Chapter 6

HEAT STRESS OF BEEF CATTLE

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INTRODUCTION

Meat is considered a rich food product and one of the main components of the diet and grub culture of people, since it will provide all the necessary food products. The effectiveness of beef cattle farming largely depends on the correct selection of breeds for one or another breeding area. However, global climate change is having a significant impact on agroecosystems, their botanical warehouse and the availability of a sufficient amount of acidic pastures for grazing animals. A comprehensive assessment of the productivity of lean meat in different agroecological regions with different climatic minds can be used to develop regional sustainability strategies and system optimization production of animal products[1, 2].

Demand for grass-fed beef is growing as consumers become increasingly interested in animal health and welfare, environmental sustainability and meat products with an altered nutritional profile and lower fat content. To maintain the functions of the body of cattle, two-thirds of the incoming energy is needed with feed. Energy expenditure increases in response to both low and high temperatures that differ from the thermal optimum of finishing animals[3].

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1. Feeding systems and animal welfare

Throughout the world, beef cattle are typically raised outdoors and exposed to natural climatic conditions, while only a small proportion are raised in closed housing systems[4]. To date, there is no consensus among researchers regarding which measures should be assessed when determining the welfare effects of beef cattle[5].

However, a document prepared in 2001 by the Scientific Committee on Animal Health and Welfare of the European Commission for Health and Consumer Protection identified the main reasons for inadequate levels of welfare in various cattle production systems in Europe.

In total, there are three main beef production systems: pasture-raised (mostly breeding cows), outdoor feedlot finishers, and indoor finishers. Depending on the production system, various factors can influence the occurrence of heat stress in beef cattle. For this, ensuring animal welfare is extremely important, which significantly reduces the risk of various pathologies[6].

The pasture system is usually adopted for raising cows kept in semi-natural conditions, being on pasture from at least spring to autumn. Specific protocols have been developed to assess animal welfare in grasslands. The protocol evaluates indicators for animal, resource and livestock management[7].

Providing an adequate source of cold, clean drinking water is essential to maintaining the animal's core body temperature within normal limits. Water temperature is thought to influence rumen temperature and thus blood temperature, which influences the brain centers that control feed intake. Above ground water pipes should be shaded by covering them with tall grass. The manager should at least check the temperature of the water in the trough. Increasing temperatures from 70 °F to 95 °F can increase total water requirements by approximately 2.5 times [8].

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A feedlot is an intensive environmental system in which exacerbating factors for heat stress include keeping cattle in confined areas that interfere with some of their natural ways of coping with heat stress (for example, migrating to cooler areas, seeking shelter in the shade, etc.) and a high-energy feeding plan. Cattle in feedlots engage in aggressive interactions (for example, head banging, pushing, moving) more often and for longer periods of time compared to animals that use pastures[9].

The indoor finishing system involves young beef cattle coming from grazing systems being transported by truck and housed in roofed buildings where they are housed until finishing is complete[10].

The effectiveness of some technological solutions in combating the manifestations of heat stress may have different effectiveness depending on the sex of the animal. Thus, there is evidence that cooling a cattle feeding complex with a sprinkler-fan cooling system significantly increased the rate of weight gain in heifers, but not in bulls[11].

High quality feed generates less heat from rumen digestion than low quality feed, and hot weather diets require close inspection[8].

The main problems of welfare of beef calves when using intensive technologies are: high density of animals in groups; unsatisfactory, from a welfare point of view, type of flooring; diets high in starch; limited space at feeders and drinkers. In European technologies for raising beef calves, it is mandatory to introduce a new production system in accordance with European Council Directives 91/629/EEC and 97/2/EC.

The welfare and stress resistance of beef calves is influenced by many factors, some of them are related to the housing system (type of floor, temperature, air quality, equipment for supplying feed and water, lack of loading facilities), and others are related to animal feeding (type and quantity roughage, quality of milk substitutes). Recent research has shown that the welfare of beef cattle calves can be seriously affected by the quality of animal husbandry and particularly by negative human-animal interactions[12].

Moreover, improving the welfare of animals contributes to an increase in their productivity. Feeding systems that fed animals between 3.0 and 4.5 m^2

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per head increased live weight gain, as well as higher average daily gain and lower feed conversion ratio (kg dry matter intake/kg carcass gain)[13]. These animals performed more positive social behaviors, spent a greater percentage of their day lying down, and performed fewer aggressive interactions[14, 15].

