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ARTICLE

# The Breed and Sex Effect on the Carcass Size Performance and Meat Quality of Yak in Different Muscles

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**Abstract**

The carcass size performances and the meat quality of Gannan and Sibu yak were determined using *M. supraspinatus* (SU), *M. longissimus thoracis* (LT) and *M.quadriceps femoris* (QF). It is found that Sibu yak had significantly higher carcass weight (CW) than Gannan yak with difference of nearly 40 kg, as well as significantly higher eye muscle area (EMA), carcass thorax depth (CTD), round perimeter (RP), etc. The carcass performances of steer yak were significantly higher than heifer yak except meat thickness at round (MTR) ($p$<0.05). The results show that both yak breed and gender had significant effects on carcass performances. It could be seen that the variation of carcass size performances from breeds is as large as from gender (50.22% and 46.25% of total variation, respectively) through principal component analysis (PCA). Sibu yak had significantly higher L*, b*, WBSF, cooking loss and Fat content, while Gannan yak had significantly higher a*, press loss, protein content and moisture ($p$<0.05). Yak gender and muscle had insignificant effects on meat colour and water holding capacity ($p$>0.05). The variation of meat quality of yak from breed is up to 59.46% of total variation according to PCA. It is shown that the difference between breeds, for Gannan yak and Sibu yak, plays an important role in carcass size performance and meat quality.

**Keywords:** yak, carcass size performance, meat quality, Gannan, Sibu

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## Introduction

There are more than 16 million yaks in China which live in Tibet, Sichuan, Yunnan, Guangxi, Qinghai and Gansu accounting for about 95% in the world. The meat of yak could be a new resource for meat industry in China with high protein, low fat and unique flavour. However, the commercial potential meat of yak is limited because of lack of data of meat quality.

According to *the yak*, there are 12 officially recognized local breeds of domestic yak in China (Wiener *et al*., 2003). Gannan yak were raised in the Gannan Tibetan autonomous prefecture of Gansu, which had a strong body conformation, a relatively large skull, a short, wide and slightly protruding forehead (Wiener *et al*., 2003). Sibu yaks live in Medrogungkar County in the southeastern Lhasa municipality of Tibet, which had a large head with externally expanded horns and a rectangular-shaped body conformation with a straight back (Wiener *et al*., 2003). Gannan and Sibu yak is mainly commercial yak in China which could be available in local market, so the two breeds were analyzed in present study.

The researches about body morphology and genetic diversity of yak in China had been reported (Dou, 1984; Han, 1998; Wang *et al*., 2014; Wang *et al*., 2013), but the carcass performances among various yak breeds were little studied. Meanwhile, the quality of yak milk had been investigated (Guo *et al*., 2014; Liu *et al*., 2011; Liu *et al*., 2013), but fewer studies had involved in meat quality of yak. Some researchers are working on collecting yak meat quality data in China (Zhang *et al*, 2015). Therefore, in this study carcass performance and meat quality of *M.supraspinatus* (SU), *M. longissimus thoracis* (LT) and *M.quadriceps femoris* (QF) among Gannan and Sibu yaks with average age of 6 years which were naturally raised in local pasture were determined to provide basic data for commercial development of yak industry in China.

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## Materials and Methods

### Animals and sampling method

The yaks used in this study were Gannan yak and Sibu yak which were respectively raised in Gannan autonomous prefecture of Gansu province and Medrogungkar county in the southeastern Lhasa municipality of Tibet autonomous region with average age of 6 years. Each breed group had 12 yaks (6 steers and 6 heifers). The animals were raised on local native pasture and slaughtered in 2013. The pastures in both Gansu and Tibet are all standardized pastures of Chinese Academy of Agricultural Sciences (CAAS) with main herbages of stipa purpurea, achnatherum splendens and alfalfa. The grazing duration in one day is 10 hours (6:00 to 11:00 and 13:00 to 18:00). The yaks were slaughtered in the abattoirs belonged to local agricultural experiment stations of CAAS according to Slaughtering Regulations of the Ministry of Agriculture of China. Animal transport and slaughtering were approved by the National Administration of Cattle Slaughtering and Quarantine Regulations (CNIS, 2004).

After slaughtered, the carcass size performances were evaluated within postmortem 2 h, and the *M.supraspinatus* (SU), *M. longissimus thoracis* (LT) and *M.quadriceps femoris* (QF) were removed from left sides of all carcasses for meat quality measurement including L*, a*, b*, Warner-Bratzler shearing force (WBSF), cooking loss, press loss, protein content, fat content and moisture at postmortem 24 h.

