bar{q}}{q_a} - 1 \right) \cdot 100, \quad \text{if} \quad \bar{q} < q_a, \quad \text{then} \quad K_{SV} = \left(1 - \frac{\bar{q}}{q_a} \right) \cdot 100, \qquad (4)$$

where A – relative predominance of climate parameters %;
B – value of climate parameters in air influenced by materials;
C – value of climate parameters in air uninfluenced by materials;
S – relative pollution of air %;
V – relative freshness of air %;
K_{SV} – co-effect of air relative pollution and air relative freshness %;
q_m – factor of unipolarity ($q_m = n^+/n^-$ where n^+ – concentration of plus charged light air ions; n^- – concentration of minus charged light air ions) of air ions in the environment influenced by materials;
q_a – factor of unipolarity ($q_m = n^+/n^-$, where n^+ – concentration of plus charged light air ions; n^- – concentration of minus charged light air ions) of air ions in the environment uninfluenced by materials;
$\bar{q}$ – arithmetical mean values of factors of unipolarity.

The objective of the research was to control the possible influences of the used and produced materials on the cowshed indoor climate. The climate parameters in 5 cowsheds of AS Tartu Agro Vorbuse department production conditions were analysed in the summertime. Climate parameters were measured on 6 or 7 different places of one milking cowshed at 1 m height (Töööhutus…, 1998) during different technologies. Tables 1, 2 present data of used materials and technologies (devices: pipeline milking device "Impulsa", feeding devices wheelbarrow TU-300 and truck Avant PowerTek, manure endless chain scraper conveyer TSN-3B and natural ventilation) of the milking cowsheds. Climate parameters of the cowshed were measured in accordance with the diagnostic plan (Table 3) which was made up on the basis of summer daily routine. The choice of measuring height originated from the used mean measuring height 1 m in Finland, Sweden and Russia (OCT1981; Balanin, 1988; Simakov, 1991; Karhunen, 1992).

In connection with the fact that the electrostatic state of atmosphere has been studied in the world science since the 19th century up to today (Keskkonna…, 1998; Minh, 1963; Sanitarno, 1980; Tšiževski, 1989) and as a result of research, ionization theory and practice (Tint, 2000) have been developed and this field of research is very up-to-date and perspective in animal keeping as well.

To get a survey of the influence of technological processes on the electroclimate of inside atmosphere, it is essential to collect separate information about the materials used in the production. In cowsheds the most used materials and the objective of the presented research are silage, brewer's grains and concentrated fodder, spruce, birch and aspen sawdust, barley and turf as litter and manure as a side-product (Tomson, 2001; Viljasoo, Tomson, 2001).

Statistical data on indoor climate parameter failures of a milking parlour describes the non-conformity of air temperature and relative humidity with the requirements that have been established for the employee-milker and the cows during the period of one year. Changes in failure intensity are seasonal, which can be explained by the influence of climate conditions. Provided data can be used to predict the probability of indoor climate parameters failure. Depending on particular conditions, different number of failures can occur during a specific time period (month, season, year). Due to its insufficient accuracy, it is not enough to prognosticate by using only mean operating time of parameter. In order to ensure the qualitative level of indoor parameters, it is necessary to determine the estimated values of their workability level.

The average operating time (failure time) of a parameter and standard deviation are calculated with the following formulae:

$$\bar{t}_t = \frac{\sum_{i=1}^{n} t_i}{n}, \quad \sigma_t = \frac{1}{n-1}\sqrt{\sum_{i=1}^{n}\left(t_i - \bar{t}_t\right)^2}, \qquad (5, 6)$$

where $\bar{t}_t$ – mean operating time of parameter;
t_i – i-operating time in itself;
n – number of failures;
σ_t – standard deviation.

