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ORIGINAL ARTICLE

# Meat characteristics of Qinghai yak and semi-wild yak

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## ABSTRACT

Six domestic yaks aged 6 years, comprising three culling male and three culling female yaks, from the Qinghai Lake area and three male semi-wild yaks aged 6 months from Datong Yak Farm were used to detect the levels of amino acids, mineral elements, residual heavy metals and pesticides in yak meat. The results showed that there was little difference in amino acid levels for different types of yak by age and sex. The meat of the adult male yak was 7.35 mg/kg higher in calcium ($P < 0.05$) and 124 mg/kg higher in phosphorus ($P < 0.01$) than that of the adult female yak. There was an obvious difference in zinc content, and there was also a significant difference for copper and sulfur between adult male and female yaks ($P < 0.01$). Iron was 8.85 mg/kg higher in semi-wild yaks than in domestic yaks, but there were no differences for other minerals. The levels of residual heavy metals and residual pesticides were well within those allowed by the National Standard of China. Furthermore, the data showed that introducing wild yak's blood did not result in a quality change in the domestic yak meat. Yak meat from Qinghai Plateau has the characteristics of being non-polluted and rich in amino acids in comparison with local yellow cattle meat.

***Key words:*** *amino acid, heavy metal, mineral element, residual pesticide, yak.*

## INTRODUCTION

Yaks are mainly distributed on the Qinghai Tibetan Plateau, in what is called the 'non-pollution district', in an area with an altitude of above 3000 m. China has a total of 13 279 500 yaks, accounting for 92% of all the world's yaks, with a yearly meat yield of 300 000 ton. The yaks are mainly distributed in Qinghai, Tibet, Sichuan, Gansu, Xinjiang and Yunnan Province, with a distribution area of 3 million km$^2$. Qinghai, located between 31°39′ and 39°19′N and between 89°35′ and 103°04′E, covers an area of 722 000 km$^2$ and is 1200 km from east to west and 800 km from north to south. It is one of the largest pastoral areas in China. Qinghai has 4 786 900 yaks, accounting for 36% of all of China's yaks.

Yak meat is fine textured and scarlet in color. It is regarded as very palatable, but muscular marbling is poor. It is rich in myoglobins and has a flavor akin to game. Previous research shows that there is variation in the composition of the meat in different locations, breeds and ages of yak steers. The results showed that the dry matter ranged from 23.7% in Tianzhu White Yak (loin eye) to 44.1% in Tibetan Pali yak (rib 9–11); protein from 18.8% (rib 9–10) in Mongolia yak to 22.7 ± 1.1% in wild yak × domestic yak crosses (rib 9–11); fat from 0.95% in Datong yak (6 months) to 25.3% in Tibetan Pali yak; ash from 0.84% in Tibetan Pali Yak to 1.17 ± 0.2% in wild yak × domestic yak crosses; calcium from 0.001 to 0.04%; and phosphorous from 0.02% to 1.20% (Lei 1983; Cai 1984; Pu 1987; Zhang *et al*. 1987; Yan *et al*. 1988; Zhang 1989; Jialin 1998; Ji *et al*. 2000a; Ye 2004). In addition to location, sex, age and breed, the rearing treatment of the animals, which is reflected in body condition, must be expected to affect the meat composition of yak. The

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amino acid content of meat from different muscles of yak has been analyzed in a number of studies (for example, Mkrtchyan *et al*. 1993; Zhong 1993; Ji *et al*. 2000a,b). The ratio of essential to nonessential amino acids was found to be between 0.6:1 and 0.8:1.

There has been a relatively large amount of research on the yak's conventional nutritional composition; however, there are few systematic reports on the overall nutritional composition, amino acid constitution, and level of residual heavy metal or mineral elements in yak meat. There are also no comparative reports between the domestic yak and the wild yak. Therefore, the aim of the present study was to evaluate these factors in Qinghai yak meat.