### Carcass size performances

The carcass size performances included carcass weight (CW), carcass length (CL), carcass depth (CD), carcass thorax depth (CTD), round perimeter (RP), round width (RW), round length (RL), meat thickness at round (MTR), meat thickness at huckle (MTH) and eye muscle area (EMA). CW means the weight of carcass when the central temperature of carcass decreases to 15°C. CL means the distance from first rib to pubic symphysis. CD means the vertical dimension from body surface at spinous process of 7th thoracic vertebra to lower surface at 7th thoracic vertebra. CTD means the vertical dimension from body surface at spinous process of 3rd thoracic vertebra to lower surface at 3rd thoracic vertebra. RP means circumference around the hind leg at junction of thighbone and tibiofibula. RW means horizontal size from front thigh to flank. RL means distance from pubic symphysis to hock. MTR means the distance from meat surface to bone at central round. MTH means the distance from meat surface to transverse process at 3rd thoracic vertebra. EMA means cross sectional area of *M. longissimus thoracis* at 12th rib.

### Meat quality

Meat colour as L* (lightness), a* (redness) and b* (yellowness) was measured after exposure on air for 45 min by a portable colorimeter (CR-13, Konica-Minolta Sensing Inc., Japan) as described by Cecchinato *et al*. (2011). The variables L*, a*, b*, were measured 5 times each, and the measures were averaged before statistical analysis.

The 150 g meat from each sample was used to measure Warner-Bratzler shearing force (WBSF) and cooking loss. Yak meat was cooked in a retort pouch to a centre temperature of 70°C by heating in water bath. Temperature was monitored continuously using a stabbing temperature probe. The cooking loss was calculated through weight before and after cooking. Three cores (1.27 cm in diameter) parallel to the longitudinal orientation of the muscle fibers removed by using a portable coring device from each cooked sample were used to measure WBSF through shearing the cores perpendicular to the longitudinal orientation of the muscle fibers in the center of the cores by a shear machine (C-LM, Northeast Agricultural University, China). Particular care was taken to avoid fat or connective tissue at the point of shearing. The average of the three measurements of shear force was taken as the WBSF. The 100 g meat from each sample was used to measure press loss as described by Prieto *et al*. (2008).

Crude protein, intramuscular fat and moisture, expressed on a wet basis were determined by using 50 g meat for each sample according to ISO 937-1978; ISO 1443-1973 and ISO 1442-1973 methods, respectively.

### Data analysis

Statistical analysis in this study was conducted by using software SPSS 17.0 for windows (SPSS Inc., USA). The general linear model was used to investigate significant impact and interaction of influencing factors including breeds, genders and muscles. Factor analysis was performed by using principal component analysis mode. Data were autoscaled over the variables (mean value of each variable subtracted, followed by division by the standard deviation) prior to principal component analysis (PCA). Rotation of factors was performed by multiplying PCA factors by an unit orthogonal matrix. The coordinates of samples given by factor scores and the coordinates of variables by factor loadings are shown in a 2D-plot of the PCA factors. The relationship between samples and variables can be interpreted by comparing the directions rela-

**Table 1. The effect of breeds and genders on carcass size performances of yak**

| Items | Breed | | Gender | | Significance[1] | |
|---|---|---|---|---|---|---|
| | Gannan | Sibu | Steers | Heifers | B | G |
| Carcass weight CW (kg) | 113.76[b] | 152.39[a] | 155.4[a] | 107.24[b] | ** | ** |
| Carcass length CL (cm) | 113.67 | 112.25 | 118.09[a] | 107.95[b] | ns | ** |
| Carcass depth CD (cm) | 64.58 | 65.1 | 68.68[a] | 60.95[b] | ns | * |
| Carcass thorax depth CTD (cm) | 64.71[b] | 70.85[a] | 70.91[a] | 64.09[b] | * | * |
| Round perimeter RP (cm) | 48.17[b] | 68.45[a] | 60.82[a] | 53.95[b] | ** | * |
| Round width RW (cm) | 36.92[a] | 20.68[b] | 33.23[a] | 25.85[b] | ** | ** |
| Round length RL (cm) | 68.13[a] | 62.25[b] | 69.45[a] | 61.45[b] | ** | ** |
| Meat thickness at round MTR (cm) | 9.88[b] | 14.08[a] | 11.89 | 11.68 | ** | ns |
| Meat thickness at huckle MTH (cm) | 4.44[b] | 5.68[a] | 5.83[a] | 4.18[b] | * | ** |
| Eye muscle area EMA ($cm^2$) | 22.26[b] | 33.67[a] | 30.23[a] | 24.67[b] | ** | * |

[1]Significance of influencing factor were evaluated through general linear model. ns, $p>0.05$, *$p<0.05$, **$p<0.01$; B, breeds, G, gender.
[a-c]Significance of difference $p<0.05$.

tive to the centre of the coordinate system of scores and loadings.