In order to study the workability of climate parameter by the probability of its working without failures, in case of the variation factor with formula

$$v_t = \frac{\sigma_t}{\bar{t}_t} \qquad (7)$$

of determined numerical values (normal distribution law (NJS), 0…0,399; Weibull distribution law (WJS) 0,4…0,765; exponent distribution law (EJS) > 0,765) the subordinance of parameter workability to following distribution laws (Viljasoo, 1998)

$$P_t = \frac{1}{\sigma_t\sqrt{2\pi}}\exp\left(-\frac{\left(t_i - \bar{t}_t\right)^2}{2\sigma_t^2}\right), \qquad (8)$$

$$P_t = \exp\left(-\left(\frac{t_i}{a}\right)^b\right), \quad P = \exp(-\lambda \cdot t_i), \qquad (9, 10)$$

where P_t – probability of work without failures;
a,b – Weibull parameters (Selivanov, Artemjev, 1978);
λ – parameter of failure flow ($\lambda = t_i / \bar{t}_t$).

Depending on the outcomes of indoor climate parameter failures, it is recommended to establish an estimate on the workability of a parameter (Viljasoo, 1998). According to fuzzy set theory, this can be acceptable in the range of satisfactory, good, very good, excellent and complete.

Diagnosing yearly the indoor climate parameters of the cold milking parlours was carried out at Leeli (Mikson, 2000) and PLC Revino (Bajeva, Bajeva, 2005) and the warm milking parlours at Vana-Võidu and Kärevere Agricultural Association farms (Mikson, 2000) during the milking 04:00…07:00 in the morning and 15:00…18:00 in the evening, making it a 6 h milking day.

Diagnostic appliance DATA LOGGER ALMEMO 8990-8 with measuring sensors that had measurement error of ±1…±3% from final value, was used to record the data on milking days in real time.

Microsoft Word and Excel were used for data processing.

Results

As it can be seen from Table 1 by microclimate indices compared with a zero experiment (with air), the temperature ϑ_k has dropped to some extent in case of all the materials. It can be based on the convention, as a result of which the mobility of microscopic substance is accompanied with heat delivery to liquid, gas or granulated stuff. Relative air humidity depends on the initial humidity of the material. In the given case it decreases because of the concentrates and it increases more or less with other materials. Thus it can be reasoned that most materials used in animal husbandry increase the relative air humidity.

The general increase in air velocity during a preservation time of 12 h is caused, compared with zero experiments, by freshness.

As far as indoor climate indices are concerned, the content of O_2 in the air does not change much depending on the materials. The ammonia content in the air is reduced by turf (45%), sawdust (35…44%) and concentrates (41%), as NH_3 absorption in the materials takes place. As to the litter, it is purposeful, but in case of concentrates it is harmful. Experiments with fresh manure have shown that this material sooner connects ammonia. Silage (279%) increases the NH_3 content in the air the most.

The mixed materials with a preservation time of 12 h reduced the content of ammonia in the air up to 79%.

The indices about electroclimate show that litter increases the total amount of air ions (7…162%) at the cost of n^+ ions (1…225%) and n^- ions (2…129%). As the data in Table 1 characterizing unipolarity factor q shows, turf (40%) improves the most the sanitary-hygienic condition of the production environment, while spruce sawdust (20%) worsens it to some extent. This may be caused by the chemical composition of resin in spruce timber. Among fodders, concentrates (23%) and brewer's grains (9%) have a negative effect on air ionization in the production environment while silage, which releases big amounts of n^- ions (22%), improves the sanitary-hygienic state of the environment (62%).

Thus, it may be concluded that NH_3 as a chemical substance is harmful to biological organisms in bigger amounts than the limit 25 ppm (Tint, 2000) and useful, however, from the sanitary-hygienic viewpoint as n^- ion. Manure increases the ion quantity of the air (2…28%) at the cost of n^+ ions (13…33%) and n^- ions (6…28%). Manure as a side-product has negative impact on the sanitary-hygienic conditions (2…66%).