## MATERIALS AND METHODS

Six domestic yaks over 6 years old, comprising three culling male and three culling female animals, were selected from Heimahe Township, Gonghe County near Qinghai Lake. They were all in good health condition without supplementary feeding or fattening. Three male semi-wild yaks aged 6 months old were obtained from DaTong Yak Farm, and all were in good health condition with natural grazing, whole milk suckling and no fattening.

After slaughtering, 0.5 kg meat samples were taken from the front legs, rear legs and eye muscle in 12–13 ribs. The samples were collected and frozen. All samples were analyzed at the Analysis and Detection Center, Sichuan Academy for Agriculture, China.

### Chemical analysis

*Amino acids*

Amino acids were assayed by National Standard of China (GB)/T 5009.124-2003.

*Minerals*

Minerals were detected by atomic absorption spectrophotometer methods with the following standards: Mg, GB/T 5009.90-2003; Cu, GB/T 5009.13-2003; Zn, GB/T 5009.14-2003; Mn, GB/T5009.90-2003; Ca, GB/T5009.92-2003; Fe, GB/T5009.90-2003; Na, GB/T 5009.91-2003; K, GB/T 5009.91-2003; P, GB/T 5009.87-2003; and S, conventional analyses of Agriculture Chemistry for Soil.

*Residual heavy metals*

Residual heavy metals were detected by: Hg, GB/T 5009.17-2003; Pb, GB/T 5009.12-2003; As, GB/T5009.11-2003; Cd, GB/T 5009.15-2003; and Cr, GB/T 5009.123-2003.

*Residual pesticides*

The following residual pesticides were assayed: benzenehexachloride (BHC) by GB/T 5009.162-2003, with a minimum detection amount of 0.0001 mg/kg; dichlorodiphenyltrichloroethane (DDT) by GB/T 5009.162-2003, minimum 0.0001 mg/kg; auromycin by GB/T 5009.116-2003, minimum 0.07 mg/kg; oxytetracycline by GB/T 5009.116-2003, minimum 0.07 mg/kg; and sulfa by NT/T 5029-2001, minimum 0.05 mg/kg.

### Statistical method

Using SPSS software the results of all indexes were analyzed in terms of ANOVA between male and female yak, and between domestic and semi-wild yak. The sum of squares were analyzed by type III of non-balanced two factorial ANOVA.

## RESULTS AND DISCUSSION

### Levels of amino acid

The results in Table 1 show that there were no significant differences in amino acid levels between adult male and female yaks (including total essential amino acids and total nonessential amino acids), except for methionine. There were also no significant differences in levels of amino acids, total essential amino acids and total nonessential amino acids between domestic and semi-wild yak. The results are similar to those reported by Xie and Yang (2004) for adult yak aged over 6.5 years. This shows that there is little difference in the levels of amino acids for different types of yaks by age and sex.

According to our unpublished data (Luo *et al.* 2001), the total amino acids for yak were more than 1100.3 mg/100 g higher ($P < 0.05$) than for local yellow cattle, while total nonessential amino acids were 838.5 mg/100 g higher ($P < 0.01$), and total essential amino acids were 261.8 mg/100 g higher (not significant, $P > 0.05$). Histidine and glutamic acid in yak meat were 80.5 mg/100 g and 395.8 mg/100 g higher, respectively ($P < 0.01$), while arginine and alanine were 86.1 mg/100 g and 87.9 mg/100 g higher, respectively ($P < 0.05$), when compared with yellow cattle meat.