There are many aspects of the welfare of beef cattle that must be carefully studied: animal management, processing, feeding and climatic stress, social hierarchy, weaning effects, acclimatization, habituation and temperament [16].

Monitoring points include: animal factors (genetics, temperament, previous health status, ethological factors) and management factors (diet, unit design, resource provision, pregnancy management, herd structure, husbandry attitudes and skills). While current industry and producer initiatives exist to address some of these challenges, continuous improvement of well-being requires clear, reliable and repeatable measures that quantify current and future states of well-being. Existing indicators of well-being are examined, as well as proxy indicators that can signal the presence of improved or decreased well-being[17].

2. Livestock monitoring models for animal welfare and productivity

LiGAPS-Beef (Livestock Production Simulator for General Analysis of Livestock Production Systems – Cattle Beef) is a general mechanical model designed to quantify growth potential and feed-limited growth, providing insight into the biophysical capabilities of increasing beef production. The LiGAPS-Beef model combines three submodels that jointly simulate the production and growth of beef cattle. Overall, the model simulates the interactions between cattle genotype, climate, feed quality and feed availability. The modeled factors corresponded well with the reported

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occurrence of heat stress, energy deficiency, and protein deficiency at specific periods during the experiments[18].

In total, the input data to the LiGAPS-Beef model are 89 general cattle parameters, 27 breed-specific parameters, 24 diet or feed composition parameters and daily weather data[19].

However, modeling shows how much meat products we can get under certain feeding and housing conditions, but the economic feasibility of meat animal husbandry is also affected by the quality of the products. Thus, under the influence of chronic heat stress in ruminants, a decrease in the concentration of glycogen in muscles is observed, which leads to an increase in final pH and WHC, prolonged oxidation of proteins and lipids, oxidative stress and reducing the shelf life of meat[20].

A high reliable relationship was revealed between the indicators of the temperature-humidity index (THI) outside and inside the lightweight structure, which allows us to build a linear regression model with a high level of prediction (R 2 = 0.9932)[21].

For beef cattle, the calculation of daily grass growth (DHGgDM m-2 d-1) is very important, which was calculated from the difference between the grass mass before grazing and the grass mass without grazing during the grazing period using the equation [22]:

$$\mathrm{DHGgDM}\, m^{-2}\, d^{-1} = \frac{\mathrm{ECHM}\left[\mathrm{gDM}\ m^{-2}\right] - \mathrm{Pre\,Hm}\left[\mathrm{gDM}\ m^{-2}\right]}{D\left[d\right]},$$

where ECHM is the mass of grass on the pasture, PreHM – mass of grass before grazing, a D – duration of grazing period in days.

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Potential grass consumption per animal and kg body weight is calculated using the equation:

$$PHS\left[\mathrm{gDM}\,d^{-1}\right]=\frac{\left(\mathrm{ECHM}\left[\mathrm{g}\,m^{-2}\right]-\mathrm{Post\,Hm}\left[\mathrm{g}\ m^{-2}\right]\right)\mathrm{x\,A}\left[m^{2}\right]}{D\left[d\right]x\,BW\left[kg\right]},$$

where ECHM – mass of herbal cover cell, PostHM – mass of herbal cover after grazing, A – area of animal pen, D – length of grazing period in days, a BW – average body weight of the entire grazing group.

Under physiological conditions, the following factors have been established that influence the level of consumption of grass mass: body size and condition, physiological condition of animals, quantity and quality of concentrated additives, feed advantages, feed availability and grazing system[23].

It is important to identify critical points and manage risks. Management largely regulates the effects of heat stress. Control factors can be divided into four different categories: feed, water, environmental influences and behavior. Understanding these risk factors and how each affects animal stress will help develop risk management strategies and how to implement them. Management strategies that can be applied at the right time and to the right groups of animals will increase benefits to animals and limit costs to producers[24].

3. Biological mechanisms of heat stress development in beef cattle

The ability of animals to withstand severe thermal stress during heat waves was examined physiologically by assessing fluctuations in skin, rectal and body temperatures, as well as respiratory and pulse rates[25].

