Physiological and Biochemical Parameters of Hu Sheep in the Zizhong Area of Sichuan Province in Winter

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Abstract [**Objectives**] This study was conducted to investigate the adaptability of housed Hu sheep in the Zizhong area of Sichuan Province in winter. [**Methods**] Ten adult male and ten adult female sheep, healthy and free from infectious diseases, were selected to measure and analyze their physiological indicators, as well as blood physiological and biochemical parameters. [**Results**] The body temperatures of both male and female sheep were within the normal range, with no significant difference observed ($P>0.05$). However, the respiratory rate and heart rate of ewes were significantly higher than those of rams ($P<0.05$). Regarding blood physiological indicators, total white blood cell count, total red blood cell count, and red blood cell distribution width-coefficient of variation in ewes were significantly higher than those in rams ($P<0.05$), while 8 indicators including lymphocyte count, lymphocyte percentage, and hemoglobin content showed no significant differences between rams and ewes ($P>0.05$). For blood biochemical indicators, albumin, urea nitrogen, and alanine aminotransferase in rams were significantly higher than those in ewes ($P<0.05$), whereas alkaline phosphatase and creatine kinase in ewes were significantly higher than those in rams ($P<0.05$). Eleven indicators, including total protein, globulin, and albumin/globulin ratio, showed no significant differences between sexes ($P>0.05$). [**Conclusions**] This study obtained the physiological and biochemical indicators of Hu sheep in the Zizhong area of Sichuan Province, providing theoretical support for feeding management and disease diagnosis of Hu sheep in this area.

Key words Hu sheep; Respiratory rate; Physiological parameter; Heart rate; Biochemical parameter

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The Hu sheep is a renowned multiparous sheep breed in China, celebrated for its characteristics such as rapid early growth, early maturity, year-round estrus, multiple births and multiple lambs, and the aesthetically pleasing patterns of its lamb fur. Its formation history can be traced back over 800 years to the Southern Song Dynasty, when northern people brought a group of Mongolian sheep southward and settled in the Taihu Lake region of Jiangsu and Zhejiang. Through centuries of enclosed pen domestication, reproduction and propagation, germplasm selection and elimination, as well as the development of the "mulberry-dyke and fish-pond" farming culture in the Taihu Lake Basin involving traditional mulberry planting and silkworm rearing, feeding sheep with withered mulberry leaves, and using sheep manure to fertilize fields for grain production, the Hu sheep breed was ultimately formed[1]. The central production areas are located in the Taihu Lake Basin, including Wuxing, Nanxun, and Changxing in Huzhou City, Zhejiang Province, Tongxiang, Xiuzhou, Nanhu, and Haining in Jiaxing City, and Wuzhong, Taicang, and Wujiang counties in Jiangsu Province[2]. In recent years, with the utilization of the excellent high reproductive characteristics of Hu sheep, the breeding of Hu sheep and its crossbreeding with other local varieties have been carried out nationwide, effectively promoting the development of the meat sheep industry.

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When a livestock or poultry breed is introduced to a new region, the animals must adapt physiologically and in terms of blood physicochemical aspects to the new environment. Parameters such as body temperature, heart rate, and respiratory rate intuitively reflect the physiological responses of livestock and poultry to environmental conditions. Blood physiological and biochemical indicators reflect the immune status, metabolic condition, and functional state of vital organs such as the liver and kidneys. Therefore, when raising livestock in a new region, targeted adaptability monitoring is essential. The introduction of White Suffolk sheep and White Dorper sheep to the Henan region[3], as well as the introduction of Hu sheep to the Liangshan Prefecture in Sichuan[4], the Chongqing region[5], the Henan region[6], and the alpine region of Northwest China[7], has demonstrated their adaptation to local forage and climatic conditions. Monitoring the physiological and blood physiological and biochemical indicators of Hu sheep enables further assessment of their physical condition in new environments.

