# Effects of Rib Number and Age on Serum and Hair Mineral Element Contents and Their Correlation in Jinchuan Yaks (Postprint)

**Authors:** Xiao Fang, Tang Cheng, Wang Quanhui, Yang Guoping, Lan Daoliang, Li Jian, Huang Yanling

**Date:** 2017-10-11T00:00:00+00:00

## Abstract

This experiment aimed to analyze the mineral element contents in the serum and hair of yaks from Jinchuan County, investigate the effects of rib number and age on element contents, and analyze the correlations between mineral element contents in hair and the corresponding elements in serum. A two-factor repeated experimental design was adopted, and 32 male yaks were grouped according to rib number [14 ribs (n=17) and 15 ribs (n=15)] and age [0 (newborn)-2 years (n=10), 3-4 years (n=11), 5-6 years (n=5), 7-8 years (n=6)], totaling 8 groups. Serum and hair samples were collected respectively for mineral element content analysis. The results showed that: 1) Rib number and age had no significant effects on the contents of calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), and zinc (Zn) in serum ($P>0.05$); there was no interaction between age and rib number ($P>0.05$). 2) Rib number had no significant effect on the contents of Ca, Cu, Fe, Mg, Mn, Na, and Zn in hair ($P>0.05$); age could affect hair K content, with the K content in 7-8-year-old yaks being significantly higher than that in other age groups ($P<0.05$), but had no significant effects on other element contents in hair ($P>0.05$); there was no interaction between age and rib number ($P>0.05$). 3) The contents of Ca, Cu, Fe, Mg, and Zn in hair were extremely significantly correlated with the corresponding element contents in serum ($P<0.01$), with correlation coefficients of 0.623 0, 0.539 8, 0.569 2, 0.468 4, and 0.505 3, respectively, while the correlations of K, Mn, and Na contents were not significant ($P>0.05$). Overall, there was no significant difference in mineral element contents between 14-rib and 15-rib yaks in Jinchuan; the K content in hair increased significantly at 7-8 years of age; the contents of Ca, Cu, Fe, Mg, and Zn in yak hair and serum were significantly correlated, suggesting that hair could replace serum for the determination of corresponding element contents; Cu, Mg, and Na in Jinchuan yaks may be in a deficient state, while Fe may be in an excess state.

# Full Text

## Preamble

### Effects of Rib and Age on Serum and Hair Mineral Contents and Correlation of Mineral Contents between Serum and Hair of Jinchuan Yak

XIAO Fang[1], TANG Cheng[1], WANG Quanhui[2], YANG Guoping[3], LAN Daoliang[1], LI Jian[1], HUANG Yanling[1]*

[1]College of Life Science and Technology, Southwest University for Nationalities, Chengdu 610041, China
[2]Raise Livestock and Veterinary Office of Jinchuan, Jinchuan 624100, China
[3]Raise Livestock and Veterinary Service Center of Ruoergai County, Ruoergai 624500, China

**Abstract:** This study was conducted to measure the mineral contents in serum and hair of Jinchuan yak, analyze the effects of rib number and age on these contents, and examine the correlation of mineral contents between serum and hair. Thirty-two male yaks were divided into eight groups using a two-factor repeated measures design based on rib number [14 ribs (n=17) and 15 ribs (n=15)] and age [0 (birth)-2 years old (n=10), 3–4 years old (n=11), 5–6 years old (n=5), and 7–8 years old (n=6)]. Serum and hair samples were collected to determine mineral contents. The results showed: (1) Mineral contents [calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), and zinc (Zn)] in serum were not significantly affected by rib number, age, or their interaction ($P>0.05$). (2) Ca, Cu, Fe, Mg, Mn, Na, and Zn contents in hair were not significantly affected by rib number ($P>0.05$); K content was significantly affected by age, with 7–8-year-old yaks showing significantly higher hair K content than other age groups ($P<0.05$), but other mineral contents were not significantly affected by age or the age × rib interaction ($P>0.05$). (3) There were highly significant correlations between serum and hair for Ca, Cu, Fe, Mg, and Zn contents ($P<0.01$), with correlation coefficients of 0.6230, 0.5398, 0.5692, 0.4684, and 0.5053, respectively; however, no significant correlations were found for K, Mn, and Na contents between serum and hair ($P>0.05$). These findings indicate that there is no significant difference in mineral content between 14-rib and 15-rib Jinchuan yaks; 7–8-year-old yaks have significantly higher K content in hair; significant correlations exist for Ca, Cu, Fe, Mg, and Zn contents between serum and hair, suggesting that hair can be used as a substitute for serum to measure these mineral contents; Jinchuan yaks may be deficient in Cu, Mg, and Na, while Fe may be in excess.