THI was developed at the University of Missouri in the 1950s. THI is calculated based on the temperature and humidity in the animal's habitat. It indicates the temperature and humidity at which cows show symptoms of

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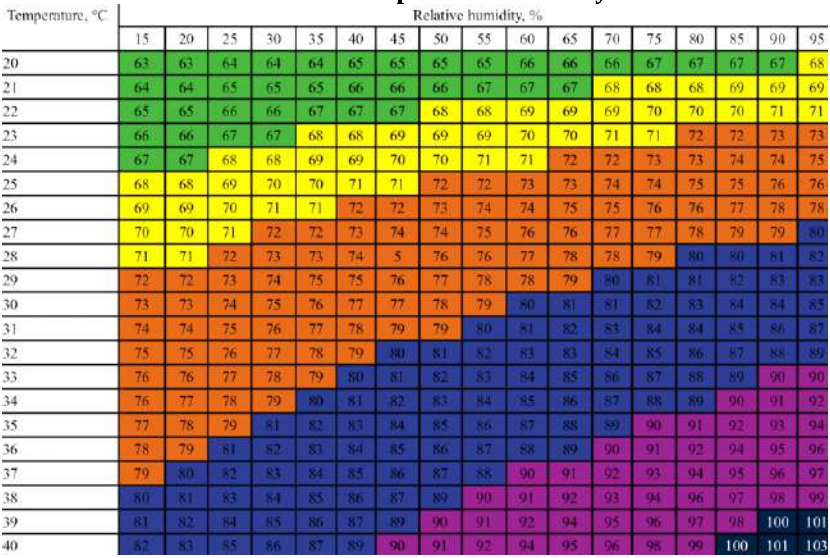
stress. The darker the color, the greater the stress – even death of livestock (THI above 99).

Table 1

Determination of temperature-humidity index



Temperature, °C	Relative humidity, %																
	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
20	63	63	64	64	64	65	65	65	65	66	66	66	67	67	67	67	68
21	64	64	65	65	65	66	66	66	67	67	67	68	68	68	69	69	69
22	65	65	66	66	67	67	67	68	68	69	69	69	70	70	70	71	71
23	66	66	67	67	68	68	69	69	69	70	70	71	71	72	72	73	73
24	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75
25	68	68	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76
26	69	69	70	71	71	72	72	73	74	74	75	75	76	76	77	78	78
27	70	70	71	72	72	73	74	74	75	76	76	77	77	78	79	79	80
28	71	71	72	73	73	74	5	76	76	77	78	78	79	80	80	81	82
29	72	72	73	74	75	75	76	77	78	78	79	80	81	81	82	83	83
30	73	73	74	75	76	77	77	78	79	80	81	81	82	83	84	84	85
31	74	74	75	76	77	78	79	79	80	81	82	83	84	84	85	86	87
32	75	75	76	77	78	79	80	81	82	83	83	84	85	86	87	88	89
33	76	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	90
34	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
35	77	78	79	81	82	83	84	85	86	87	88	89	90	91	92	93	94
36	78	79	81	82	83	84	85	86	87	88	89	90	91	92	94	95	96
37	79	80	82	83	84	85	86	87	88	90	91	92	93	94	95	96	97
38	80	81	83	84	85	86	87	89	90	91	92	93	94	96	97	98	99
39	81	82	84	85	86	87	89	90	91	92	94	95	96	97	98	100	101
40	82	83	85	86	87	89	90	91	92	94	95	96	98	99	100	101	103

Compared with the autumn-spring period (THI = 61.84 ± 0.42), the winter group (THI = 42.97 ± 0.95) showed a significant increase in the level of malondialdehyde, and the summer group (THI = 86.09 ± 0.23) showed significant increases in cortisol, interleukin (IL)-10, IL-1β, and tumor necrosis factor-α levels[26]. This indicates a seasonal threat of stress associated with temperature fluctuations.

Adverse effects of heat stress on beef cattle are observed at higher THI compared to dairy cattle. These differences are due to breed characteristics, production, metabolism, feeding plans and management systems. In fact, the higher temperature threshold for beef cattle production is 30 °C below 80 % and 27 °C above 80 %[27]. Unlike dairy cows, the impact of heat stress on the

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beef sector cannot be immediately measured as it is not reflected in daily production indicators such as milk and can vary depending on several factors (breed, stage of production (for example, beef cows against animals in cultivation/processing) and production system). Regardless of cattle category and production system, heat stress primarily affects animal welfare[28].