Zizhong County is located in the central part of the Sichuan Basin, along the middle reaches of the Tuojiang River, with a latitude of 29°34′ - 30°24′ N and a longitude of 104°27′ - 105°07′ E. It has a humid subtropical monsoon climate with distinct seasons, mild temperatures, abundant rainfall, early spring, long summer, and short autumn and winter. The area experiences neither intense heat in summer nor severe cold in winter, and has a long frost-free period. This area boasts abundant agricultural resources, with ample feed resources such as straw and forage, providing a material foundation for the development of housed sheep farming. In this study, Hu sheep that had been acclimatized and raised for over one year in the Zizhong area of Sichuan Province were selected as research objects, and their physiological and blood physiological

and biochemical parameters were measured in winter to further monitor the health status of the sheep during the winter season.

Materials and Methods

Experimental animals

Hu sheep that had been introduced to and raised in the Zizhong area of Sichuan for at least one year were selected as research objects. A total of 10 male and 10 female adult sheep aged 3 – 5 years were randomly selected from the adult male and female flocks. The sheep were housed and fed using a "concentrate + hay" feeding method.

Physiological indicators

In January 2020, between 6:00 and 8:00 a. m., physiological indicators including rectal temperature, heart rate, and respiratory rate were measured while maintaining a quiet environment. The sheep were restrained and kept in a calm state during the measurement.

Blood sample collection

Blood samples (6 – 8 ml) were collected from the jugular vein of fasting sheep in the morning. Approximately 3 – 4 ml of blood was injected into a vacuum blood collection tube containing EDTA-K2 as an anticoagulant and mixed thoroughly. Another 3 – 4 ml of blood was injected into a vacuum blood collection tube without anticoagulant. The samples were stored at low temperature, and blood physiological and biochemical indicators were analyzed by the Shuangliu Aixin Animal Hospital.

Statistical analysis

Statistical analysis of the collected data was performed using IBM SPSS Statistics 22 software. The results were expressed as mean ± standard deviation ($\bar{x} \pm S$).

Results and Analysis

Physiological indicators

As shown in Table 1, for Hu sheep introduced to and raised in the Zizhong area of Sichuan, the body temperatures of rams and ewes in winter were (39.15 ± 0.26) and (38.99 ± 0.45) ℃, respectively, both within the normal variation range of body temperature for sheep, with no significant difference between sexes ($P > 0.05$). The respiratory rates of rams and ewes were (34.10 ± 1.52) and (36.60 ± 3.10) breaths/min, respectively, showing a significantly higher respiratory rate in ewes than in rams ($P < 0.05$). The heart rates were (70.10 ± 4.93) beats/min for rams and (88.20 ± 8.59) beats/min for ewes, also showing a significantly higher heart rate in ewes than in rams ($P < 0.05$).

Table 1 Physiological parameters of Hu sheep in winter

Sex	Sample No. (N)	Body temperature//℃	Respiratoryrate breaths/min	Heart rate beats/min
Ram	10	39.15 ± 0.26	34.10 ± 1.52	70.10 ± 4.93
Ewe	10	38.99 ± 0.45	36.60 ± 3.10	88.20 ± 8.59
P value		0.34	0.03	0.00

Blood physiological indicators

As shown in Table 2, for Hu sheep in winter, the total red blood cell counts of rams and ewes were (10.97 ± 1.03) × 10^{12}/L and (12.52 ± 1.72) × 10^{12}/L, respectively. The total white blood cell counts were (283.33 ± 13.92) × 10^9/L and (304.33 ± 17.98) × 10^9/L, respectively. The lymphocyte counts were (209.14 ± 17.90) × 10^9/L and (226.45 ± 12.81) × 10^9/L, respectively. The total platelet counts were (290.50 ± 25.55) × 10^9/L and (259.90 ± 28.19) × 10^9/L, respectively. The hemoglobin content were (117.10 ± 11.40) and (127.00 ± 10.54) g/L, respectively. The blood physiological indicators of ewes, including total white blood cell count, total red blood cell count, and red blood cell distribution width-coefficient of variation, were significantly higher than those of rams ($P < 0.05$). However, blood physiological indicators such as lymphocyte count, lymphocyte percentage, hemoglobin content, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and total platelet count showed no significant differences between rams and ewes ($P > 0.05$).

