Growth Performance, Carcass Composition and Meat Quality of Jiulong-yak (*Bos grunniens*)

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ABSTRACT : Estimated liveweights, carcass characteristics, the proximate composition and amino-acid composition of the whole rib cut of the 10th/12th thoracic vertebrae have been determined for Jiulong-yak. The animal grows rapidly up to puberty at 2-3 years of age. At those ages, females reached 143.0±34.7 kg and 184.0±30.8 kg (SD) respectively, which was 60 to 80% of their mature weight at 6 to 7 yr old, then the rate of growth significantly slowed down. Males continued to rapidly increase body weight until an older age possibly due to the selection procedures. Animals included 20 males aged from 2.5 to 6.5 yr, seven females aged of 4.5 yr and 11 steers aged of 4.5-5.5 yr were slaughtered for carcass determination and chemical analysis of meat samples. Dressing-out percentage and ribeye area ranged from 48.53-55.04% and 48.02-68.56 cm^2 respectively, both of which differed by age and sex. Yak meat is scarlet in color and intramuscular marbling is poor. The 10th/12th rib-cut contained 24.99-31.93% dry matter; 19.98-22.58% protein; 2.52-10.86% fat and 0.93-1.00% ash. Meat from females and steers contained a higher percentage of fat than those from bulls. The pH of M. Longissimus dorsi measured at 24 h post-mortem ranged from 5.84-6.11. Amino acid composition was similar to that for other red meat, except for a lower content of methionine (1.26 g/100 g meat). The results indicated that yak meat can make a valuable contribution to the diets for the highlanders. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 3 : 410-414)***

Key Words : Jiulong-yak, Meat Performance, Meat Quality

INTRODUCTION

The yak (*Bos grunniens*) is one of the world's most remarkable domestic animals - a herbivore living on the "roof of the world", in and around the Himalayas and north, in areas of altitude ranging from 2,500 m to 5,500 m with no absolutely frost-free periods, and mostly above the tree line. Yaks provide food (meat and milk), transport, shelter (hair) and fuel where few other animals will survive. There are an estimated 13.65 million yaks in the world, of which 94.5% are distributed in China. The remaining are mainly distributed in Mongolia, Countries of Russian federation, Nepal, Bhutan, India, Afghanistan and Pakistan (Cai and Wiener, 1995). Yak meat is the staple animal-protein food and the most important component of economic income for the highlanders in these areas.

Also, there is a growing demand for yak meat in most areas of China as yak meat is ecologically and non-intensively produced and because of the shortage of beef supply by cattle (*Bos taurus*). However, meat performance and quality of meat from the yak have not been systematically determined. Yak meat is still one of the few types of meat that has not been studied in detail biochemically. Some work has been reported on meat performance and meat composition of the yak, but a single age group with limited numbers of the animals was usually used in these studies (Wei et al., 1981; Pu et al., 1987). Comprehensive data describing meat performance and meat quality of the yak are lacking. This makes it difficult to evaluate human dietary nutrition in Qinghai-Tibetan Plateau and the lower output efficiency of yak production, i.e., the output of per unit area of the pasture is invariably low.

Jiulong-yak, with a total population of 60,000 animals, has been widely recognized as a distinct breed since the 1980's (Cai, 1980; Zheng, 1986), however, meat performance and meat quality have not yet been well characterized. The objective of this study therefore, was to determine meat performance and meat quality of the Jiulong Yak in terms of liveweights, carcass characteristics, and nutritive composition of the meat at different ages and for males and females.

MATERIALS AND METHODS

Measurement of liveweights

The yaks were randomly selected from the natural grazing systems of pastoral areas in Jiulong County of Sichuan; they had not received any supplementation. Fifty-one calves were weighed at the time of birth. Linear body dimensions were measured for 489 males and 1,113 females aged from one to eight years in June. Their liveweights were estimated by "[heart girth (m)]^2×[body length (m)]×70" (Cai, 1992).

