The influence of climatic factors on the quality of livestock products obtained from different breeds of cattle

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Abstract. The climatic conditions of the sharply continental climate of the Stavropol Territory influenced the skin of gobies of the Kalmyk, Kazakh white-headed and Hereford breeds. During the year, the skin of animals changed, which contributed to the adaptation of the body to the climatic conditions of the dry zone. These conditions influenced the histology and morphology of the skin of 18-month-old gobies of Kalmyk, Kazakh white-headed and Hereford cattle breeds (6 animals of each breed). The results of the study showed that the greatest thickness of the skin has the Kazakh white-headed bullocks (6544±153 microns). The smallest thickness of skin was in animals of the Hereford breed (5602±140 microns). Kalmyk and Kazakh white-headed bulls had a higher content of fine (downy) hair than Hereford bulls did. The content of sebaceous glands in Kalmyk bulls was 1.5 times higher than that in Hereford bulls and 1.1 times higher than that in the Kazakh white-headed breed. The number of sweat glands in the Hereford breed was 1.4 times higher than that in animals of the Kalmyk breed and 1.3 times higher than that in the Kazakh white-headed. The highest content of type I collagen is detected in the skin of animals of Kalmyk and Kazakh white-headed breeds. The presence of a greater thickness of the dermis in combination with an increased content of sebaceous glands in the skin indicates a higher adaptive capacity of animals of the Kazakh white-headed and Kalmyk breeds of cattle to live in extreme weather conditions and affects the quality of raw materials.

1. Introduction

In our country, highly productive European breeds of cattle are widely used in various natural and climatic zones. Animals are brought into areas with a similar climate and environmental conditions that are more or less different from the climate where the imported breed was formed. Animals are forced to adapt to new conditions of existence. The main natural and climatic factors acting on the body are air temperature, humidity, atmospheric pressure, etc. Mostly, these factors act in the form of a complex, but some become dominant in certain conditions. In the Stavropol Territory, animals of the Hereford breed were brought mainly from Great Britain, and animals of the Kalmyk and Kazakh breeds were bred in Russia. Therefore, due to the peculiarities of development, they react differently to the conditions of a new environment for them and, as a consequence, show different growth rates even with the same level of feeding and maintenance, have different feed costs for production, as well as different degrees of formation of individual tissues. Indicators of such fitness can be the level of productivity of animals, the duration of their use, skin and hair, and others.
The dermis is a multifunctional organ that is a thermoregulator, an organ of the senses and touch. The skin protects the body from external influences through a multitude of nerve endings, acts as a receptor unit of the skin analyzer of the external environment (tactile, pain, temperature sensitivity). Through many sweat and sebaceous glands, a number of metabolic products are secreted through the skin, through the mouths of hair sacs and skin glands, the skin surface can absorb a small amount of solutions. The blood vessels of the skin can hold up to 10% of the blood of the animal's body. According to the development and condition of the skin, the state of health of the animal, its constitutional type of productivity directions, determine the adaptive ability of the animal to survive in extreme environmental conditions. According to the development and condition of the skin, the health status of the animal, its constitutional type of directions of productivity is judged, the adaptive ability of the animal to survive in extreme environmental conditions is determined.

The structure and features of the skin and hair of cattle are of great importance when adapting to low temperatures. In cattle, the skin makes up 3–8% of the total weight of the animal. In a bull, the mass of the skin can be in the range of 60–80 kg, its thickness ranges from 2 to 6 mm. Numerous studies have established inter-breed, age and seasonal differences in skin thickness. The data available in the literature indicate that during the year the skin and hair of animals undergo significant changes, which contributes to better adaptation and thermoregulation of the body [1, 2]. With the help of morphological methods, it is possible to assess the breed belonging at an early age, the acclimatization ability of animals, and to predict future productivity in early ontogenesis. A well-developed skin and hair protects animals from overheating in summer and hypothermia in winter, as well as from the effects of atmospheric precipitation. Animal skin is dense and durable. Adaptation to cold occurs due to the intensive deposition of subcutaneous fat and an increase in hair growth, reaching a genetically determined maximum value [4]. An animal can resist a further increase in the cold load only by an increase in heat production, but at the same time, part of the feed energy is spent on generating heat, and not on the growth of the animal or an increase in its productivity. The study of the skin of animals in the dry-steppe zone of the Stavropol Territory is of great importance, it has characteristic features in cattle of different breeds and varies depending on the natural and climatic conditions.

Despite the existence of works devoted to the study of the morphology of the skin of cattle [1–8], many aspects of the regularities of the morphofunctional organization of the skin are insufficiently studied and need further in-depth research, clarification and addition.