Table 2 Blood physiological parameters of Hu sheep in winter

Sex	Sample No. (N)	Total white blood cell count//10^9/L	Lymphocyte count//10^9/L	Lymphocyte percentage//%	Hemoglobin concentration//g/L	Total red blood cell count//10^{12}/L	Hematocrit %
Ram	10	283.33 ± 13.92	209.14 ± 17.90	74.37 ± 6.22	117.10 ± 11.40	10.97 ± 1.03	51.87 ± 5.20
Ewe	10	304.33 ± 17.98	226.45 ± 12.81	74.63 ± 5.93	127.00 ± 10.54	12.52 ± 1.72	54.96 ± 8.19
P value		0.009	0.37	0.971	0.22	0.03	0.33

Sex	Sample No. (N)	Mean corpuscular volume (MCV)//fl	Mean corpuscular hemoglobin (MCH)//pg	Mean corpuscular hemoglobin concentration (MCHC)//g/L	Red cell distribution width-coefficient of variation (RDW-CV)//%	Total platelet count//10^9/L
Ram	10	44.29 ± 10.16	10.68 ± 0.35	225.90 ± 5.96	10.81 ± 0.28	290.50 ± 25.55
Ewe	10	43.93 ± 3.23	10.13 ± 0.80	230.43 ± 9.67	11.82 ± 0.35	259.90 ± 28.19
P value		0.92	0.06	0.22	0.000	0.12

Blood biochemical indicators

As shown in Table 3, for Hu sheep in winter, the following blood biochemical parameters were recorded for rams and ewes, respectively: blood total protein content, (81.27 ± 5.26) and (77.13 ± 2.94) g/L; globulin content, (81.27 ± 5.26) and (77.13 ± 2.94) g/L; albumin content, (29.79 ± 2.64) and (27.66 ± 1.44) g/L; alanine aminotransferase content, (29.80 ± 2.65) and (20.44 ± 2.23) U/L; alkaline phosphatase content, (94.90 ± 8.52) and (125.11 ± 7.86) U/L, respectively; creatine kinase content, (214.00 ± 18.94) and (311.67 ± 25.29) U/L;

cholesterol content, (1.49 ± 0.12) and (1.48 ± 0.18) mmol/L; and glucose content, (4.09 ± 0.39) and (3.65 ± 0.95) mmol/L. In the blood, indicators such as albumin, urea nitrogen, and alanine aminotransferase in rams were significantly higher than those in ewes ($P < 0.05$), while indicators such as alkaline phosphatase and creatine kinase in ewes were significantly higher than those in rams ($P < 0.05$). Indicators including total protein, globulin, albumin/globulin ratio, calcium, glucose, inorganic phosphorus, amylase, cholesterol, total bilirubin, creatinine, and urea nitrogen/creatinine ratio showed no significant differences between sexes ($P > 0.05$).

Table 3 Blood biochemical parameters of Hu sheep in winter

Sex	Sample No. (N)	Albumin g/L	Total protein g/L	Globulin g/L	Albumin-to-globulin ratio (A/G ratio)	Calcium (Ca) mmol/L	Glucose (Glu) mmol/L	Blood urea nitrogen (BUN) mmol/L	Inorganic phosphorus (IP) mmol/L
Ram	10	29.79 ± 2.64	81.27 ± 5.26	51.48 ± 7.27	0.60 ± 0.12	2.30 ± 0.12	4.09 ± 0.39	4.61 ± 0.32	1.69 ± 0.21
Ewe	10	27.66 ± 1.44	77.13 ± 2.94	48.36 ± 4.53	0.57 ± 0.05	2.32 ± 0.21	3.65 ± 0.95	3.12 ± 0.24	1.47 ± 0.17
P value		0.046	0.053	0.283	0.435	0.722	0.195	0.002	0.287

Sex	Sample No. (N)	Amylase (AMS) // U/L	Cholesterol (CHOL) mmol/L	Alanine aminotransferase (ALT) // U/L	Total bilirubin (TBIL) μmol/L	Alkaline phosphatase (ALP) // U/L	Creatinine (CREA) μmol/L	Urea nitrogen-to-creatinine ratio (BUN/CREA ratio)	Creatine kinase (CK) U/L
Ram	10	13.00 ± 1.24	1.49 ± 0.12	29.80 ± 2.65	8.25 ± 0.75	94.90 ± 8.52	108.60 ± 10.80	10.90 ± 0.98	214.00 ± 18.94
Ewe	10	5.00 ± 0.44	1.48 ± 0.18	20.44 ± 2.23	8.39 ± 0.58	125.11 ± 7.86	92.22 ± 8.37	8.67 ± 0.65	311.67 ± 25.29
P value		0.080	0.993	0.011	0.886	0.014	0.076	0.112	0.004