Table 1. Factors influencing the microclimate in a cowshed

No.	Factors	Microclimate					Paraclimate	
		ϑ_k °C	W_s %	ϑ_P °C	W_a g/kg	v m/s	O_2 %	NH_3 ppm
1.	**Foods**	Preservation time 12…96 h, the biggest values of relative predominances (underweights) %						
1.1.	Grass	–	30	38	32	60	2	137
1.2.	Fresh hay	1	6	10	8	90	2	129
1.3.	Silage	(4)	27	67	22	–	–	279
1.4.	Brewer`s grains	(4)	30	73	30	(13)	–	(7)
1.5.	Concentrates	(1)	(6)	(6)	(2)	(21)	–	(41)
2.	**Litters**	Preservation time 12…96 h, the biggest values of relative predominances (underweights) %						
2.1.	Old hay	3	–	(0,5)	–	(11)	–	(18)
2.2.	Spruce sawdust	(5)	11	–	–	(10)	–	(35)
2.3.	Birch sawdust	(3)	2	11	(12)	–	–	(44)
2.4.	Aspen sawdust	(1)	8	7	7	(12)	–	(35)
2.5.	Barley straw	–	2	2	1	10	–	(51)
2.6.	Turf	(5)	17	46	19	(16)	–	(45)
3.	**Products**	Preservation time 12…96 h, the biggest values of relative predominances (underweights) %						
3.1.	Manure	(1)	4	7	6	42	–	(64)
3.2.	Spruce sawdust manure	(1)	16	19	16	6… (12)	–	(74)... (17)
3.3.	Birch sawdust manure	(1)	11	13	11	32	–	(79)... 15
3.4.	Aspen sawdust manure	(1)	13	15	13	56	–	(74)... (40)
3.5.	Barley straw manure	(1)	19	24	21	10… (21)	(1)	(78)... 17
3.6.	Turf manure	(1)	13	16	14	16	(1)	(78)... (20)

Table 1 continued

No.	Factors	Electroclimate						
		n^+ cm^{-3}	n^- cm^{-3}	$\sum n^{\pm}$ cm^{-3}	q n^+/n^-	V %	S %	K_{sv} $q=1.3\%$
4.	**Foods**	Preservation time 12…96 h, the biggest values of relative predominances (underweights) %						
4.1.	Grass	(20)	24	8	$\|0.39\|$	36	–	70
4.2.	Fresh hay	(61)	79	27	$\|0.13\|$	78	–	90
4.3.	Silage	(26)	22	7	$\|0.28\|$	62	–	78
4.4.	Brewer`s grains	17	8	11	$\|0.51\|$	–	9	61
4.5.	Concentrates	41	13	22	$\|0.58\|$	–	23	55
5.	**Litters**	Preservation time 12…96 h, the biggest values of relative predominances (underweights) %						
5.1.	Old hay	(1)… 225	(11)… 129	(7)… 162	$\|0.78\|$	–	11… 42	40
5.2.	Spruce sawdust	22	2	7	$\|0.42\|$	–	20	68
5.3.	Birch sawdust	15	17	16	$\|0.42\|$	2	–	68
5.4.	Aspen sawdust	18	(28)	(21)	$\|0.76\|$	–	16	42
5.5.	Barley straw	1	29	18	$\|0.38\|$	20		71
5.6.	Turf	(25)	23	9	$\|0.26\|$	40	–	80
6.	**Products**	Preservation time 12…96 h, the biggest values of relative predominances (underweights) %						
6.1.	Manure	28… (7)	6… (21)	14… (15)	$\|1.00\|$ $\|0.89\|$	–	27… 16	23… 32
6.2.	Spruce sawdust manure	26	(18)… 28	(11)… 27	$\|1.02\|$ $\|0.72\|$	– 2	22… –	22… 45
6.3.	Birch sawdust manure	33… 7	(9)… (3)	6… 2	$\|1.06\|$ $\|0.84\|$	– –	47… 12	18… 35
6.4.	Aspen sawdust manure	13… 29	(21)… 11	(8)… 20	$\|1.16\|$ $\|0.87\|$	– –	43… 16	11… 33
6.5.	Barley straw manure	(2)… 42	(3)… 15	(3)… 28	$\|1.11\|$ $\|0.61\|$	– –	2… 22	15… 53
6.6.	Turf manure	27… 26	(21)… (24)	(5)… (2)	$\|1.31\|$ $\|0.84\|$	– –	62… 66	(0,8) … 35