Assessing the impact of increasing or decreasing temperature from field monitoring is difficult due to the delayed effects on physiology. Indeed, the risk of mortality in feedlot cattle depends on the temperature of the current day, as well as on exposure to temperature in previous days. As with dairy cows, heat stress in beef cattle is associated with a higher risk of mortality[29].

The pooled mortality risk associated with 1°C above the heat threshold was estimated to be 5.6 % (5.0, 6.2) for dairy cattle and 4.6 % (0.9, 8.7) for beef cattle livestock Knowledge of the thermoneutral zone and temperature impacts outside this zone is of primary interest to farmers as it can help determine when appropriate preventive and mitigation measures should be implemented[30].

In such conditions, the need to ensure the welfare of beef cattle increases enormously; if animals become inactive, spend less time eating (especially during the daytime) and less time for social interactions, appropriate measures should be taken immediately to restore their welfare.

Thyroid hormone-mediated cell signaling plays a key role in the regulation of body temperature, energy consumption, and metabolic adaptation to heat. Heat stress in cows regulates the level of thyroid hormones[31].

Bovine skeletal muscle, including the longest dorsi muscle, is primarily composed of skeletal muscle fibers (myofibrils), but also contains fat cells, connective tissue or extracellular matrix, and various other cell types, including satellite cells. , immune cells and blood vessels The ratio of muscle to fat cells changes depending on the amount of fat deposited. Growth of

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muscle and fat cells typically occurs when mass increases due to both hyperplasia (increase in cell number) and hypertrophy (increase in cell size[32, 33].

The molecular events of microRNA alterations associated with heat stress cause disruption of cellular homeostasis and molecular function, and impair the functions of micro- or macromolecules, such as protein and lipid synthesis and DNA/RNA stability, involved in the stress response[34, 35].

Heat stress can be classified into two main classes: chronic heat stress, in which the increase in environmental temperature continues for a long period of time (days to even weeks), allowing adaptation to the environment, and acute heat stress, in which there is a rapid and short-term increase in ambient temperature. Both of these two types of heat stress are capable of stimulating numerous physicochemical reactions, such as suppression of immune and endocrine functions, changes in blood amino acids, decreased bioavailability of cellular energy, increased expression of HSP mRNA, and upregulation of inflammatory genes (NF-κB and TNF-α) and PMEL and MC1R, increased oxidative stress and decreased antioxidant enzymes (superoxide dismutase (SOD), glutathione peroxidase (GPx) and malondialdehyde (MDA)), which subsequently impairs intestinal cell function and structure[36, 37].

Given the challenges and limitations in identifying heat stress in grassland animals, some researchers are proposing the use of unmanned aerial vehicles

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as a non-invasive and practical approach to studying behavioral indicators of heat stress[38].

It is also extremely important to ensure not only the growth and development of bulls in hot conditions, but also the preservation of their breeding qualities. Males exhibit reduced sperm quality and fertility for several weeks after the onset of heat stress[39]. Increased ambient temperature leads to increased testicular temperature, which causes hypoxia and increased production of ROS as metabolic byproducts. An increase in the frequency and depth of breathing leads to increased alkalosis, which interferes with the delivery of oxygen to the tissues. Reactive oxygen species (ROS) are produced by cellular metabolism[40]. They play an important role in regulating sperm function, increasing sperm capacity and acrosomal reaction, and binding to the membrane with membrane[41].

Thus, a consequence of heat stress during spermatogenesis is a decrease in sperm quality, which leads to a decrease in the yield of viable embryos and decreased fertility[42].

Comparative studies of the sensitivity to heat stress of fattening bulls of the Angus and Nelor breeds showed some differences in the consumption of dry matter of feed[43].

Sperm motility of stressed breed Angus bulls returned to normal values 8 weeks after the end of heat stress[44].

In finishing steers, heat stress decreased basal circulating glucose concentrations (7 %) and tended to increase (30 %) plasma insulin concentrations, but plasma non-esterified fatty acid concentrations were stable[45].

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Moderate heat stress suppresses the fraction of active polysomal ribosomes from more than 60 % (preheating) to less than 30 %. The return to physiological levels results in an increase in protein synthesis, called “recovery”[46].