Conclusion and Discussion

Physiological indicators such as body temperature, respiratory rate, and heart rate reflect the internal environment and external adaptability of an animal's body, serving as important criteria for assessing whether an animal is healthy. Differences in breed, sex, and climate have certain effects on these indicators[7]. The body temperatures of Hu sheep introduced to the Zizhong area in winter were (39.15 ± 0.26) ℃ for rams and (38.99 ± 0.45) ℃ for ewes; the respiratory rates were (34.10 ± 1.52) breaths/min for rams and (36.60 ± 3.10) breaths/min for ewes; and the heart rates were (70.10 ± 4.93) beats/min for rams and (88.20 ± 8.59) beats/min for ewes. All indicators were within the normal healthy range for sheep. However, the respiratory rate and heart rate of ewes were significantly higher than those of rams. During this period, the ewes may have been in the gestation stage, requiring maintenance of normal fetal development, resulting in relatively higher basal metabolism. Therefore, during winter, ewes should be provided with a higher nutritional level and more meticulous feeding management.

In humans, routine blood tests (blood physiological indicators) are of great significance in clinical auxiliary diagnosis, disease assessment, treatment effect monitoring, and health screening. For livestock and poultry such as cattle, sheep, and pigs, routine blood testing also plays a role that cannot be overlooked. The detection of blood physiological indicators mainly involves the measurement of various parameters such as white blood cells, red blood cells, and platelets. By observing changes in the number and morphological distribution of blood cells, this examination helps determine the blood status and detect diseases in both humans and animals. Among the 11 blood physiological indicators measured in this study for Hu sheep, only indicators such as total white blood cell count, total red blood cell count, and red blood cell distribution width-coefficient of variation showed significant differences between rams and ewes. Other eight indicators, including lymphocyte count, lymphocyte percentage, hemoglobin content, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and total platelet count, exhibited relatively small differences between rams and ewes. Meanwhile, all 11 indicators were within the normal blood physiological ranges for sheep in China.

The detection of blood biochemical indicators generally includes assessments of liver function, kidney function, blood glucose, blood lipids, and electrolytes. These indicators reflect the liver's metabolic, synthetic, and detoxification functions, the kidney's filtration and excretion functions, as well as changes in the body's blood glucose, blood lipid, and electrolyte levels. When sheep are introduced from their original habitat to other regions for breeding, they gradually adapt to the new environment, leading to changes in their blood biochemical indicators, which in turn cause changes in various functions of the body. The winter blood biochemical indicators of Hu sheep introduced to the Zizhong area for breeding were within the normal ranges for sheep in China. Most indicators remained relatively balanced and stable between rams and ewes, while indicators such as albumin, urea nitrogen, alanine aminotransferase, alkaline phosphatase, and creatine kinase showed differences. The results of this study provide a theoretical basis for the further adaptive breeding of Hu sheep in the Sichuan region and the development of the industry.

References

[1] LI YF, LI JT, YIN YY, *et al.* Development status and countermeasures of Hu sheep industry in Huzhou[J]. Animals Breeding and Feed, 2017 (1): 55. (in Chinese).

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aligns with the major trend of the biscuit industry toward healthy "low-sugar, low-fat and high-fiber" products put forward by Huajing Industrial Research Institute, and shows obvious potential for industrialization.

References

[1] Time-honored brands accelerate the layout of "national trend + health" [N]. Gusu Evening News, 2024 - 03 - 14. (in Chinese).

[2] Settlement of Suzhou Daoxiangcun freshly-baked store in Pingjiang Road [N]. Jiangnan Times, 2024 - 03 - 11. (in Chinese).

[3] WANG LN, LUAN YX. Development of quinoa and blueberry crisp biscuits[J]. Cereal & Food Industry, 2024(6): 42 - 45, 61. (in Chinese).