## Results and Discussion

### Carcass size performances

The ANOVA in general linear model of carcass size performances are shown in Table 1. The CW of Sibu yak was nearly 40 kg significantly higher than Gannan yak. The difference of CW between steers and heifers was approximately up to 50 kg. There were significant differences on carcass size performances between Sibu yak and Gannan yak except CL and CD. The distribution of data of CW between different breeds, as well as between different genders is similar to CTD, RP and EMA. It implied that the heavier carcass of yak could be attributed to the higher meat yield in the middle carcass and the round. According to general linear model ANOVA, both yak breed and gender had significant effects on CW and EMA, as well as CTD, RP, RW and RL. The CL and CD were only significantly influenced by the factor of yak breed, while MTR was only significantly affected by the factor of yak gender.

In order to assessing the relationship between carcass size performances and yak breeds and genders, and to analyze the variation of influencing factors, principal component analysis (PCA) was used after autoscaling of data. The relationship between samples and variables can be interpreted by comparing the directions relative to the centre of the coordinate system of scores and loadings. The direction of points relative to the centre of the coordinate system, of both score and loading plot, provides information about important relationships. The same direction between score and loading plot means this variable (loading plot) is dominant in this sample (score plot). The coordinates of samples in a 2D-plot of the PC's are given by their so-called 'scores' and should be interpreted as a visualization of the relationship between samples. The positions of the variables in the plot are given by their 'loadings' and visualize how the variables contribute to the separation of samples. By comparing the directions relative to the centre of the coordinate system of scores and loadings (samples and variables) the data can be interpreted. Fig. 1 shows the scores and loadings of PCA on carcass size performances of yak. The first PCA factor describing 50.22% of total variation illustrates the difference between different breeds which could be reflected by the fact that Sibu yak on the right of Fig. 1 has PC1 scores higher than 1.0 and Gannan yak on the left has PC1 scores lower than -1.0. The second PCA factor describes 46.25% of the total variation and illustrates the difference between steers and heifers. It could be seen that the variation of carcass size performances from breeds is as large as from gender.

The PC1 in the PCA-plot (Fig. 1) divides the carcass size performances into two groups. One group including RW, RL and CL has negative loading values on PC1 which dominated in Gannan yak, because loading plots of these variables and score plots of Gannan yak (negative scores) had the same direction to the centre of the coordinate system. The other group including MTR, RP, EMA, CTD, CW, MTH and CD has positive loading values on PC1 which dominated Sibu yak, because loading plots of these variables and score plots of Sibu yak (positive scores) had the same direction to the centre of the coordinate system. All of the carcass size performances have negative loading values on PC2 which implied that the yak steers have larger carcass than heifers.