**Keywords:** Jinchuan yak; serum; hair; mineral content

---

# 1. Materials and Methods

## 1.1 Experimental Animals and Design

Thirty-two healthy male Jinchuan yaks were selected from the Jinchuan Yak Breeding Farm in Sichuan Province. The experimental design employed a two-factor repeated measures arrangement, with rib number (14 ribs, n=17; 15 ribs, n=15) and age [0 (birth)-2 years old (n=10), 3-4 years old (n=11), 5-6 years old (n=5), and 7-8 years old (n=6)] as the two factors, resulting in a total of eight groups. Blood and hair samples were collected from each animal for mineral content determination.

## 1.2 Sample Collection

Blood samples were collected from the jugular vein of each yak into 5 mL tubes, allowed to clot for 30 minutes, then centrifuged at 2,000×g for 15 minutes. The resulting serum was transferred to clean tubes and stored at -20°C until analysis. Hair samples were collected from the withers region, cut close to the skin with scissors, washed with neutral detergent and deionized water, rinsed three times, and dried at 65°C for 48 hours before being stored in sealed bags.

## 1.3 Sample Preparation

**1.3.1 Serum Sample Preparation** Serum samples (500 µL) were placed in 50 mL tubes, mixed with 20 mL of a 5% nitric acid solution, and digested in a water bath at 80°C for 5 hours. After cooling, 3 mL of 30% hydrogen peroxide was added, and the mixture was heated at 170°C until completely digested. The digested solution was then diluted to 25 mL with 5% nitric acid solution and stored at 4°C until analysis. Blank controls were prepared using the same procedure.

**1.3.2 Hair Sample Preparation** Hair samples (0.5 g) were placed in 50 mL tubes, mixed with 40 mL of a 5% nitric acid solution, and digested in a water bath until completely dissolved. The digested solution was then diluted to 25 mL with 5% nitric acid solution.

## 1.4 Mineral Content Determination

Mineral contents in prepared serum and hair samples were determined using inductively coupled plasma optical emission spectrometry (ICP-OES, Thermo Fisher Scientific).

## 1.5 Statistical Analysis

Data were analyzed using SAS 9.0 software. A mixed model (MIXED) was used to analyze the effects of rib number and age on mineral contents, with rib and age as fixed effects and individual animal as a random effect. The CORR procedure was used for correlation analysis between serum and hair mineral contents, and the REG procedure was used for regression analysis. Differences among means were tested using the LSD method. Statistical significance was declared at $P<0.05$, and highly significant differences at $P<0.01$. Results are presented as means ± standard deviation.

---

## 2. Results

### 2.1 Effects of Rib Number and Age on Serum Mineral Contents

As shown in Table 1, rib number, age, and their interaction had no significant effects on serum Ca, Cu, Fe, K, Mg, Mn, Na, or Zn contents ($P>0.05$).

### 2.2 Effects of Rib Number and Age on Hair Mineral Contents

Table 2 shows that rib number had no significant effect on hair Ca, Cu, Fe, K, Mg, Mn, Na, or Zn contents ($P>0.05$). Age significantly affected hair K content, with 7-8-year-old yaks having significantly higher K content than other age groups ($P<0.05$), but had no significant effect on other mineral contents. The interaction between age and rib number was not significant for any mineral content ($P>0.05$).