As it can be seen from Table 2, the manure disposal technology increased the relative and absolute humidity of the air and the dew point in a cowshed the most. The relative predominance of the relative and absolute humidity and dew point increased, compared to outdoor air 49%, 51% and 45%, respectively.

Table 2. The impact of tehnological processes on the indoor climate of a cowshed

No.	Situation and technological processes	Microclimate					Paraclimate	
		ϑ_k °C	W_s %	ϑ_P °C	W_a g/kg	v m/s	O_2 %	NH_3 ppm
1.	**Outdoor climate**	**24.06**	**54.70**	**14.35**	**10.18**	**0.23**	**20.98**	**8.39**
2.	Empty shed	The biggest values of relative predominances (underweights) %						
		(1… 11)	27… 44	0… 38	16… 43	(50)… 45	(2)… 0.6	67… 94
3.	Cows entering shed	(5)… 13	1… 5	0… 44	32… 51	(5… 51)	0,3… (2.7)	17… 94
4.	Feeding (concentrates)	(3)… 16	3… 42	8… 47	8… 56	38… 48	0… (2.4)	48… 104
5.	Distribution of minerals	(5)	3… 10	2… 5	2… 5	(45)	0	–
6.	Feeding (grass)	(5)… 17	28… 47	31… 54	34… 65	(43… 48)	(0.95… 3.0)	91… 170
7.	Feeding (brewer`s grains)	(4)… 17	6… 47	34… 51	38… 60	(47)… 65	0.2… (2.2)	55… 195
8.	Milking	(12)… 19	2… 43	30… 51	34… 60	(48)… 147	0.2… (4.7)	71… 328
9.	Cows leaving shed	12… (3)	2… 15	34… 0	37… 0	(51… 61)	0… (2)	27… 0
10.	Manure disposal	(5)… 16	2… 49	8… 45	8… 51	(55)… 33	0… (2.2)	32… 278
11.	**Mean**	**(5.4)… 15.7**	**23.4**	**26.8**	**33.3**	**(45.8)… 62.7**	**(2.46)… 0.16**	**92.8**
No.	Situation and technological processes	Electroclimate						
		n^+ cm^{-3}	n^- cm^{-3}	$\sum n^{\pm}$ cm^{-3}	q n^+/n^-	V %	S %	K_{sv} $q=0,88$ %
1.	**Outdoor climate**	**343**	**338**	**731**	**0.88**	**–**	**–**	**–**
2.	Empty shed	The biggest values of relative predominances (underweights) %						
		71… (61)	64… (20)	67… (37)	16… (53)	53	16	11
3.	Cows entering shed	(60)	(60)	(60)	25	22	39	(2)
4.	Feeding (concentrates)	54… (52)	43… (58)	48… (47)	132	18	132	39
5.	Distribution of minerals	(26)	(5)	(15)	22	22	–	(22)
6.	Feeding (grass)	6… (66)	45… (53)	26… (59)	(27)	27	–	(24)
7.	Feeding (brewer`s grains)	(69)	(65)	(65)	(30)	30	8	(9)
8.	Milking	47… (55)	41… (58)	43… (57)	65… (5)	5	65	14
9.	Cows leaving shed	11… (50)	20… (28)	16… (38)	(32)	32	–	(19)
10.	Manure disposal	24… (26)	10… (31)	(29)	77… (32)	32	77	11
11.	**Mean**	**35.… (51.7)**	**37.2… (42.0)**	**40.0… (45.2)**	**67.4… (29.8)**	**26.8**	**56.2**	**19… (15)**

Compared to outdoor air, the relative predominance of air humidity increased the most in the cowshed during the cows entering the shed (5%) which may be caused by the vapour from sweating and panting in the cowshed air. While distributing grass and brewer's grain, the relative predominance of the relative air humidity increased 47% respectively, caused by the nature of wet forage.