In the 1990s, there was intensive use in Qinghai of wild yak semen by artificial insemination (AI), or the

**Table 1** Levels of amino acids (mg/100 g) in meat from domestic and semi-wild yaks

| Amino acid | Domestic yak | | | Semi-wild yak ($n = 3$) | Average (all yaks) ($n = 9$) |
|---|---|---|---|---|---|
| | Male ($n = 3$) | Female ($n = 3$) | Average ($n = 6$) | | |
| Threonine | 1 030.0 ± 28.3 | 1 085.0 ± 21.2 | 1 057.5 ± 74.6 | 1 125.0 ± 35.4 | 1 080.0 ± 48.2 |
| Valine | 1 085.0 ± 21.2 | 1 155.0 ± 21.2 | 1 120.0 ± 44.0 | 1 195.0 ± 63.6 | 1 145.0 ± 58.9 |
| Methionine | 538.5 ± 10.6* | 608.5 ± 2.1* | 573.5 ± 40.9 | 581.0 ± 12.7 | 576.0 ± 32.4 |
| Isoleucine | 1 055.0 ± 49.5 | 1 115.0 ± 7.1 | 1 085.0 ± 45.1 | 1 140.0 ± 42.4 | 1 103.3 ± 48.9 |
| Leucine | 1 830.0 ± 56.6 | 1 920.0 ± 42.4 | 1 875.0 ± 66.1 | 1 980.0 ± 70.7 | 1 910.0 ± 81.0 |
| Phenylalanine | 1 021.5 ± 40.3 | 1 065.0 ± 21.2 | 1 043.3 ± 36.4 | 1 080.0 ± 42.4 | 1 055.5 ± 38.9 |
| Lysine | 2 070.0 ± 56.6 | 2 175.0 ± 49.5 | 2 122.5 ± 74.6 | 2 220.0 ± 84.9 | 2 155.0 ± 85.5 |
| Cystine | 204.0 ± 17.0 | 223.5 ± 2.1 | 213.8 ± 15.0 | 238.0 ± 24.0 | 221.8 ± 20.2 |
| Tyrosine | 784.0 ± 26.9 | 839.5 ± 17.7 | 811.8 ± 37.0 | 876.0 ± 18.4 | 833.2 ± 44.6 |
| Histidine | 880.0 ± 11.3 | 931.5 ± 33.2 | 905.8 ± 36.0 | 961.5 ± 44.5 | 924.3 ± 44.8 |
| Arginine | 1 415.0 ± 63.6 | 1 455.0 ± 35.4 | 1 435.0 ± 48.0 | 1 510.0 ± 56.6 | 1 460.0 ± 59.3 |
| Aspartic acid | 2 095.0 ± 49.0 | 2 200.0 ± 56.7 | 2 147.5 ± 74.6 | 2 295.0 ± 63.6 | 2 196.7 ± 99.7 |
| Serine | 875.0 ± 25.5 | 905.0 ± 15.6 | 890.0 ± 24.4 | 943.5 ± 19.1 | 907.8 ± 34.6 |
| Glutamic acid | 3 415.0 ± 120.3 | 3 555.0 ± 77.8 | 3 485.0 ± 115.6 | 3 630.0 ± 113.1 | 3 533.3 ± 127.2 |
| Glycine | 965.5 ± 30.4 | 935.5 ± 16.3 | 950.5 ± 26.4 | 987.0 ± 18.4 | 962.7 ± 29.0 |
| Alanine | 1 295.0 ± 35.4 | 1 345.0 ± 35.4 | 1 320.0 ± 40.8 | 1 380.0 ± 42.4 | 1 340.0 ± 48.2 |
| Proline | 823.5 ± 10.6 | 828.0 ± 26.9 | 825.8 ± 16.9 | 886.5 ± 12.0 | 846.0 ± 34.4 |
| Total essential amino acids | 9 618.0 ± 251.7 | 10 176.5 ± 166.2 | 10 052.3 ± 558.0 | 10 435.0 ± 394.6 | 10 169.8 ± 508.2 |
| Total nonessential amino acids | 11 774.0 ± 332.3 | 12 155.0 ± 297.0 | 11 959.5 ± 347.0 | 12 593.0 ± 369.8 | 12 170.8 ± 454.7 |

Values are expressed as mean ±standard deviation. Values within the same row followed by asterisks are significantly different: *$P < 0.05$.

