

Hematological, Blood Chemical and Hormonal Changes in Hanwoo (Korean Native Cattle) Raised at Different Altitudes

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Abstract : Despite the risk of high altitude disease (HAD), raising cattle at higher altitudes does have advantages such as beef quality due to minimal chance of infection and stress. The ideal situation is to determine the optimum altitude suitable for raising cattle while at the same time minimizing the risk of HAD. Therefore, in this study, we documented the health status of three groups of steers, raised at three different altitudes (200 m, 400 m and 800 m) in Gangwon province, using routine hematological, biochemical and hormonal tests. The red blood cell counts and hemoglobin concentration were highest in the 800 m group, and lowest in the 200 m group, possibly due to hypoxia induced myeloid and erythroid stimulation. The mean concentration of AST, BUN and serum cortisol were lowest in the 800 m. These findings suggest the stress factor will contribute the general health status of animal and indicate a difference in the Hanwoo groups raised at 800 m compared to 200 m, where the cattle raised at the higher altitude exhibit better health status compared to the lower altitude, possibly due to less stressful environment in the higher altitude.

Key words : altitude, Hanwoo, hematology, blood biochemistry, hormone value.

Introduction

Cattle raised in high altitude are prone to develop brisket disease (also known as high altitude disease; HAD). The signs and symptoms are lethargy, weakness, collapse, diarrhea, bulging eyes and edema with the brisket region being most pronounced. The cattle are affected from at the altitude of 1,500m and are more severely affected with higher altitude. Pulmonary hypertension subsequent with right side heart failure caused by hypoxia is the main cause of death (7). In contrary, cattle raised in high altitude have a better meat quality and daily weight gain, since lower oxygen saturation in the atmosphere improves cardiopulmonary function and oxygen utilization. Colder environmental temperature in higher altitude also contributes to improve meat quality by means of enhancing metabolic rate (1,5).

In general, cattle have smaller size of sweat gland and thus are weaker tolerance to heat whereas stronger tolerance to cold due to poor function of sweat gland (3,5). Cold environment can minimize risks from infectious diseases mediated by insects (e.g. mosquitoes, fleas or ticks) and stress from environment (e.g. noise, pollution). Less stress and risk of infection will surely help to maintain better health status and thus help to produce better quality of beef. Therefore raising cattle in higher altitude will be a better place for producing good quality of beef.

However, the scientific dilemma is which altitude is the most suitable for raising cattle, because cattle are being prone to fatal HAD with increasing altitude.

Unfortunately, the health status and growth efficiency influenced by altitude are poorly studied. Most studies are focused on pathophysiological effects caused by raising at the very high altitude (higher than 1,500 m) to minimize risk of HAD (2,8). There is no HAD report from the cattle raised at the moderately high altitude (500-1,000 m from the sea level). Therefore, more fundamental studies are required to prove the beneficial effects from the raising cattle at the moderately high altitude. In this study, thus, we investigated the health status influenced by raising in different altitude (ranging from 200 m to 800 m), using the complete blood cell counts and serum biochemistry.

Materials and methods

Animals

Fattening steers raised in three different altitudes (200 m, 400 m and 800 m) in Gangwon province (Korea) were selected for this study. All animals were 30 months of age. Fourteen steers were selected from herd raised in 200 m altitude whereas 18 and 22 steers from herd raised in 400 m and 800m altitude, respectively. To minimize the effect from diet, the animals were fed with the same diet for the study period.

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Hematology and serum biochemistry and hormonal assay

All blood samples were collected during summer season. A blood sample (2 mL) was collected from the jugular vein and immediately placed into EDTA blood bottles for hematology (1 mL) and lithium heparin for biochemistry (1 mL). Hematology was measured using an automated cell counter (HEMAVET 950, Drew Scientific Group Company, USA). For blood chemical examination, serum glucose, creatine phosphokinase (CPK), aspartate transaminase (AST), urea nitrogen (UN) and creatinine were measured on automated chemical analyser (FUJI DRY-CHEM 3500i, Fuji Film Corporation, Japan). For hormonal assay, serum cortisol and thyroid hormone (T 4) were measured on automated enzyme immunoassay system (AIA-360, TOSHO, Japan).