Compared to outdoor air, the relative predominance of relative air humidity was the highest in the cowshed during the distribution of grass and during milking, 42%, 47% and 43%, respectively. This may be due to the vapour coming from the sweating cows and the evaporation of the humid brewer's grains.

The increment of the value of the dew point in the cowshed occurred the most (54%) while distributing grass due to technological processes and the influence of used-produced materials. At the same time the absolute humidity of the air rose by 65%.

During the disposal of manure in the cowshed, the ammonia relative predominance was 278%, compared to outdoor air. Such a concentration of ammonia in the air is permissible for a short time, although it may harm the health of animals and people.

The relative predominance of ammonia was 328%, compared to outdoor air, being the highest during the milking time in the dung passage. This could be caused by the fact that the milked cows were more irritated and produced more intensively excrements and urine.

During the distribution of grass its mechanical influencing takes place and as a result the number of n^- air ions enhances up to 45%, which improves the relative freshness of the cowshed air by 27%.

The concentration of n^+ and n^- air ions increased more during milking (43%) and distribution of concentrate (48%). When grass was given, the number of n^+ and n^- air ions diminished, caused by the effect of a tractor's exhaust gases on the electroclimate of the cowshed.

The relative freshness 53% was the highest in an empty cowshed, which decreases in the course of different technological processes, but it will still be dominating compared to relative pollution.

In an empty cowshed, the relative pollution of the air was 16% which causes the n^+ air ion predominance. During milking the relative pollution of the air increased to 65%, which could be caused by the irritation of cows and increased excrements.

Compared to outdoor air, the predominance of relative pollution was the highest when feeding concentrates (132%), disposing of manure (77%), milking (65%) and while the cows entered (39%).

Grass and brewer's grains raised the relative freshness of the environment, compared to outdoor air, 27% and 30%, respectively. Comparing the results to the relative pollution of the air calculated on the basis of experiment-data in Table 1, concerning brewer's grains, the positive result about the brewer's grains may have been obtained by the increase in relative air freshness during the distribution of grass.

The relative freshness of air, compared to outdoor air, increased by 32% when the cows left the cowshed.

As it can be seen from Table 3, the indoor climate of cowsheds does not correspond to the established norms of micro-, para- and electroclimate in either of the following parameters: air temperature, dew point, absolute humidity, air volume per animal and total air ions.

Table 3. Register's header of diagnosed data

No.	Factors	Microclimate							
		ϑ_k °C	W_s %	ϑ_P °C	W_a g/kg	v m/s	Q W/m^2	Q_s W	W_l g/h
1.	Outdoor climate	24.06	54.70	14.35	10.18	0.23	–	–	–
2.	**Microclimate norms**	**5… 20**	**60… 85**	**≤ 15**	**≤ 10**	**0.2… 1.0**	**≤ 30**	**305… 775**	**340… 920**
3.	Microclimate in cowshed	21.17... 28.64	55.0… 82.05	14.35... 22.1	10.18... 16.80	0.09... 0.57	–	–	–
4.	Mean microclimate	24.91	67.50	18.20	13.57	0.33	–	–	–
5.	Microclimate conformity to norms	NO	YES	NO	NO	YES	–	–	–