use of semi-wild yak bulls with natural mating, to try to improve the domestic yak productivity and 'rejuvenate' the yak population. There are some comparable data from observations of the F1 (half wild yak blood), B1 (one-quarter wild yak blood) and local yak under the same feeding management system in southern Qinghai (Yan 2002). It was found that the body measurements and weights of the semi-wild (F1) and quarter-wild yak (B1) were higher than those of domestic yak of the same age. The birth weight, height, length and heart girth of F1 were greater than the domestic yak calves, particularly at 18 months old. The measurements of both the F1 and the B1 were greater than those of domestic yak. The economic benefit was great, as the average production performance was increased by 20% in offspring (Luo 2001).

From the preliminary analysis, there is no obvious difference in chemical composition between domestic yak meat and wild blood yak meat, partly because wild yak and domestic yak belong to the same family. Due to long-term domestication, the domestic yak is docile and its body structure has become smaller, while simultaneously being under the special situation of residing in cold alpine grassland, leading to its deterioration. However, the body constitution of the semi-wild yak exhibits an obvious improvement, showing stronger adaptability against the harsh environment in highland areas. The results showed that introducing wild yak's blood did not result in meat quality change in domestic yak.

## Levels of mineral elements

The results in Table 2 show that there were significant differences in calcium ($P < 0.05$) and phosphorus ($P < 0.01$) levels between adult male and female yaks. The adult male yak was 7.35 mg/kg higher in calcium and 124 mg/kg higher in phosphorus than the adult female yak. Zinc showed a significant difference ($P < 0.05$) and there was also a significant difference for copper and sulfur between adult male and female yaks ($P < 0.01$). Iron was 8.85 mg/kg higher in semi-wild yaks than in domestic yaks, but there were no differences for other minerals.

Xie and Yang (2004) studied Maiwa yak aged 1.5–6.5 years old. They reported the following levels: Mg, 180.17 mg/kg; Cu, 0.56 mg/kg; Zn, 26.88 mg/kg; Mn, 0.3088 mg/kg; Ca, 53.05 mg/kg; Fe, 23.23 mg/kg; Na, 485 mg/kg; K, 3117 mg/kg; S, 960 mg/kg; and P, 1850 mg/kg. The levels of Mg, Cu, Na and S were much higher in the present study than those reported by Xie and Yang (2004), and Zn, Mn, Ca, and P were much lower, but Fe and K were similar in both studies.

**Table 2** Levels of mineral elements (mg/kg) in meat from domestic and semi-wild yaks

| Mineral | Domestic yak | | | Semi-wild yak ($n = 3$) | Average (all yaks) ($n = 9$) |
|---|---|---|---|---|---|
| | Male ($n = 3$) | Female ($n = 3$) | Average ($n = 6$) | | |
| Magnesium | 251.67 ± 11.02 | 267.67 ± 2.08 | 259.67 ± 11.27 | 249.33 ± 4.51 | 256.22 ± 10.54 |
| Copper | 1.52 ± 0.06** | 1.38 ± 0.05** | 1.45 ± 0.09 | 1.13 ± 0.25 | 1.34 ± 0.21 |
| Zinc | 13.50 ± 0.42* | 13.25 ± 0.35* | 13.38 ± 0.35 | 13.50 ± 0.14 | 13.42 ± 0.29 |
| Manganese | 0.15 ± 0.01 | 0.17 ± 0.01 | 0.16 ± 0.02 | 0.16 ± 0.02 | 0.16 ± 0.02 |
| Calcium | 19.90 ± 3.54* | 12.55 ± 1.34* | 16.23 ± 4.77 | 17.50 ± 0.57 | 16.65 ± 3.76 |
| Iron | 21.95 ± 0.64 | 24.65 ± 1.34 | 23.30 ± 1.78* | 32.15 ± 1.20* | 26.25 ± 4.80 |
| Sodium | 793.33 ± 115.04 | 803.33 ± 35.12 | 798.33 ± 76.27 | 893.33 ± 205.02 | 830.22 ± 128.18 |
| Potassium | 3483.33 ± 104.08 | 3283.33 ± 28.87 | 3383.33 ± 129.10 | 3466.67 ± 152.75 | 3411.11 ± 134.11 |
| Sulfur | 2967.67 ± 57.74** | 3361.67 ± 53.93** | 3164.17 ± 222.05 | 3305.67 ± 100.48 | 3211.33 ± 195.82 |
| Phosphorous | 303.67 ± 0.58** | 179.67 ± 16.01** | 241.67 ± 68.67 | 333.67 ± 20.01 | 272.33 ± 71.86 |

