ТЕХНОЛОГІЯ ВИРОБНИЦТВА І ПЕРЕРОБКИ ПРОДУКЦІЇ ТВАРИННИЦТВА

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Influence of high temperatures on the behavior, productivity and bioenergetic characteristics of goats

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Abstract. The research was carried out in IE «Babyni kozy» of Kyiv region at a goat farm where a stable-pasture system of goats is used. In winter, goats are kept at free-stall housing on a deep litter and during the grazing period, on a forage area. Goats are milked on a milking parlor into the milk line. The article presents the results of researches of the influence of ambient temperature during the thermo neutral period and during the period of high temperatures on the productivity, daily behavior and bioenergetic characteristics of Saanen goats. A group of goats of the Saanen breed of the 3rd lactation was formed during the period of the milk yield increasing. The research was performed in thermo neutral period (average daily air temperature was up to + 22.3 °C) and during the period of temperature load at an average daily air temperature of + 27.6 °C. Each period lasted 12 days.

It has been found that goats responded to the change in temperature by reducing of productivity by 10.70 % (0.35 kg). Hereby, the mass fraction of fat in goat's milk during this period increased by 0.09 %. During the period of high temperatures, goats spent a little less time eating food, watering and walking, but rested more in a supine position compared to the thermo neutral period. In general, in both temperature periods, the duration of the main acts of behavior in goats corresponded to physiological norms. The decrease in the duration of feed consumption during the temperature load caused a decrease in the number of feed reactions and the duration of chewing the cuddy in goats. The energy index, i.e. the amount of net energy consumption of feed, which transfers into milk energy during the temperature load decreased by 1.42 MJ %. Net energy consumption per 1 MJ of milk energy during the period of high temperatures has increased by 0.62 MJ.

Key words: goats, temperature, productivity, metabolic energy, behavior, bio-energy.

Introduction. Climate is a component that has a greater influence on animal welfare as well as on productivity, which is a limiting factor in the exploitation of animals for economic purposes (Souza et al., 2012). According to scientists, goats are the most stress-resistant animals compared to other domestic ruminants (Silanikov, 2015). However, it is also well known that high temperatures affect the productivity of small ruminants (Fonseca et al., 2016).

Heat stress causes significant financial losses. On average, it is estimated that 80 % of them are due to reduced milk productivity, and 20 % are related to animal health. This mainly concerns reproduction and immunity. During heat stress, the risk of scar acidosis increases significantly. This is due to reduced consumption of food, especially its bulk, reduced saliva (buffer) in the rumen, slowing rumination (Das et al., 2016).

Behavioral, morphological, physiological and genetic bases are one of the key mechanisms of adaptation of small ruminants under heat stress (Berihulay, et al., 2019).

As soon as goats are exposed to high temperatures, they activate their physiological adaptation. This is manifested in changes in behavior, phy-

siological, biochemical and endocrinological reactions of the blood to regulate body temperature and of maintain homoeothermic (Aleena, J. et al., 2018). Adaptation processes are energy consuming and animals do not direct their energy to production (Sejian, V. et al., 2018).

This behavior-reducing behavior is a typical characteristic of adapted goat breeds. The negative impact of heat stress on animal productivity can be explained by reduced feed consumption, digestibility and efficiency of use (Dangi, S.S. et al., 2015).

Although goats have the ability to adapt to the conversion of low-quality feed from pastures into products, if heat stress lasts longer, it can affect their productivity. Dairy animals are especially sensitive to heat stress, where a large amount of energy is needed for milk production. And dairy goats during lactation are prone to heat stress (Ominski, K.et al., 2002).

A very effective element of adaptation to external influences is the ability of animals to adapt their behavior to changes under environmental conditions. In this way, animals provide themselves protection from adverse climatic conditions, as well as provide themselves with food, avoid various stresses, and through sexual activity ensure the preservation of the genus (Voronyuk, 2019).

The aim of the research was to study the productivity, daily behavior and bio-energetic evaluation of Saanen goats in different periods of temperature load.