Table 3 continued

No.	Factors	Paraclimate							
		O_2 %	CO_2 %	CO ppm	NH_3 ppm	NO_2 ppm	SO_2 ppm	H_2S ppm	T mg/m^3
1.	Outdoor climate	20.98	0	–	8.39	–	–	–	–
2.	**Paraclimate norms**	**20… 21**	**≤ 0.25**	**≤ 10**	**≤ 25**	**≤ 2**	**≤ 1**	**≤ 0.5**	**≤ 5**
3.	Paraclimate in cowshed	19.99... 21.11	–	–	8.39… 35.91	–	–	–	–
4.	Mean paraclimate	20.55	–	–	22.15	–	–	–	–
5.	Paraclimate conformity to norms	YES	–	–	YES	–	–	–	–

No.	Factors	Paraclimate							
		H m^3/h	H_0 m^3	N h^{-1}	S_a m^2	h_a m	R μSv/h	E lx	$\overline{X}$ $dB(A)$
		19	20	21	22	23	24	25	26
1.	**Paraclimate norms**	**≥ 100**	**≥ 30**	**1…5**	**5…9**	**3…6**	**≤ 0.15**	**≥ 40**	**≤ 87**
2.	Paraclimate in cowshed	> 100	16.4… 39.6	> 3	6.1… 9.7	2.7… 4.1	–	–	–
3.	Mean paraclimate	> 100	26.7	> 3	7.6	3.4	–	–	–
4.	Paraclimate conformity to norms	YES	NO	YES	YES	YES	–	–	–

No.	Factors	Electroclimate						
		n^+ cm^{-3}	n^- cm^{-3}	$\sum n^{\pm}$ cm^{-3}	q n^+/n^-	V %	S %	K_{sv} q=1.3%
1.	Outdoor climate	343	388	731	0.88	–	–	+32
2.	**Electroclimate norms**	**≥ 400… ≤ 3000**	**≥ 600… ≤ 5000**	**≥ 1000… ≤ 8000**	**≤ 1.0… 1.3**	**> 0**	**≤ 30**	**± 30%**
3.	Electroclimate in cowshed	449… 194	516… 229	987… 447	0.77… 0.95	12.5	8.0	+41… +27
4.	Mean electroclimate	322	373	717	0.86	2	–	+34
5.	Electroclimate conformity to norms	NO	NO	NO	YES	YES	YES	YES

According to the data of a scientific publication (Reppo *et al.*, 1999), the total energetic loading of a milker's work is 151 W. This concludes that a milker's work is in accordance with regulations established by legislation (Töökeskkond, 2006) for average work in a temporary workplace (II B), the energetic norm of which is in the range of 133…292 W. In accordance with regulations established by legislation, the optimal indoor climate temperature in a milker's work environment is 13…19 ºC in winter period and 15…22 ºC in summer and the optimal relative humidity in summer as well as in winter is 40–70%. The optimal air temperature for the animals, depending on their health and productivity, is 5…20 ºC (Reppo, Pals, 2001; Liiske, 1992) and the optimal relative humidity is 60…85% (Liiske, 1992).

Table 4 shows that in winter, the temperature parameter in the milking parlour of an uninsulated cowshed was in accordance with the norms for two milking days (12.8 h) and not in accordance with the regulations for the following milking day (6.3 h). In spring and summer, the temperature parameters as to cows were often not in accordance with the norms, the operating times (5.8 and 4.8 h) were on average only 3.5 times longer than times relating to failure. In autumn, the air temperature stayed within the requirements.

Table 4 shows that in autumn and winter in the milking parlour of an uninsulated cowshed the time relating to failure of relative humidity as to cows (2.8 and 4.6 h) lasted longer then the operating time, by 1 and

1.5 times, respectively. A conclusion can be made that nonconformity is higher than conformity. In spring and summer, the operating time (5.8 and 3.8 h) was longer, by 1.7 and 1.1 times, respectively.

Table 5 indicates that in spring and summer, the air temperature during the operating time in the milking parlour of an insulated cowshed was longer as to milker than the failure time, 1 and 1.2 times respectively. But the time of the air temperature relating to failure was longer than the operating time as to milker, 1.9 times in winter and 2.3 times as to cow in summer. In autumn, the air temperature of the warm milking parlour was within the requirements.