[4] DONG GX, YU JX, ZHANG XW. The application and development trend of erythritol in low-sugar baked goods[B]. Grain and Food Industry, 2025, 32(5): 52 - 55. (in Chinese).

[5] PEI T, LI JY, WANG Y, *et al.* Industry development and cultivation technology research progress of *Vacciniium macrocarpon*[A]. Jilin Forestry Science and Technology, 2022(2): 32 - 37. (in Chinese).

[6] TANG YY, SUN J. Research progress on non-volatile components and functional activities of *Jasminum sambac* (L.) Aiton[J]. Food Research and Development, 2021, 42(11): 189 - 195. (in Chinese).

[7] ZHANG YX, CUI XY, GUO XY, *et al.* Overview of the application of erythritol in foods[J]. Guangxi Sugarcane Industry, 2024, 44(2): 122 - 125. (in Chinese).

[8] ZHANG YY, WANG R. Advances in biological functions and clinical applications of erythritol[J]. Food and Fermentation Industries, 2024, 50(3): 357 - 365. (in Chinese).

[9] China Food News: EU imposes high anti-dumping duties, domestic erythritol industry accelerates innovation [N]. China Food Newspaper, 2024 - 07 - 29(6). (in Chinese).

[10] LIANG HD, LUO W. Development of low sugar biscuit with jasmine flavor[J]. Modern Food, 2020(19): 106 - 110. (in Chinese).

[11] ZHANG CF, XIA QL, YIN LB, *et al.* The formula optimization of soy bean dregs fiber and cranberry biscuit with response surface methodology [J]. Science and Technology of Food Industry, 2016, 37(12): 222 - 226. (in Chinese).

[12] Li AS, Tang ZF, Xiao N, *et al.* Comparison of different formulas of sugar-free single-cluster crisp biscuit[J]. The Food Industry, 2022, 43(4): 1 - 5. (in Chinese).

[13] Standardization Administration of China, State Administration for Market Regulation. General rules for biscuit quality: GB/T 20980—2021[S]. Beijing: Standards Press of China, 2021. (in Chinese).

[14] RÓZYŁoRPŁATEKA, DZIKID, *et al.* Functional properties of short bread cookies sweetened with erythritol and enriched with black currant pomace[J]. Journal of Food Science and Technology, 2024, 61(3): 564 - 575.

[15] SUN H, FU WJ, GUO LL, *et al.* Development of low sugar oat purple potato biscuit[J]. Bulletin of Fermentation Science and Technology, 2023, 52(3): 145 - 150. (in Chinese).

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU

(Continued from page 41)

[2] China National Commission of Animal Genetic Resources. Animal genetic resources in China: Sheep and goats[M]. Beijing: China Agriculture Press, 2011. (in Chinese).

[3] SHI HB, WANG YQ, LI YX, *et al.* Analysis of seasonal blood physiological and biochemical indexes of White Suffolk sheep and White Dorper sheep in Henan Province[J]. China Herbivore Science, 2019, 39(1): 9 - 14. (in Chinese).

[4] JILI AM, MENG QY, ANLA Z. Observation on adaptability of housed Hu sheep in Yuexi County, Sichuan[J]. Sichuan Animal & Veterinary Sciences, 2024, 11: 26 - 28. (in Chinese).

[5] WANG GF, LI J, JIANG J, *et al.* Determination of growth development and blood physiological and biochemical indicators of Hu sheep in hot and humid areas of Southwest China[J]. Heilongjiang Animal Science and Veterinary Medicine, 2018, 11: 122 - 124. (in Chinese).

[6] LIU CC, HAN ZQ. Study on adaptability and germplasm characteristics of Hu sheep in Henan region[J]. Heilongjiang Animal Science and Veterinary Medicine, 2017, 2(A): 92 - 95. (in Chinese).

[7] XIE YL, LIANG XL, YANG YG. Physiological and biochemical indexes of Hu sheep in the alpine region of Northwest China[J]. Acta Pratalturae Sinica, 2017, 26(9): 221 - 227.

Editor: Yingzhi GUANG Proofreader: Xinxiu ZHU