### 2.3 Correlation and Regression Analysis Between Serum and Hair Mineral Contents

Correlation analysis revealed highly significant positive correlations between serum and hair for Ca, Cu, Fe, Mg, and Zn contents ($P<0.01$), with correlation coefficients of 0.6230, 0.5398, 0.5692, 0.4684, and 0.5053, respectively. No significant correlations were found for K, Mn, or Na contents between serum and hair ($P>0.05$). Regression equations between serum (x, μg/mL) and hair (y, μg/g) mineral contents are presented in Table 4.

---

## 3. Discussion

### 3.1 Effects of Rib Number and Age on Serum Mineral Contents

Mineral nutrition is crucial for maintaining normal physiological functions, growth, and development in animals. Serum mineral content is an important indicator of mineral status. Previous studies have reported inconsistent results regarding the effects of breed and age on serum mineral contents. Mullis et al. [10] found that serum Cu content in Simmental cattle was significantly higher than in Angus cattle, while Zn and Fe contents showed no significant differences. Littledike et al. [11] reported that serum Ca and Mg contents differed among beef cattle breeds, with Simmental cattle having higher Ca content than Angus, and Hereford cattle having higher Mg content than

Simmental, while Cu and Zn contents showed no significant differences. In contrast, the present study found no significant differences in serum Ca, Cu, Fe, K, Mg, Mn, Na, or Zn contents between 14-rib and 15-rib Jinchuan yaks, suggesting that rib number does not significantly affect serum mineral status in this breed. This discrepancy may be attributed to differences in genetic background and physiological characteristics among breeds.

Age-related changes in serum mineral contents have also been reported. Studies by Liu et al. [12] showed that serum K, Na, Ca, P, Cl, and Mg contents in grazing yaks varied significantly with age. However, Zhang et al. [13] found no significant effect of age on serum P content in yaks, while Yang et al. [14] reported that serum P and K contents in growing yaks were not significantly different from those in adult yaks. The present results indicate that age had no significant effect on serum mineral contents in Jinchuan yaks, which aligns with some previous reports [13-14] but differs from others [12]. These inconsistencies may be related to differences in feeding conditions, physiological states, and environmental factors among studies.

### 3.2 Effects of Rib Number and Age on Hair Mineral Contents

Hair mineral content is influenced by multiple factors including breed, sex, age, and physiological status. Combs [15] suggested that hair mineral analysis could serve as an indicator of long-term mineral status in livestock. Gabryszuk et al. [5] found no significant differences in hair mineral contents between Booroola and Polish Merino sheep. Wells et al. [16] reported significant differences in hair Ca, Mg, P, Cu, Zn, Fe, and Mn contents among 11 breeds of horses. Asano et al. [17] found that hair mineral contents in riding horses were not significantly affected by breed. The present study found no significant effect of rib number on hair mineral contents in Jinchuan yaks, consistent with some previous reports [5, 17].

Age significantly affected hair K content, with 7–8-year-old yaks having significantly higher levels than younger age groups. This may be related to changes in metabolic rate and physiological function with age. Previous studies have shown that hair mineral contents can reflect long-term mineral status and may be influenced by age-related changes in mineral metabolism [5]. However, age had no significant effect on other mineral contents in the present study, suggesting that hair mineral status remains relatively stable across different age groups in Jinchuan yaks, except for K.

### 3.3 Correlations Between Serum and Hair Mineral Contents

Several studies have demonstrated significant correlations between serum and hair mineral contents, suggesting that hair analysis can be used as a non-invasive alternative to serum analysis for assessing mineral status. Dastgheib et al. [7] reported significant correlations between serum and hair Zn, Cu, and Fe contents in humans. Patra et al. [8] found significant correlations for Zn and Fe between serum and hair in cattle exposed to environmental contaminants, but not for Cu. Biricik et al. [9] observed significant correlations for Fe but not for Cu or Zn between serum and hair in mares. The present study found highly significant correlations for Ca, Cu, Fe, Mg, and Zn between serum and hair, indicating that hair analysis can reliably reflect the status of these minerals in Jinchuan yaks. However, the lack of significant correlations for K, Mn, and Na suggests that hair may not be a suitable indicator for these minerals, possibly due to differences in their incorporation mechanisms into hair or their physiological regulation.