Heat stress affects digestion in ruminants, and can cause disruption of protective functions in the digestive tract[47].

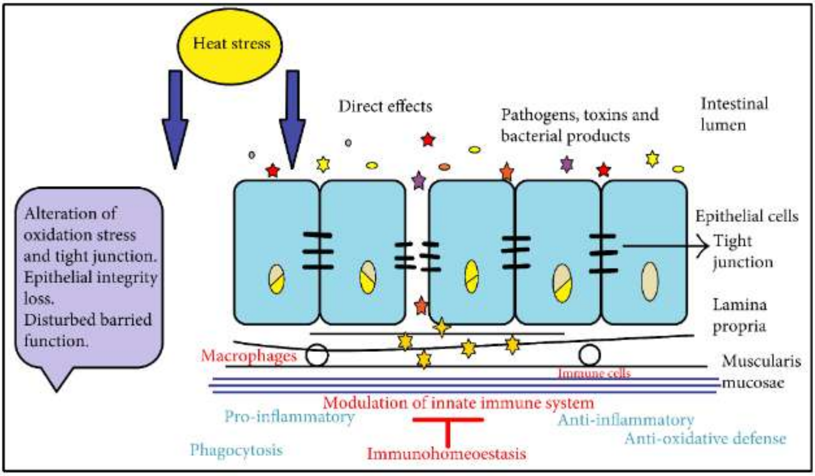

Fig. 1. Effects of chronic heat stress on the intestinal mucosa[29]

Disruption of the epithelial barrier in the intestine allows entry of molecules in the intestinal lumen as well as opportunistic microbiota and entry into intestinal-associated immune organs and causes an inflammatory response. Most investigators have described that proinflammatory cytokines, such as TNF-α, INF-γ, IL-1β, and IL-13, lower the barriers by decreasing the expression of tight junction proteins and promoting epithelial apoptosis. Changes in cytokines and their consequences associated with tight junctions

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during the inflammatory process are complex and require additional research[48].

Heat stress also affects carcass quality, which is reflected in the amount of subcutaneous and intramuscular fat[49].

Intramuscular fat content of skeletal muscle, including the longest dorsi muscle, also known as marbled fat, is one of the most important factors determining the quality of beef in several countries, including South Korea, Japan, Australia and the United States.

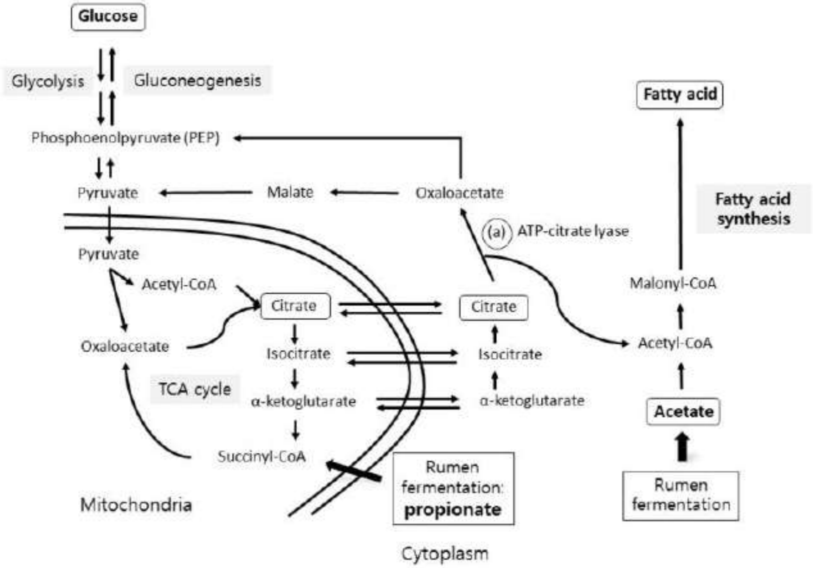

Fig. 2. Fatty acid synthesis in ruminants[50]

As this figure shows, microorganisms in the rumen ferment polysaccharides into volatile fatty acids such as acetate, propionate and butyrate. Acetate and propionate can promote FA synthesis. Acetate is

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converted to acetyl-CoA in the cytoplasm of ruminant cells and is used for fatty acid synthesis. Propionate is transported into the mitochondria where it enters the tricarboxylic acid cycle via succinyl-CoA and can be used as a substrate for glucose production via gluconeogenesis. Glucose that is synthesized from propionate or leaves the rumen and is absorbed in the small intestine can generate citrate in the tricarboxylic acid cycle, from where it can be transported into the cytosol. Citrate in the cytosol is decomposed into oxaloacetate and acetyl-CoA by ATP-citrate lyase, and acetyl-CoA can be used for the synthesis of fatty acids[31].