Statistical analysis

A paired *t*-test was done using software packages (Minitab ver 14, Minitab inc, USA). If *p*-value was <0.05, we considered the result was statistically significant.

Results

In hematological evaluation, total WBC counts were the highest in the 800m group ($7.55 \pm 1.82 \times 10^3/\mu\text{L}$), whereas were lowest in the 200 m group ($5.46 \pm 1.65 \times 10^3/\mu\text{L}$) (Table 1). Total RBC counts were also the highest in the 800 m group ($8.72 \pm 1.38 \times 10^6/\mu\text{L}$) and lowest in 200 m group ($7.24 \pm 1.66 \times 10^6/\mu\text{L}$). In parallel to total RBC count,

PCV were the highest in the 800 m group ($42.69 \pm 5.52\%$) and lowest in the 200 m group ($35.59 \pm 7.62\%$) (Table 1). However, mean corpuscular hemoglobin concentration (MCHC) was the lowest in the 800 m group (29.97 ± 3.63) and the highest in the 200 m group (31.59 ± 2.85). No statistically significant difference was observed in other hematological parameters.

Blood glucose, aspartate transaminase (AST), creatine phosphokinase (CPK), creatinine, and serum urea nitrogen (UN) were measured to investigate general health status of steers raised in the different altitude. There was no statistically significant different in blood glucose, CPK and creatinine levels in each group of steers tested. However, in AST measurement indicating damage of liver, muscle and red blood cell, steers raised in 800 m altitude (800 m group) showed the lowest level (75.27 ± 13.14 U/L) in the test groups, whereas steers in 200m altitude (200 m group) showed the highest level (89.78 ± 83.06 IU/L) (Table 2). Furthermore, percent of steers showing higher than 100 U/L AST level indicating actual damage was not significantly different between 200m group (21.4%) and 400 m group (22.2%), while the percent of steers was only 4.35% in 800 m group. In urea nitrogen measurement indicating the renal function of removing nitrous waste, steers in 800 m group showed the lowest level (13.19 ± 2.06 mg/dL) in the test groups, whereas steers in 200 m altitude (200 m group) showed the highest level (17.14 ± 5.16 mg/dL) (Table 2). In addition, percent of steers showing higher than 15 mg/dL level indicating actual reduction of renal func-

Table 1. Hematological difference in Hanwoo raised at different attitudes

Altitude	Reference	200 m (n = 14)	400 m (n = 18)	800 m (n = 22)
tWBC ¹ ($\times 10^3/\text{mL}$)	4-12	5.46 ± 1.65^b	6.86 ± 2.89^{ab}	7.55 ± 1.82^a
Neutrophil ($\times 10^3/\text{mL}$)	0.6-4.1	2.17 ± 0.88	2.75 ± 1.43	2.72 ± 0.76
Lymphocyte ($\times 10^3/\text{mL}$)	2.5-7.5	2.80 ± 0.76^b	3.22 ± 1.10^b	3.94 ± 1.03^a
Monocyte ($\times 10^3/\text{mL}$)	0-1.2	0.26 ± 0.15	0.32 ± 0.20	0.37 ± 0.14
Eosinophil ($\times 10^3/\text{mL}$)	0-2.4	0.18 ± 0.11^b	0.54 ± 0.60^a	0.49 ± 0.33^a
Basophil ($\times 10^3/\text{mL}$)	0-0.4	0.05 ± 0.06	0.04 ± 0.03	0.05 ± 0.04
tRBC ² ($\times 10^6/\text{mL}$)	5-10	7.24 ± 1.66^b	7.26 ± 1.57^b	8.72 ± 1.38^a
Hb ³ (g/dL)	8-16	11.16 ± 2.15^b	11.74 ± 2.19^{ab}	12.67 ± 1.26^a
PCV ⁴ (%)	24-46	35.59 ± 7.62^b	37.74 ± 8.70^b	42.69 ± 5.52^a
MCV ⁵ (fL)	40-60	49.48 ± 4.40	51.91 ± 3.24	49.27 ± 3.71
MCH ⁶ (pg)	11.1-18.0	15.61 ± 1.77^{ab}	16.35 ± 1.65^a	14.76 ± 2.17^b
MCHC ⁷ (g/dL)	28.2-38.0	31.59 ± 2.85	31.54 ± 3.15	29.97 ± 3.63
RDW ⁸ (%)	12-27	21.01 ± 1.04	21.83 ± 1.06	21.73 ± 1.30
Platelet ($\times 10^3/\text{mL}$)	200-800	143.86 ± 145.12	157.72 ± 155.65	244.05 ± 148.35
MPV ⁹ (fL)	5-20	5.15 ± 3.00	5.48 ± 3.37	5.01 ± 2.13