Values are expressed as mean ± standard deviation. Values within the same row followed by asterisks are significantly different: *$P < 0.05$; **$P < 0.01$.

**Table 3** Levels of residual heavy metals (μg/kg) in meat from domestic and semi-wild yaks

| Heavy metal | Domestic yak | | | Semi-wild yak ($n = 3$) | Average (all yaks) ($n = 9$) |
|---|---|---|---|---|---|
| | Male ($n = 3$) | Female ($n = 3$) | Average ($n = 6$) | | |
| Mercury | 2.7 ± 1.7 | 3.7 ± 1.6 | 3.2 ± 1.5 | 2.6 ± 0.5 | 3.0 ± 1.2 |
| Lead | 83.0 ± 5.7** | 60.0 ± 8.5** | 71.5 ± 14.5 | 78.0 ± 5.7 | 73.7 ± 12.0 |
| Arsenic | 8.5 ± 5.6 | 9.3 ± 4.1 | 8.9 ± 4.0 | 6.3 ± 2.5 | 8.0 ± 3.6 |
| Cadmium | 11.7 ± 0.6 | 7.6 ± 2.4 | 9.6 ± 2.7 | 10.1 ± 1.8 | 9.8 ± 2.4 |
| Chromium | 40.0 ± 21.2* | 53.5 ± 14.8* | 46.8 ± 16.9 | 40.0 ± 5.7 | 44.5 ± 13.8 |

Values are expressed as mean ± standard deviation. Values within the same row followed by asterisks are significantly different: *$P < 0.05$; **$P < 0.01$.

## Residual heavy metals

The results in Table 3 show that there were significant differences in iron ($P < 0.01$) and chromium ($P < 0.05$) levels between adult male and female yaks. Other residual heavy metals showed no differences. There were no differences in any heavy metals between domestic and semi-wild yaks. The levels of all heavy metals were lower than standard NY5044-2001 (Hg ≤ 0.05 mg/kg, Pb and As ≤ 0.50 mg/kg, Cd ≤ 0.1 mg/kg, and Cr ≤ 0.1 mg/kg). The results for chromium were similar to results of Xie and Yang (2004), while levels of other metals were much lower than results from Xie and Yang (2004).

## Residual pesticides

All samples were assayed for BHC, DDT, aureomycin, oxytetracycline and sulfa. None of these pesticides were found at the minimum level of detection of the relevant technique. In accordance with the Agricultural Ministry non-environmental pollution products standard NY5004-2001 'Non-environmental pollution foodstuff-beef', if BHC, DDT, aureomycin, oxytetracycline and sulfa are ≤0.1 mg/kg, Ivermectin is ≤0.02 mg/kg, and there is no chloramphenicol, this foodstuff is classified a non-environmental pollution foodstuff. If BHC, aureomycin, oxytetracycline are ≤0.07 mg/kg, DDT is ≤1 ug/kg, sulfa is ≤0.05 mg/kg, and Ivermectin is ≤0.02 mg/kg, this foodstuff is classified an excellent foodstuff. We can therefore conclude that the yak meat came up to the standard of high quality meat lacking residual pesticide.

Yak meat from Qinghai Plateau has the characteristics of being non-polluted and rich in amino acids compared with local yellow cattle meat. The residual heavy metal and pesticide levels are far below the National Standard of China.

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