Post-slaughter carcass measurements and sampling

In practice, yaks intended for meat are slaughtered, whenever possible, only in the autumn when they are in good, fat condition. Therefore, the slaughter trial was

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Table 1. Linear body dimensions (cm) and estimated body weight (kg) at different age (means±SD)

Age (years)	No. of animals	Ht. at withers	Body length	Heart girth	Estimated livewight[1]
Male					
birth[2]	27	66.1±3.6	66.6±3.5	75.1±3.8	15.9±2.3
1	204	95.4±6.6	100.6±7.4	120.5±12.4	104.0±24.5
2	132	104.2±6.1	114.5±8.3	139.0±10.7	157.0±32.3
3	92	111.5±5.3	124.5±13.7	154.7±10.2	209.3±38.8
4	36	118.0±5.6	132.8±7.7	169.1±11.8	268.1±46.2
5	14	125.0±7.0	140.0±8.1	181.9±18.4	328.3±60.0
6	5	133.0±6.9	152.4±8.6	192.4±7.4	395.4±37.3
7	3	135.0±2.6	160.7±10.7	209.3±11.0	493.8±59.5
8	3	139.0±5.6	175.3±4.2	214.3±10.2	565.5±68.4
Female					
birth	24	64.3±3.1	62.5±5.5	75.5±3.5	15.5±2.5
1	199	92.2±5.3	98.4±7.0	118.5±8.8	97.8±19.3
2	125	102.3±4.9	110.8±11.9	134.7±14.5	143.0±34.7
3	164	107.1±4.9	119.7±6.6	147.6±9.9	184.0±30.8
4	161	110.6±6.4	125.3±7.3	152.8±12.4	206.7±33.6
5	148	111.9±4.4	127.0±11.4	158.0±9.9	223.1±37.1
6	120	111.9±4.7	130.9±6.1	159.3±9.6	233.6±31.8
7	87	111.8±4.7	131.1±6.7	161.9±9.0	241.6±32.2
8	109	112.0±4.3	131.5±6.0	162.7±8.3	244.5±28.9

[1] Liveweights at different ages were estimated from: "[heart girth (m)]^2×[body length (m)]×70".
[2] Birth weights of the calves were measured at the time of calving by weighing.

carried out in the pastoral area of Jiulong County in October. The animals were chosen at random from yak herds and kept under all-year-round grazing without supplementary feeding. Animals included 20 males aged from 2.5 to 6.5 yr, seven females aged 4.5 yr and 11 steers aged from 4.5 to 5.5 yr. Ribeye area was measured at the 12th and 13th rib on both sides of the carcass, using a transparent grid divided into 1cm^2 units. Backfat thickness over *M. Longissimus dorsi* (LD) at 5th/6th thoracic vertebrae was measured with a stainless steel ruler. Hot carcass weight was measured without removing the subcutaneous fat, and maintaining the testicles and kidney and pelvic fat. Dressing percentage (DP) was calculated according to the formula: (hot carcass weight/slaughter weight)×100. Slaughter weight was determined by weighing the animals after feed deprivation ≥24 h. A whole carcass was dissected into muscle, fat and bone, then, meat percentage calculated by "(muscle weight/slaughter weight)×100". The pH of LD was measured at 1 and 24 h post-mortem by making a scalpel incision at the 5th/6th rib and inserting a glass electrode attached to a portable pH meter (pHS-29, Shanghai) approximately 2.5 cm into the muscle.

The whole rib cut of the 10th/12th thoracic vertebrae from each animal were packed and frozen at -20°C, then the samples were stored in iceboxes and taken over three days to the laboratory of Southwest University for Nationalities in Chengdu for subsequent analysis.

Chemical analysis

The proximate composition : Moisture of 10th/12th rib-cut was determined by vacuum oven. Fat content was measured using a slightly modified version of the extraction method of Hara and Radin (1978). Minced rib-cut, approximately 15 g in duplicate, was homogenised in a total of 150 ml hexane:isopropanol (3:2 v/v). After adding 65 ml of 6.67% Na_2SO_4-solution to the filtered homogenate, the solution was left to separate into two phases. The hexane phase was evaporated to dryness on a rotary evaporator at 30°C and the lipid content of the samples was estimated by weighing the remaining lipid fraction. Protein was determined by the macro-Kjeldahl procedure (AOAC, 1980). All analyses were conducted in triplicate.