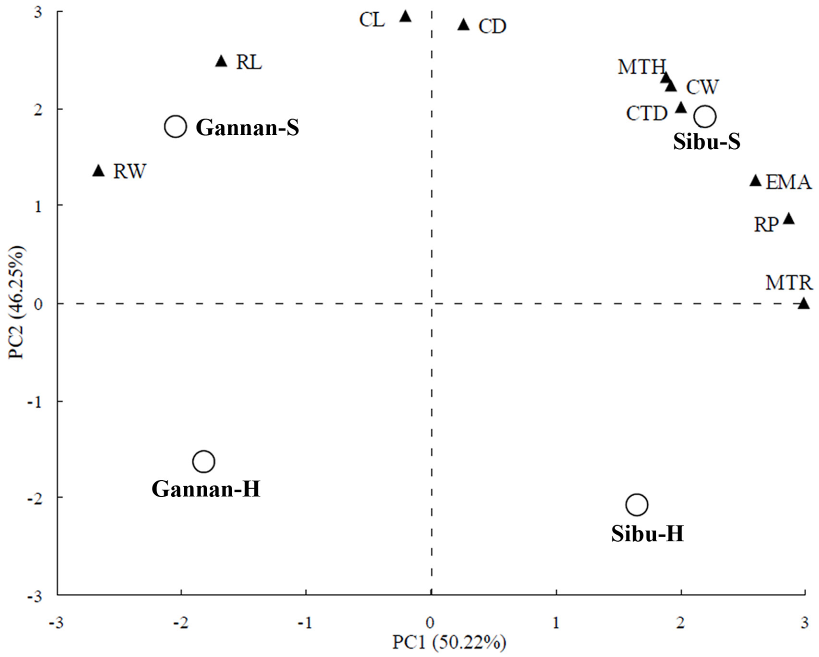


**Fig. 1. Result of principal component analysis of carcass size performances of Gannan and Sibu yak with different genders.** The plot shows scores (○) and loadings (▲), giving the position of samples and carcass size performances, respectively. S, steers; H, heifers; CW, carcass weight; CL, carcass length; CD, carcass depth; CTD, carcass thorax depth; RP, round perimeter; RW round width; RL round length; MTR meat thickness at round; MTH, meat thickness at huckle; EMA, eye muscle area.

## Meat quality

The results of ANOVA in general linear model of meat quality of different muscles from Gannan and Sibu yak with both steers and heifers are shown in Table 2. The meat quality variables include meat colour (L*, a* and b*), technological parameters (WBSF, cooking loss and press loss) and chemical compositions (protein content, fat content and moisture).

The L* average value of three muscles from both steers and heifers Sibu yak is higher than 50, while that of Gannan yak did not exceed 40. However, this difference does not exist between different genders and different muscles. The Average value of a* of Gannan yak is significantly higher than Sibu yak, while b* of Gannan yak is significantly lower than Sibu yak. The relative strength of redness (a*) and yellowness (b*) of Gannan yak is contrary to Sibu yak. There is no significant difference in a* and b* between different genders and between different muscles which is similar to L*. The ANOVA in general linear model also indicates that yak gender and muscle had insignificant effects on meat colour (Table 2).

Many factors could influence meat colour such as breeds,

**Table 2. The effect of breeds and genders on meat quality of yak**

| Items | Breed | | Gender | | Muscle | | | Significance[1] | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Gannan | Sibu | Steer | Heifer | SU | LT | QF | B | G | M |
| L* | 38.11[b] | 50.1[a] | 42.98 | 44.04 | 42.76 | 44.94 | 42.71 | ** | ns | ns |
| a* | 21.15[a] | 7.53[b] | 15.11 | 14.93 | 16.04 | 14.48 | 14.45 | ** | ns | ns |
| b* | 9.63[b] | 11.14[a] | 10.03 | 10.58 | 10.44 | 10.29 | 10.17 | ** | ns | ns |
| WBSF (kg) | 6.13[b] | 8.4[a] | 7.45 | 6.86 | 5.76[b] | 8.64[a] | 7.05[ab] | ** | ns | ** |
| Cooking loss (%) | 27.86[b] | 33.2[a] | 30.49 | 30.03 | 31.48 | 29.09 | 30.2 | ** | ns | ns |
| Press loss (%) | 22.28[a] | 13.68[b] | 18.11 | 18.71 | 16 | 20.41 | 18.89 | ** | ns | ns |
| Protein (g/100g) | 21.7[a] | 19.68[b] | 21.07 | 20.58 | 19.75[b] | 21.13[a] | 21.46[a] | ** | ns | ** |
| Fat (g/100g) | 1.31[b] | 1.96[a] | 1.32[b] | 1.85[a] | 1.81 | 1.64 | 1.34 | ** | ** | ns |
| Moisture (g/100g) | 76.8[a] | 74.87[b] | 76.28[a] | 75.65[b] | 75.53[b] | 76.37[a] | 75.91[b] | ** | ** | ** |

[a-c]Significance of difference $p<0.05$

[1]Significance of influencing factor were evaluated through general linear model. ns, $p>0.05$, *$p<0.05$, **$p<0.01$; B, breed, G, gender, M, muscle.

gender, age, postmortem temperature, pH decline and oxidation (Calnan *et al*., 2014; Fuentes *et al*., 2014; Humada *et al*., 2014; Sikes *et al*., 2014). Karamucki *et al*. (2013) pointed out that myoglobin expression could play a very important role in formation of beef colour. Moloney *et al*. (2013) found that diet rich in unsaturated fatty acid could influence the compositions of fatty acid in beef which were closely related to meat colour stability such as silage.