Table 5 shows that in winter and summer in the milking parlour of an insulated cowshed the relative humidity operation time as to cows and milkers was longer than the failure time, by 2.1; 2.6 and 2.1 times, respectively. In spring, the parameter failure time were longer as to cow as well as to milker, by 1.1 and 9.7 times, respectively.

Conclusions

Owing to the development of science and machinery, technological processes become more complicated and exact. This can be achieved, considering many possible parameters. A long -time practice of animal keeping has led to certain preferences, but the research on micro-, indoor and electroclimates has enabled the scientists to motivate them.

The research on indoor climate in animal keeping is necessary for the estimation of the effect of the chosen materials and technological processes on the production environment, the efficiency of man and animals, their health and production.

The chosen method of the experiment enables to investigate the effect of different materials and its modelled co-effect on the atmosphere of the production environment. It can be considered further in designing ventilation systems in animal production buildings and choosing materials and processes.

Regulations on indoor climate parameters must be considered from the aspects of a milker and a cow.

Table 4. Reliability indices of air temperature and relative humidity, corresponding to the most suitable working environment for dairy cows (5…20 °C, 60…85%) in an uninsulated milking parlour

Indices of reliability	**Symbol, unit**	**Air temperature °C**			**Air relative humidity %**			
		winter	spring	summer	autumn	winter	spring	summer
Operating time relating to failure	$\bar{t}_t, h$	12.8	5.8	4.8	2.6	3.1	5.9	3.9
Failure time relating to revival	$\bar{t}_f, h$	6.3	1.6	1.4	2.8	4.6	3.4	3.4
Standard deviation relating to failure	σ_t, h	4.8	2.2	1.1	1.3	0.5	0.8	2.0
Standard deviation relating to revival	σ_f, h	1.9	0.4	0.3	0.7	0.8	0.3	1.4
Variation factor (operating time)	v_t	0.373	0.378	0.231	0.483	0.148	0.134	0.524
Variation factor (failure time)	v_f	0.297	0.28	0.221	0.232	0.178	0.092	0.417

Table 5. Reliability indices of air temperature and relative humidity, corresponding to the most suitable working environment for milkers (13…19 °C winter-spring, 15…22 °C summer-autumn, 40…70%) and dairy cows (5…20 °C, 60…85%) in an insulated milking parlour

Indices of reliability	**Symbol, unit**	**Air temperature °C**				**Air relative humidity %**				
		winter	spring	summer		winter	spring		summer	
		milker	milker	cow	milker	cow	cow	milker	cow	milker
Operating time relating to failure	$\bar{t}_t, h$	2.7	4.3	8.8	3.9	4.0	1.6	1.0	5.7	8.4
Failure time relating to revival	$\bar{t}_f, h$	5.2	4.1	3.9	3.3	1.9	1.8	9.7	2.2	4.0
Standard deviation relating to failure	σ_t, h	1.4	0.8	2.6	1.1	1.1	0.1	0.0	1.4	3.0
Standard deviation relating to revival	σ_f, h	2.2	1.8	1.1	0.7	0.2	0.2	2.6	0.3	2.4
Variation factor (operating time)	v_t	0.52	0.191	0.3	0.272	0.300	0.077	0.000	0.238	0.361
Variation factor (failure time)	v_f	0.42	0.449	0.268	0.199	0.11	0.091	0.263	0.137	0.601

In order to bring the indoor climate parameters of milking parlour into accordance with the requirements, it is necessary to launch additional warming and refrigerating units and use them during milking.

The milking rooms of warm and cold milking parlours can be reconstructed with additional insulation material and/or find solutions by building ventilation systems.

The probability of the nonfailure operation of indoor climate parameters in a milking parlour depends on normal and Weibull distribution laws.

Although the workability of indoor climate parameters (operating time relating to failure) is sufficient for the 60 % probability of nonfailure operation, it can be considered on a good level if it is correspondent to the value of ≥ 70%.

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