### 3.4 Mineral Status Assessment in Jinchuan Yak

Mineral nutrition is essential for maintaining normal physiological functions, growth, and productivity in grazing animals. The present study provides baseline data on mineral contents in serum and hair of Jinchuan yaks. Compared with reference values reported by Underwood and Suttle [20] and Puls [21], serum Na content in Jinchuan yaks was within the normal range (3,105–3,220 mg/L [21]), while serum K content was higher than the reference value (97 mg/L [21]). Serum Ca content was within the normal range (90 mg/L [20]), but the Ca content in the diet may not meet the requirements for optimal growth and production (0.1%-0.5% of DM, NRC [1996]). Serum Mg content was within the normal range (25 mg/L [20]), but hair Mg content (277.69 µg/g) was lower than the reference range (130–455 mg/kg DM [21]), suggesting potential Mg deficiency. Serum Fe content was higher than the normal range (1.1 mg/L [24]), indicating possible Fe excess, which could interfere with Cu and Mn absorption [26-27]. Serum Cu content was lower than the normal range (0.6 mg/L [24]), and hair Cu content was also low (6.7–32.0 mg/kg DM [22]), suggesting Cu deficiency. These findings indicate that Jinchuan yaks may be deficient in Cu, Mg, and Na, while Fe may be in excess, which warrants attention in nutritional management.

## 4. Conclusions

1. There was no significant difference in mineral content between 14-rib and 15-rib Jinchuan yaks.
2. Hair K content was significantly higher in 7–8-year-old yaks compared with younger age groups.
3. Significant positive correlations were found between serum and hair for Ca, Cu, Fe, Mg, and Zn contents, suggesting that hair analysis can be used as a non-invasive method to assess the status of these minerals.
4. Jinchuan yaks may be deficient in Cu, Mg, and Na, while Fe may be in excess, indicating the need for appropriate mineral supplementation strategies.

## References

[1] JIANG Gu, YANG Zhanqing, ZHANG Weimin, et al. Study on the relationship between trace element nutrition and disease resistance, reproductive performance in Jinchuan yaks[J]. Chinese Journal of Animal Science, 2013, 34(16): 251-256.

[2] YANG Zhongzhi. Studies on mineral nutrition and supplementation strategies for grazing yaks on the Qinghai-Tibetan Plateau[D]. PhD Thesis. Lanzhou: Lanzhou University, 2008.

[3] LONG R J, DONG S K, WEI X H, et al. The effect of supplementary feeds on the bodyweight of yaks in cold season[J]. Livestock Production Science, 2005, 93(3): 197-204.

[4] HAN Z Q, LI R R, LI K, et al. Assessment of serum trace elements in diarrheic yaks (Bos grunniens) in Hongyuan, China[J]. Biological Trace Element Research, 2016, 171(2): 333-337.

[5] GABRYSZUK M, BARANOWSKI A, CZAUDERNA M, et al. Content of mineral elements in the blood plasma and wool of Booroola and Polish Merino sheep. (in Polish)[J]. Biuletyn Magnezologiczny, 2001, 6(3): 253-259.

[6] HASAN M Y, KOSANOVIC M, FAHIM M A, et al. Trace metal profiles in hair samples from children in urban and rural regions of the United Arab Emirates[J]. Veterinary and Human Toxicology, 2004, 46(3): 119-121.

[7] DASTGHEIB L, MOSTAFAVI-POUR Z, ABDORAZAGH A A, et al. Comparison of Zn, Cu, and Fe content in hair and serum in Alopecia Areata patients with normal group[J]. Dermatology Research and Practice, 2014, 2014: 784863.

[8] PATRA R C, SWARUP D, SHARMA M C, et al. Trace mineral profile in blood and hair from cattle environmentally exposed lead and cadmium around different industrial units[J]. Journal of Veterinary Medicine Series A, 2006, 53(10): 511-517.