The WBSF of Sibu yak is significantly higher than Gannan yak. This phenomenon may be attributed to higher altitudes at which Sibu yak live. The meat of Sibu yak and Gannan yak also had WBSF exceeding 6 kg which could be consider as tough meat. For different muscles, LT has highest WBSF. There is no significant difference between steers and heifers. Cooking loss of Sibu yak is significantly higher than Gannan yak, while press loss of Sibu is significantly lower. It could be found that the gender factor and muscle factors had no significant influence on water holding capacity through ANOVA in general linear model. The results of our work implied that the breed was the most important influencing factor on tenderness and water holding capacity of yak meat rather than gender and muscle. The breeds of beef cattle have been proven to affect the meat quality including tenderness and water holding capacity (Garcia *et al*., 2008; Koutsidis *et al*., 2008; Suekawa *et al*., 2010). This rule was also suitable for yak local breeds.

It is indicated that Gannan yak had significantly higher protein content, lower fat content and higher moisture comparing to Sibu yak through ANOVA in general linear model (Table 2). The gender factor had insignificant effects on protein content, fat content and moisture, while gender factor had no significant effects on protein content and muscle factor had no significant effects on fat content.

Fig. 2 shows the scores and loadings of PCA on meat quality of yak. The PC1 describes 59.46% of total variation and illustrates the difference between Gannan yak and Sibu yak. The PC1 scores of all samples of Gannan yak are negative, while scores of Sibu are positive. PC2 could distinguish different muscles of Sibu yak. For Sibu yak, PC2 scores of QF are highest, followed by LT, SU again. But for Gannan yak, the difference among genders and muscles could not be told through PC2 scores. PC3 and PC4 (describing 9.52% and 7.64% of total variation, respectively, not show) could not illustrate the difference from any influencing factors (breed, gender and muscle). The results demonstrate how the breed plays a role in meat quality of yak which is similar to the outcome of ANOVA.

According to loading values on PC1, a*, press loss, protein content and moisture dominated Gannan yak, while L*, b*, cooking loss, WBSF, and fat content dominated Sibu yak.

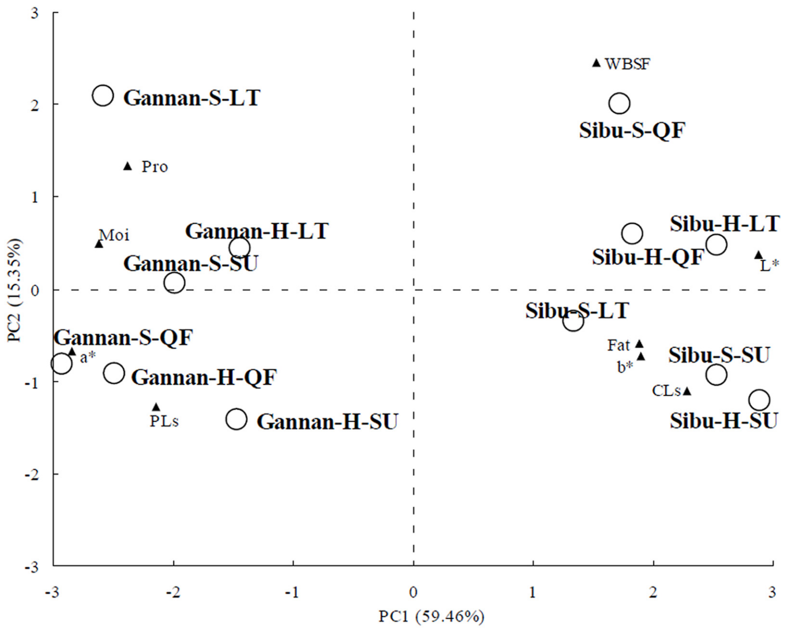


**Fig. 2. Result of principal component analysis of meat quality of Gannan and Sibu yak with different genders and different muscles.** The plot shows scores ( ○ ) and loadings ( ▲ ), giving the position of samples and meat quality, respectively. S, steers; H, heifers; SU, *M.supraspinatus*; LT, *M. longissimus thoracis*; QF, *M.quadriceps femoris*; WBSF, Warner-Bratzler shearing force; CLs, cooking loss; PLs, Press loss; Pro, protein content; Fat, fat content; Moi, moisture.

## Conclusion

Both breed and gender have an effect on carcass size of yak. It could be seen that the variation of carcass size performances from breeds is as large as from gender. Gannan yak have higher size in RW, RL and CL, while Sibu yak have higher size in MTR, RP, EMA, CTD, CW, MTH and CD. Meanwhile, it is indicated that the steers of yak have larger carcass than heifers. Yak breed has significant effects on all parameters of meat quality, while yak gender and muscle had insignificant effects on meat colour and water holding capacity. In conclusion, for Gannan yak and Sibu yak, the difference between breeds plays an important role in carcass size performance and meat quality.

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