Consequently, there are several critical points for disruption of fatty acid synthesis during heat stress, these are disruption of ruminal digestion and the formation of volatile fatty acids and disturbance of glucose metabolism.

Heat stress increases the body temperature of cattle; this causes an acclimation response to reduce the heat generated during digestion, resulting in decreased feed intake[51]. Reduced feed intake due to heat stress conditions reduces cattle blood glucose and carbohydrate metabolites by affecting glycolysis and gluconeogenesis pathways[52, 53].

It was shown that the levels of glucose, galactose, lactose, ribose and arabitol in blood serum were reduced in the mild and severe heat stress groups compared to the control, and the content of myoinositol and acetic acid was significantly higher in the group of beef calves with severe heat stress. These changes in blood carbohydrate metabolites appeared to be related to heat stress and its effect on glucose metabolism[54]. Heat stress increases protein breakdown and AA mobilization, allowing further energy production for maintenance and growth[55].

As the largest reservoir of protein and amino acids, muscle protein metabolism has a direct impact on whole body amino acid levels and protein

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metabolism. Under stress, muscle is catabolized to substrates (amino acids) for energy supply through gluconeogenesis in the liver[56, 57].

Insulin-like growth factor-1(IGF-1) is synthesized and released from the liver, then transported into the blood to regulate body growth and protein metabolism. It increases muscle amino acid uptake and protein synthesis, and inhibits protein catabolism through binding to IGF-1R and triggering the downstream effectors S6K1 and eukaryotic translation initiation factor 4E-binding protein-1[58, 59].

4. Heat stress and beef cattle breeding in Ukraine

Beef cattle breeding includes about fifty beef breeds of cattle. The selection of such animals has been carried out for the previous 300 years, and its goal is to effectively "convert" feed into high-quality beef. The lack of specialized beef cattle in Ukraine, the low efficiency and high cost of imports have necessitated the development of beef breeds taking into account soil and climatic zones. As a result of painstaking work, Ukrainska (1993), Volynska (Volyne (1994)), Poliska (1999) and Pivdenna (Southern (2009)) meat breeds were created and approved [60].

Ukrainian producers have compiled a rating of beef cattle breeds in Ukraine. Based on their popularity, the breeds were ranked in the following order: Volynska (Volyne) meat; Aberdeen Angus; Poliska meat; Pivdenna (Southern) meat; Simmental meat; Ukrainian meat; Limousine; Charolais; Sira Ukrainian (Grey Ukrainian); Znamensky type of Poliska meat; Hereford; Blonde d'Aquitaine[61].

Taking into account global trends in the development of the breeding process in relation to global warming, a zebu breed of beef cattle was created

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in Ukraine – the Pivdenna (Southern) beef cattle for breeding in the hot climate of the steppe zone of Ukraine. In 2008, it was tested and recognized as a selection achievement in animal husbandry.

The Taurian type of the pivdenna beef breed was created by the method of complex reproductive crossing of cows of the Chervona Stepova (Red Steppe) breed with bulls of the world's best breeds of beef cattle, Shorthorn and Santa Gertrude, followed by hybridization of two- and three-breed crosses with Cuban zebu. As a result of the hybridization, arrays of animals with a polyheterozygous genotype structure were obtained. Breeding them "inside" ensured the stable transmission of traits to descendants, since with this structure of the genotype, polyhybrid cleavage occurs, which minimizes or eliminates the appearance of extreme variants. The choice of zebu was due to the fact that zebu-like breeds can easily tolerate long-term exposure to an environment with high temperatures (≥35 ºC), while maintaining the constancy of homeostasis, animal health and level of productivity. The body temperature of zebu and zebu-like cattle increases by 1 ºC only at ambient temperatures ≥43 ºC[62].