Materials and Methods. The research was carried out in IE «Babyni kozy» of Tetiiv district of Kyiv region (49 ° 23 '2' 'N, 29 ° 52' 45 " E) at a goat farm where a stable-pasture system of goats is used. In winter, goats are kept at free-stall housing on a deep, long-lasting litter, and during the grazing period, on a forage area. Goats are milked on a milking parlor into the milk line. A group of goats of Saanen breed of the 3rd lactation was formed during the period of the milk yield increasing (end of the first-beginning of the second month of lactation) in the amount of 15 heads. The research was carried out during two periods: the first period – thermoneutral one (average daily air temperature up to + 22.3 ° C and the second period – temperature load (average daily temperature + 27.6 ° C. Each period lasted 12 days. The level of feeding at the farm is high; the energy value of the consumed feed was 24–29 MJ/goat.

The daily goats behavior was studied according to the method to which during 2 consecutive days every 10 minutes in experimental groups, the number of goats were recorded which actively or passively consumed food, rested standing or lying near the feeder or on the litter, moved, consumed water during the observation period.

Energetic and productivity indices and specific energy consumption for milk were determined by methods (NRC, 2001):

$$EI = (E\ lactation \cdot 100) : (E\ support + E\ lactation)$$

Where: EI is energy index, %;
E support is net energy of support, MJ;
E lactation is net energy of lactation, MJ.

$$PI = H\ (fat\ corrected\ milk\ yield\ 4\ \%\ (FCMY) : : (E\ support + E\ lactation)$$

Where: PI is productivity index (milk production adjusted for 4 % fat, per 1 MJ of net energy consumption), kg / MJ;
H (fat corrected milk yield 4 % (FCMY) - yield of milk adjusted for 4 % fat, kg;
E support is net energy of support, MJ;
E lactation is net energy of lactation, MJ.

Net energy consumption per 1 MJ of milk energy, MJ = Total net energy consumption per day / Net milk energy per day

The obtained data were statistically processed using STATISTICA (Version 11.0, 2012) software. The Student's *t*-test was used to estimate the statistical significance of the obtained values. Data were considered significant at $P < 0.05$, $P < 0.01$, $P < 0.001$.

Results. Weather and climatic conditions are an important component of the proper organization of dairy goats and significantly affect their milk productivity (Silanikove, 2015). Heat stress leads to a significant reduction in dry matter consumption, milk yield, milk quality and reproductive performance (Salama et al., 2014).

The results prove that the increase in ambient temperature caused a decrease in average daily milk yield by 0.35 kg and an increase in the mass fraction of fat in milk by 0.09 % ($P < 0.05$) (Table I). The maintenance of metabolic energy and the release of OE with milk were lower during the temperature load by 0.40 MJ.

Changes of external conditions lead to a restructuring of the adaptive behavior of animals, their motor activity, which allows using of ethological properties to assess the state of the organism at different temperatures (Borshch et al., 2017a; Borshch et al., 2017b).

The researches have shown that during different periods of temperature load, the duration of food eating by animals was in the range of 4.47–4.70 h (Table II).

Table 1 – **I: Productivity and daily costs of metabolic energy in goats.**

Indicator	Period	
	I	II
	n=15	n=15
Live weight, kg	56.8±0.62	56.8±0.62
Mass fraction of fat in milk,%	3.62±0.036	3.71±0.023*
Average daily milk yield for 10 days, kg	3.27±0.19	2.92±0.21
Metabolic energy, MJ	23.25±0.15	22.85±0.14
Allocated ME with milk, MJ	6.21±0.41	5.81±0.63

Note: as compared with I period $^{*}P < 0.05$.

Table 2 – **II: The effect of heat stress on the behavioral aspects of goats.**

Behavior	Period	
	I	II
	n=15	n=15
Eating time, min	282±3.66	268±4.25*
Lying time, min	488±11.10	515±12.08
Drink water time, min	37±0.49	44±0.37***
Walking time, min	236±2.72	209±2.92***
Standing time, min	364±3.68	373±3.57
Located in the milking area time, min	25±0.25	24±0.29
Are in the milking machine time, min	8±0.09	7±0.15***

Note: as compared with I period $^{*}P < 0.05$; $^{***}P < 0.001$.