[9] BIRICIK H, OCAL N, GUCUS A I, et al. Seasonal changes of some mineral status in mares[J]. Journal of Equine Veterinary Science, 2005, 25(8): 346-348.

[10] MULLIS L A, SPEARS J W, MCCRAW R L. Effects of breed (Angus vs. Simmental) and copper and zinc source on mineral status of steers fed high dietary iron[J]. Journal of Animal Science, 2003, 81(1): 318-322.

[11] LITTLEDIKE E T, WITTUM T E, JENKINS T G. Effect of breed, intake, and carcass composition on the status of several macro and trace minerals of adult beef cattle[J]. Journal of Animal Science, 1995, 73(7): 2113-2119.

[12] LIU Xianqing, ZHANG Youshe. Mineral element contents in serum of grazing yaks[J]. Chinese Journal of Animal Science, 2013, 41(15): 6713-6766.

[13] ZHANG Yong, DENG Qun, YANG Zhanqing, et al. Study on blood biochemical indices of 14-month-old yaks[J]. Yak Science, 1995, 12(2): 22-24, 27.

[14] YANG Zhongzhi, WANG Li, LIU Dengke, et al. Study on mineral status of growing yaks[J]. Grassland and Livestock, 1988(1): 17-41.

[15] COMBS D K. Hair analysis as an indicator of mineral status of livestock[J]. Journal of Animal Science, 1987, 65(6): 1753-1758.

[16] WELLS L A, LEROY R, RALSTON S L. Mineral intake and hair analysis of horses in Arizona[J]. Journal of Equine Veterinary Science, 1990, 10(6): 412-416.

[17] ASANO K, SUZUKI K, CHIBA M, et al. Twenty-eight element concentrations in mane hair samples of adult riding horses determined by particle-induced X-ray emission[J]. Biological Trace Element Research, 2005, 107(2): 135-140.

[18] STRAIN W H, PORIES W J, FLYNN A, et al. Trace element nutriture and metabolism through head hair analysis NIOSH/00151490[R]. [S.l.]: [s.n.], 1972: 383-397.

[19] WANG Jingqing, ZHANG Jianhua, LIU Guowen, et al. Research progress on hair analysis for mineral status assessment[J]. Chinese Journal of Preventive Medicine, 2005, 12(5): 1-60.

[20] UNDERWOOD E J, SUTTLE N F. The mineral nutrition of livestock[M]. 3rd ed. London: CABI, 1999.

[21] PULS R. Mineral levels animal health: diagnostic data[M]. Clearbrook, British Columbia: Sherpa International, 1988.

[22] MCDONALD I W. The nutrition of the grazing ruminant[J]. Nutrition Abstracts and Reviews, 1968, 38: 381-395.

[23] ALCROFT R, SCARNELL J, HIGNETT S L. A preliminary report on hypothyroidism in cattle and its possible relationship[J]. Veterinary Record, 1954(66): 367.

[24] MCDOWELL R. Minerals animal human nutrition[M]. 2nd ed. Amsterdam: Elsevier, 2003.

[25] HALL J O. Appropriate methods of diagnosing mineral deficiencies in cattle[C]//Proceedings of the tri-state dairy nutrition conference. [S.l.]: [s.n.] 2006: 43-50.

[26] SPEARS J W. Trace mineral bioavailability in ruminants[J]. The Journal of Nutrition, 2003, 133(5): 1506S-1509S.

[27] HANSEN S L, ASHWELL M S, MOESER A J, et al. High dietary iron reduces transporters involved in iron and manganese metabolism and increases intestinal permeability in calves[J]. Journal of Dairy Science, 2010, 93(2): 656-665.

**Note:** Tables 1-4 referenced in the text contain the detailed numerical data for serum and hair mineral contents across different rib numbers and age groups, correlation coefficients, and regression equations. These tables follow standard scientific formatting with means ± standard deviations and significance indicators.

*Note: Figure translations are in progress. See original paper for figures.*