When studying the heat resistance of full-aged cows of the Pivdenna (Southern) beef breed in the thermoneutral zone, it was found that the value of the heat resistance index (THRI) is 81.64 ± 0.62, which is significantly higher than that of other breeds of dairy and beef cattle ((57 ± 1,03 – 79 ± 1,01) and close to the THRI value of zebu and zebu-like cattle (85 ± 1.16). Under heat load, when the temperature difference of 7º and 13º is 17–20 ºC (increasing from 17–20 to 35–40 ºC), THRI probably (P>0.999) increases, which ensures the preservation of temperature homeostasis and body temperature within the physiological norm [63].

A blood test indicates that the body of Taurian type cows responds to temperature stress by increasing the amount of albumin in the blood serum by 23.8 % from 26.0 ± 0.16 to 32.2 ± 0.08 g/l. 0.999) and a decrease in the total amount of globulins by 11 % from 52.4±0.13 to 47.2 ± 0.07 g/l, which ensures the preservation of colloid-osmotic pressure. With a general decrease in the content of the globulin fraction, the content of γ-globulins probably increases by 34 % from 22.3 ± 0.12 to 29.9 ± 0.1 g/l (P > 0.999). This immunoglobulin ensures the activity of precipitation reactions, neutralization of toxins and viruses, as well as other endogenous and exogenous factors. Under heat stress, the leukocyte count probably decreases by 27.7 % from 12.06 ± 0.21 to

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9.44 ± 0.14 thousand/mm^3 ($P > 0.999$). Considering that leukocytes determine the cellular mechanisms of immunity, and blood serum proteins determine the humoral ones, both mechanisms can be considered quite developed in cows of the breed, but in the thermoneutral zone the cellular ones are dominant, and during heat stress, the humoral factors of nonspecific resistance are dominant.

High values of the correlation coefficients of the heat resistance index with indicators of immunological reactivity during thermal load indicate that it is the thermal load that is the factor that activates the body's defense mechanisms and its adaptation to the action of inadequate environmental influences[64].

In general, animals of the Tauride type have a high level of adaptation to the intense heat load caused by the meteorological characteristics of the region's climate. High THRI values, which probably increase with intense heat load, ensure the preservation of temperature homeostasis in the body.

CONCLUSIONS

Global climate change on our planet is of significant concern to beef producers. Productive animals have certain comfort temperature limits, compliance with which affects their well-being, food supply and productivity. The activity of anabolic enzymes depends on the temperature of the body and tissue, pH and the presence of the substance in sufficient quantities. It has been shown that in groups of mild and severe heat stress, the level of many carbohydrates in the blood serum is reduced, the synthesis of fatty acids is disrupted, protein catabolism increases and the concentration of amino acids increases. Which has a significant impact on maintaining heat balance, energy supply and the intensity of anabolic processes**.** An increase in body temperature as a result of heat stress in beef cattle has an extremely negative impact on its welfare, physiological state and the intensity of muscle protein synthesis. Moreover, long-term effects may last even longer. The main ways to avoid the threat of heat stress in productive animals are quite universal. This is the genetic selection of resistant breeds, re-equipment of livestock buildings, platforms and pastures with means for regulating the speed of air movement, provision of sufficient drinking water, sprinkling, shade, changing the diet towards reducing the intensity of digestion and feeding high-quality feed.

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SUMMARY

Global climate change on our planet is of significant concern to beef producers. Productive animals have certain comfort temperature limits, compliance with which affects their well-being, food supply and productivity. The activity of anabolic enzymes depends on the temperature of the body and tissue, pH and the presence of the substance in sufficient quantities. It has been shown that in groups of mild and severe heat stress, the level of many carbohydrates in the blood serum is reduced, the synthesis of fatty acids is disrupted, protein catabolism increases and the concentration of amino acids increases. Which has a significant impact on maintaining heat balance, energy supply and the intensity of anabolic processes. An increase in body temperature as a result of heat stress in beef cattle has an extremely negative impact on its welfare, physiological state and the intensity of muscle protein synthesis. Moreover, long-term effects may last even longer. The main ways to avoid the threat of heat stress in productive animals are quite universal. This is the genetic selection of resistant breeds, re-equipment of livestock buildings, platforms and pastures with means for regulating the speed of air movement, provision of sufficient drinking water, sprinkling, shade, changing the diet towards reducing the intensity of digestion and feeding high-quality feed.

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