¹total white blood cell count, ²total red blood cell count, ³hemoglobin, ⁴packed cell volume, ⁵mean corpuscular volume, ⁶mean corpuscular hemoglobin, ⁷mean corpuscular hemoglobin concentration, ⁸red blood cell distribution width, ⁹mean plasma volume.

^{a,b}Means with different superscripts in the same row significantly differ (*p* < 0.05).

Table 2. Blood biochemical difference in Hanwoo raised at different attitude

Items	Reference	200 m	400 m	800 m
Glucose (mg/dL)	75-128	85.21 ± 19.18 ^a	71.39 ± 10.94 ^b	76.77 ± 19.29 ^{ab}
AST ¹ (U/L)	17-100	89.78 ± 83.06	79.14 ± 22.93	75.27 ± 13.14
CPK ² (U/L)	49-166	347.00 ± 185.32	473.11 ± 404.72	427.59 ± 386.24
Creatinine (mg/dL)	0.4-1.4	1.34 ± 0.38	1.34 ± 0.20	1.34 ± 0.26
UN ³ (mg/dL)	9.2-15.2	17.14 ± 5.16 ^a	15.32 ± 2.70 ^{ab}	13.19 ± 2.06 ^b

¹aspartate aminotransferase, ²creatinine phosphokinase, ³urea nitrogen

^{a,b}Means with different superscripts in the same row significantly differ ($p < 0.05$).

Table 3. Hormonal difference in Hanwoo raised at different attitudes

Items	Reference	200 m	400 m	800 m
Cortisol (mg/dL)	4.5-8.5	6.49 ± 1.54 ^a	4.95 ± 1.86 ^b	4.20 ± 2.83 ^b
T 4 (mg/dL)	3-7	6.48 ± 0.86	6.79 ± 1.21	6.25 ± 0.78

^{a,b} Means with different superscripts in the same row significantly differ ($p < 0.05$).

tion were the highest in 200 m group (71.4%) and the lowest in 800 m group (8.7%). Overall health status of each group of steers was the fairest in 800m group and the poorest in the 200 m group based on CBC and blood biochemistry.

In hormonal evaluation, cortisol was increased as the altitude is lower and T4 was no statistically significant different in the different altitude (Table 3). This result implied that 200 m group of steers get more stress from the environment.

Discussion

In high-altitude environment, animals are prone to suffer cardiopulmonary failure due to relatively lower oxygen saturation in the atmosphere (hypoxia). To compensate physiological hypoxic state, animals produce more red blood cells (absolute polycythemia) and hemoglobin and accelerate respiration and blood circulation rate (pulse rate) (1,6). As previously reported, RBC index (total RBC count, PCV, hemoglobin concentration) was the highest in the 800 m group in this study (6). However, the MCHC was the lowest in the 800 m group, although hemoglobin concentration was the highest in the 800 m group. This result implies that the actual ability of oxygen saturation in the hemoglobin is the poorest in the 800 m group, possibly due to the lower oxygen tension at the high altitude. The prolonged hypoxic status stimulates the erythroid and myeloid activity in the bone marrow and thus increases the number of blood cells including RBC, WBC and platelet (4). Therefore the highest WBC and platelet counts in the 800 m group are resulted from the physiological compensation by the bone marrow stimulation responded to relatively lower oxygen tension, rather than pathological etiology.