At high temperatures, this figure decreased by 14 minutes (P <0.05).

There is a tendency to increase the duration of goats' lying time during the period of high temperature load for 27 min compared to the thermal neutral period.

It was associated with conservation of energy or thermoregulation (reducing the exposure to direct radiation) (Kaliber et al., 2016).

With increasing of temperature, water consumption by goats increased by 7 minutes (*** P <0.001). It was found that the animals moved less for 17 minutes (*** P <0.001).

The increase of ambient temperature helped to reduce the duration of animals' walking by 27 minutes (*** P <0.001) compared to the thermal neutral period.

The change in temperature profile affected the number of reactions of feed consumption by goats (Table III).

Thus, during the period of temperature loading the number of reactions of feed consumption decreased by 0.58 times. This favored the increase of the intervals duration between feed consumption reactions by 10.73 minutes.

Table 3 – **III: The state of the basic metabolism and feed reactions in goats at different temperature conditions.**

Indicator	Period	
	I	II
	n=15	n=15
The cost of metabolic energy to support life (basic metabolism), MJ	17.04±2,21	17.04±2,21
Duration of eating, min	282±3.66	268±4.25*
Number of reactions of feed consumption, times	8.84±0.27	8.26±0.43
Intervals between feed consumption reactions, min	128.73±4.73	139.46±7.03
Duration of rumination, min	468±7.38	444±9.56*
Number of bouts ruminating, times	9.76±0.76	9.45±0.59
Intervals between rumination, min	109.84±4.82	106.39±6.34
Assimilation of energy per interval, MJ	1.75±0.16	2.06±0.47
Time spent per 1 MJ, min	84.50±1.24	84.50±1.24
Assimilation of energy in one minute, MJ	0.0118±0.0008	0.0118±0.0008

Note: as compared with I period $^{*}P < 0.05$.

The duration of goats' chewing the cuddy during the second period was less by 24 minutes (* P <0.05). Reducing the duration of feed and chewing the cuddy consumption during high temperatures and increasing the intervals between these processes has helped to increase the intensity of energy assimilation by 0.31 MJ, which indicates a more rational absorption and use of feed energy.

For a more complete analysis of the influence of different periods of temperature load on the lactating goats' body, an assessment of their bioenergetic characteristics was performed. The results of the research showed that during the period of high temperatures at almost the same metabolic mass the net energy consumption of goats for the production of 1 kg of 4 % milk decreased by 0.40 MJ (Table IV).

The total net energy consumption during the temperature load was lower by 0.40 MJ, the energy index – by 1.47 %, the productivity index – by 0.09 kg of milk yield per 1 MJ compared to the thermo neutral period.

The net energy consumption per 1 MJ of milk energy under high temperature was 0.19 MJ higher. At the same time, it was released by 0.009 MJ less of energy with milk per 1 kg of metabolic live weight.

Discussion. Goats are considered more tolerant to heat stress compared to dairy cows because of their faster sweating rate and lower body weight: a surface ratio that allows greater heat transfer. It has been investigated that dairy goats that were kept under heat load in the climate chamber suffered by 22–35 % loss in feed intake and 3–10% less in milk with reduced fat, protein and lactose content (Salama et al., 2014). In our researches, it has been found that the increase of ambient temperature helped to reduce the duration of feed consumption by goats by 4.96 %, reduced the average daily milk yield by 10.7 % and increased the fat content in milk by 0.09 % (P<0.05).

It has been installed that despite the reduction of feed consumption by goats under heat stress, they gave similar milk yield to goats in the thermoneutral period at the end of lactation. However, the protein content in the milk of goats under heat stress decreased, while the milk fat content did not change (Hamzaoui et al., 2013).

Investigating the effect of temperature on the energy balance in Saanen and Anglo-Nubian goats, it was found that with increasing air temperature from 10 to 35 °C the consumption of dry and organic matter by animals decreased. Methane production in Saanen goats was higher at a temperature of 35 °C than in goats of the Anglo-Nubian breed. Metabolic energy (ME) and metabolism (q) in Saanen goats were lower comparative Anglo-Nubian goats (Lima et al., 2020).