2. Purpose of research
The purpose of the study was the influence of climate on the morphology of the skin of three breeds of cattle - Hereford, Kazakh white-headed and Kalmyk.

3. Materials and methods
The object of the study was the skin of cattle steers of Hereford, Kazakh white-headed and Kalmyk breeds grown in the Stavropol territory in the period of 2018–2019. During the growing process, the weight of steers was determined after birth at the age of 3, 8, 12, 15 and 18 months. Back skin samples for the study were taken from 18-month-old animals in October 2019 during the slaughter of steers at a meat processing plant in the village of Divnoye, Stavropol territory.

For histological studies, the material was fixed in a 12 % aqueous solution of formalin, dehydrated in ethanol of increasing concentration, and poured into paraffin. Paraffin sections 5–7 micrometers thick, made on a rotary microtome, were stained when reviewing using histological (Mayer's hematoxylin and eosin), histochemical (SHIK-reaction) and immunohistochemical methods (to detect type I collagen). To detect collagen, we used polyclonal antibodies to type I collagen (ABBIOTEC, USA, titer 1:150, with incubation for 45 minutes at room temperature) and an imaging system (BioGenex, USA). Morphometry of skin structural elements was performed on histological sections (the thickness of the epidermis and dermis, the number of hair, sweat and sebaceous glands, as well as...
vessels of the microcirculatory bed on a conditional unit of the skin area). The obtained digital indicators were subjected to statistical processing using the program "Statistica-8".

4. Results and Discussion
In the process of growing animals of all breeds in the dry steppe zone of the Stavropol Territory, they showed a good increase in body weight. Thus, at birth, Hereford bulls had a mass of 30.4±1.72 kg, Kazakh white-headed bulls – 24.3±1.94, and Kalmyk bulls – 21.9±1.69 kg at the age of 8 months, these animals had a mass of 229.2±2.35 kg, 216.5±0.77 kg and 209.6±1.89 kg, respectively. By 15 months, the weight of bulls doubled compared to the eight-month bulls and was 423.3±3.98 kg for herefords, 406.7±3.34 – for Kazakh white-headed bulls and 393.6±4.29 – for Kalmyk bulls. By 18 months, the weight of the animals increased by more than 60 kg and amounted to 488.4±1.98 kg for herefords, 471.7±1.82 – for Kazakh white-headed breeds, and 460.5±1.28 kg – for Kalmyk breeds. The analysis of the dynamics of body weight increase indicates that the animals were in optimal conditions of keeping.

The histological structure of the skin is primarily a consequence of the genotype of animals and is subject to change over time, and also depends on natural and climatic conditions. The microstructure of the skin of an animal determines the body's ability to adapt to certain environmental conditions. The results of the study showed that the skin of the studied animals demonstrates General patterns of structural and functional organization inherent in the skin of cattle. The skin consists of two main parts - the epidermis and the dermis. The epidermis is represented by a multi-layer flat keratinized epithelium, it is characterized by an uneven thickness, the variability of the thickness of the epidermis is due to the introduction of connective tissue papillae from the papillary layer of the dermis. In the epidermis, four layers are revealed in relief – stratum basal, spinosum, granulosum and corneum, while the shiny layer is poorly expressed or absent.

The stratum corneum has some stratification. The papillary layer of the dermis is represented by loose unformed connective tissue containing numerous vessels of the microcirculatory bed. This layer represented all the cellular elements of the connective tissue, the predominant cell forms are cells of fibroblastic programmed differentiation – fibroblasts and fibroblasts. The mesh layer is represented by dense unformed connective tissue. It should be noted that in the skin of the back, the mesh layer of the dermis is characterized by the greatest thickness. The borders between the papillary and reticular layers of the dermis are indistinct.

A comparative analysis of the skin cover of three breeds of cattle showed that, along with the preservation of specific typical features of the skin cover, there are a number of significant breed differences.

The thickness of the dermis was the largest in animals of the Kazakh white-headed breeds. Calmy bulls ranked second and the smallest thickness of the dermis was in animals of the Hereford breed (table 1). At the same time, animals of the Kazakh white-headed breed had the largest thickness of the epidermis (table 1). Thus, the results obtained show that there are significant differences in the thickness of skin layers between the animals of the Hereford breed (they have the smallest thickness) and the animals of the Kazakh white-headed and Kalmyk breeds. And in the thickness of the skin of the animals of the Kazakh white-headed and Kalmyk breeds, no significant differences were found.

The results obtained show that the breeds of the cattle bred in Russia (Kalmyk and Kazakh white-headed) are characterized by a greater thickness of skin compared to animals of Western European selection (Hereford). The revealed differences are primarily related to climatic conditions (for example, the Kalmyk and Kazakh white-headed breeds were bred in Russia in a sharply continental climate).