Serum chemistry routinely used to check health status. However, not much studies have done to reveal the difference in serum biochemical profiles in animals raised in different altitude. In general, serum glucose level is influenced by metabolic and nutritional status, infection, stress and environmental temperature. In stressful condition, serum glucose can be persistently high due to increased glucocorticoid pro-

duction by stress (2). However, no significant difference was observed in this study, implying serum glucose level alone will not be enough to estimate stress level. Further serum cortisol evaluation will be necessary to estimate stress level in Hanwoo raised at the different altitude.

AST level is associated with hepatic cellular damage, muscular injury and RBC destruction, whereas CPK level is associated with muscular damage. In this study, although no statistically significant difference in the mean of AST and CPK level was observed in test groups, the percent of cases having over reference range in AST level was significantly different in the groups (21.4% in 200 m group vs 4.35% in 800 m group). This result implies that more animals in the 200m have cellular damages by unidentified etiologies suggesting more stressful environment in lower altitude.

UN and creatinine reflect renal excretion of toxic nitrogen by-products. In general, the levels of UN and creatinine are associated with protein catabolism (e.g. diet, heat, exercise), kidney damage and hydration status. In this study, mean of UN level was significantly different in test groups. Furthermore, the percent of cases having over reference range in UN level was the highest in the animals at the lower altitude and the lowest at the higher altitude, implying that animals raised at the higher altitude have a better renal excretion of nitrogen by-products. Because the hydration status was not significantly differed and the same type of diet was fed in test groups, serum biochemical studies suggests overall health status is better in the group at the higher attitude than the lower altitude.

In conclusion, our hematological evaluation showed compensatory erythroid and myeloid stimulation responded to hypoxia in the Hanwoo group raised at the higher altitude. Furthermore serum biochemical and hormonal assays showed general health was better in group of Hanwoo raised at the higher altitude, possibly by less stressful and cold environment. Further study is warranted to prove the link of health status to meat quality in the moderately high altitude (800-1200 m from the sea level).

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고도별 한우의 혈액학, 혈액생화학적 및 호르몬 수치의 변화

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요 약 : 고도병(High altitude disease)의 위험에도 불구하고, 고냉지에서 한우를 사육할 경우, 감염이나 스트레스 위험이 낮아서 한우의 육질을 개선하는데 도움이 된다고 한다. 하지만 어떤 고도가 고도병의 위험성이 없이 최적의 사육 환경을 제공하는지에 대한 연구가 부족한 실정이다. 따라서 본 연구에서는 3가지 다른 고도(200 m, 400 m and 800 m)에서 사육되고 있는 한우를 대상으로 혈액 검사, 혈청 생화학 검사 및 스트레스와 관련된 호르몬 검사를 실시하였다. 본 연구에서 적혈구 수치와 혈색소의 농도는 800 m 고지에서 사육된 한우에서 가장 높았고, 200 m 고지에서 사육된 한우에서 가장 낮게 나타났다. 이러한 결과는 저산소증에 따른 골수와 적혈구 신생 자극 반응에 기인한 것으로 보인다. 혈중의 AST, BUN과 cortisol농도는 800 m 고지에서 사육된 한우에서 가장 낮게 측정되었으며, 전반적인 건강 상태도 200 m 지대에서 사육된 한우보다 800 m 지대에 사육된 한우 집단이 건강 상태가 양호한 것으로 나타났다. 이 결과는 한우의 건강에 영향을 주는 스트레스 요인이 800 m 고지에서 최소로 나타남을 의미하는 것 같다.

주요어 : 고도, 한우, 혈액학, 혈액화학, 호르몬 수치