We have defined that the period of high temperature load becomes a stress factor for goats and causes a decrease in the duration of feed consumption from 282 minutes up to 268 minutes and chewing the cuddy – from 468 to 444 minutes. However, the duration of lying increases from 488 to 515 minutes.

Investigating the effect of heat stress and lack of water on the behavioral responses of milk goats was found reduction in walking from 226 to 209 min/day and increase in lying from 417 to 457 min/day (Kaliber et al., 2016). Heat stress increased digestibility, which might partially compensate the reduction in feed intake (Fonseca, 2016).

Our studies have revealed a decrease in total net energy consumption during high temperatures by 0.40 MJ and an increase in net energy consumption by 1 MJ of milk energy by 0.19 MJ.

It was found that Saanen and Anglo Nubian goats are able to maintain homeostasis in environments between 10 and 35 ºC. On the other hand, the increase in ambient temperature leads to lower intake, resulting negative energy balances. Above 20 °C, goats tend to decrease fasting heat production, as an attempt to spare heat load in hot environments (Lima et al., 2020).

Table 4 **– IV: Bioenergetic characteristics of goats at different temperature loads.**

Indicator	Period	
	I	II
	n=15	n=15
Metabolic live weight, kg	42.6	42.6
Net energy consumption per 1 kg of 4% milk, MJ	6.21	5.81
Total net energy consumption (ME support + ME allocated with milk), MJ/day	23.25	22.85
Energy index, %	21.76	20.29
Productive index, 4% fat-corrected milk yield at 1 MJ	0.142	0.131
Net energy consumption per 1 MJ of milk energy, MJ	3.74	3.93
Energy with milk per 1 kg of metabolic live weight, MJ is allocated	0.146	0.137

Conclusion. The period of high temperature load becomes a stress factor for goats and causes a decrease in feed activity – the duration of feed and chewing the cuddy consumption and, as a consequence, a decrease in productivity. The duration of rest in the supine position increases.

At the same input of exchange energy for basic exchange, net energy consumption in goats for the production of 1 kg of 4% milk, energy and productivity indices are reduced.

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Вплив високих температур на поведінку, продуктивність та біоенергетичні характеристики кіз

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Анотація. В статті наведені результати досліджень впливу температури навколишнього середовища у термонейтральний період та у період високих температур на продуктивність, добову поведінку та біоенергетичні ознаки кіз зааненської породи. Дослідження проводили у ФОП «Бабині кози» Київської області за стійлово-пасовищної системи утримання кіз. Взимку застосовувалось безприв'язне утримання тварин на глибокій підстилці, в пасовищний період – на вигульно-кормовому майданчику. Доїння кіз проводилось на доїльній установці у молокопровід.

Було сформовано групу кіз зааненської породи 3-ї лактації у період роздою у кількості 15 голів. Дослідження проводили у термонейтральний (середня добова температура повітря становила до +22,3°С) і в період температурного навантаження за середньодобової температури повітря + 27,6°С. Кожен період тривав по 12 діб.

Встановлено, що на зміну температури кози відреагували зниженням продуктивності – на 10,70 % (0,35 кг). При цьому масова частка жиру в молоці кіз в цей період підвищилась на 0,09 %. У період високих температур кози дещо менше часу витрачали на поїдання кормів, напування та ходьбу, але більше відпочивали у положенні лежачи, порівняно з термонейтральним періодом. В цілому, в обидва температурні періоди тривалість основних актів поведінки у кіз відповідала фізіологічним нормам. Зниження тривалості споживання корму у період температурного навантаження спричинило зменшення чисельності кормових реакцій та тривалості жуйки у кіз. Енергетичний індекс, тобто кількість нетто-витрат енергії кормів, яка переходить в енергію молока у період температурного навантаження, знизився на 1,42 МДж %. Чисті витрати енергії на 1 МДж енергії молока у період високих температур збільшились на 0,62 МДж.

Ключові слова: кози, температура, продуктивність, обмінна енергія, поведінка, біоенергетика.

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