The deepest occurrence of hair follicles was observed in animals of the Kazakh white-headed and Kalmyk breeds of cattle. At the same time, the highest hair density was observed in animals of the Kalmyk breed, and the smallest – at Hereford. It should also be noted that the Kalmyk and Kazakh whiteheads had 2 times higher content of fine (downy) hair in the skin compared to that of Hereford.
Since they were highly adaptable to unfavorable natural and climatic conditions in the dry steppe zone of the Stavropol Territory.

Table 1. Morphometric indicators of the skin in the back area of bulls of three breeds of cattle

| Name of parameter                                      | Hereford          | Kazakh white-headed | Kalmyk           |
|--------------------------------------------------------|-------------------|---------------------|------------------|
| Thickness of the epidermis (microns)                   | 52.8±3.9          | 66.4±3.6            | 62.7±3.1         |
| Thickness of the papillary layer of the dermis (microns)| 1070±58           | 1315±65             | 1210±51          |
| Thickness of the mesh layer of the dermis (microns)    | 4480±125          | 5163±134            | 4930±128         |
| The total thickness of the dermis (microns)            | 5602±140          | 6544±153            | 6202±145         |

The most numerous content of sebaceous glands in the skin was observed in animals of the Kalmyk breed. The content of sebaceous glands in calmyk bulls was 1.5 times higher than that in Hereford bulls and 1.1 times higher than that in the Kazakh white-headed breed. Fig. 3 and Fig. 4 demonstrate the structure of the sebaceous glands of Kalmyk bulls. The glands have a typical structure, usually their terminal secretory is located near the root of the hair, and their excretory ducts open into the vagina of the hair. The sebaceous glands are characterized by different sizes.

Animals of the Hereford breed were distinguished by a higher number of sweat glands in the skin. The number of sweat glands in them was 1.4 times higher than that in animals of the Kalmyk breed and 1.3 times higher than that in the Kazakh white-headed.

Immunohistochemical reaction to the detection of type I collagen showed that the highest content of this protein is detected in the skin of animals of the Kalmyk and Kazakh white-headed breeds, while the greatest thickness of collagen bundles was detected in animals of the Kalmyk breed, and the smallest – in animals of the Hereford breed.

The presence of a greater thickness of the dermis in combination with an increased content of sebaceous glands in the skin indicates a higher adaptive capacity of animals of the Kazakh white-headed and Kalmyk breeds of cattle to live in extreme weather conditions.

The presence of morphofunctional features of the skin in animals of different breeds raised under the same climatic conditions indicates that the leading factors determining the structural and functional characteristics of the skin are hereditary factors that limit the morphological variability within certain limits.

5. Conclusion
The results obtained show the presence of pronounced breed characteristics of the skin of the studied cattle breeds. Significant breed characteristics of the skin include the number and depth of hair, the content of hair of different diameters, the number of sweat and sebaceous glands. The results obtained indicate the greater adaptability of the skin of the Kalmyk and Kazakh white-headed breeds to living in a sharply continental climate.

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References

[1] Kayumov F, Dubovskov M P and Shevlyuk N N 2003 Comparative morphofunctional characteristics of the skin of young cattle of the Kazakh white-headed breed and its hybrids *Morphol.* **124**(5) 53

[2] Petrishchev B I and Lebengarts Ya Z 1993 Morphology and postnatal development of the skin of cattle (BOS Taurus) of purebred and crossbred animals *Ontogeny* **24**(5) 51–61

[3] Khachatryan M S 1984 Changes in the skin area of cows depending on age and milk productivity *Dokl. VASHNIL* **6** 27–8

[4] Gayen S, Prasad G and Sinha R D 1989 Comparative histological studies of the skin of Indian buffaloes and black Bengal goats *Anima. Sci.* **59**(8) 920–4

[5] Saravanakumar V R and Thiagarajan M 1992 Comparison of sweat glands, skin signs, and heat tolerance coefficients in Murra, Surti, and non-descript buffaloes *Anima. Sci.* **62**(7) 625–8

[6] Rainey P B and Travisano M 1998 Adaptive radiation in a heterogeneous environment *Nature* **394** 69-72

[7] Kosilov V I and Mironenko S I 2009 *Creation of crossbred herds in beef cattle breeding* (Moscow: Vasiz-dat) 304 p.

[8] Dzhulamanov K M 1988 *Productive qualities of gobies of different genotypes*, in: *Improvement of methods of selection and reproduction of beef cattle. Works of VNIIMS* (Orenburg) pp 45-47