Amino-acid composition : Well-homogenized and vacuum-dried 10th/12th rib-cut samples were hydrolyzed in 6 N HCl under vacuum at 110°C for 24 h. The hydrolysates were then analyzed by using automatic amino-acid analyzer (Hitachi 835-50).

Statistical analyses

The main effects of age and sex upon carcass characteristics, proximate analysis, mineral concentration, and amino-acid content were analyzed by analysis of variance using the SPSS program for Windows (SPSS, 1999). Student's t-test was used to estimate the statistical significant of differences between groups.

RESULTS AND DISCUSSION

On average, Jiulong-yaks grew rapidly after birth up to puberty at 2 to 3 yr of age. At those ages, females reached

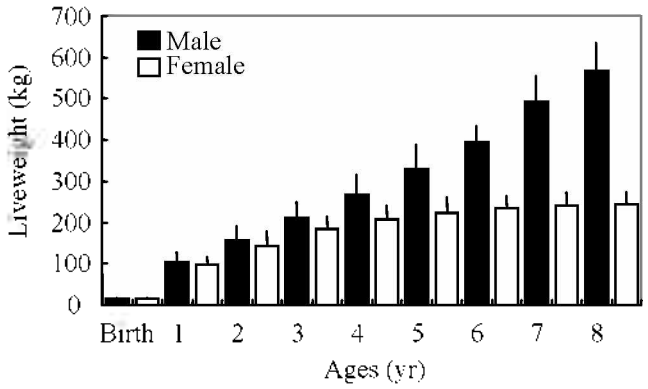

Figure 1. Liveweights (means±SD) of Jiulong-yak at different ages. Birth weights of the calves were measured at the time of calving by weighing. Liveweights at different ages were estimated from: "[heart girth (m)]^2×[body length (m)]×70".

143.0±34.7 kg and 184.0±30.8 kg (SD) respectively, which was 60 to 80% of their mature weight at 6 to 7 yr old (Table 1 and Figure 1). Beyond this age the rate of growth significantly slowed down. The bulls continued to rapidly increase body weight until an older age, but this was possibly caused by selection procedures used whereby inferior males were culled at 3 or 4 yr, at which time they were castrated and used for meat or draught purposes. After one mating with yak cows, bulls which were found to have physical defects or bad conformation were then also culled (Cai and Wiener, 1995). Thus, liveweights measured at an older age in this trial were those for the superior bulls which were selected as breeding bulls. It appeared that both of male and female Jiulong-yak continued to grow longer than cattle breeds (Berg and Butterfield, 1976). This probably resulted from restricted growth at earlier ages caused by malnutrition in the prolonged winter.

Compared with other breeds of yak in the world listed by Cai and Wiener (1995), Jiulong-yak has advantages in meat performance (larger body size and liveweights at different ages). Although the relative importance of genotype and environment was not clear because they were measured in different locations, reports from Qinghai and Gansu (Zhong et al., 1994a), Luhuo County (Zhong et al., 1994b) and Li County (Ren and Wu, 1995) of Sichuan showed that the introduced Jiulong-yaks and their crosses had a higher growth rate than the local breeds of the yak. Thus, the superiority of Jiulong-yak might be mainly contributed by its genotype. The mean liveweights obtained in the present study were lower than the values reported by Cai (1980) for the same breed, because measurements were taken at the end of warm season (October) in that study. In the area where the yak grazed, grass starts to grow from May, goes to seed in August and then wilts. The animals grew in body weight in the warm season (May to November) and lost weight during winter (December to April). The relationship between liveweights and season under natural grazing conditions has been well documented (Lv, 1980).

The results, in Table 2, showed that dressing percentage of Jiulong-yak ranged from 47.58 to 55.04%. At the same age of 4.5 years, dressing percentage, meat percentage, ribeye area and marbling score were significantly higher ($p<0.05$) in steers and bulls than in females. At the same liveweights of 2.5-3.5 yr old males and 4.5 yr old females, carcass characteristics did not differ significantly between sexes ($p>0.05$), except for a thicker backfat ($p<0.05$) in the females. Beyond age of 2.5-3.5 years, ratio of muscle to bone and marbling score of LD were significantly higher ($p<0.05$) in steers and bulls than in females. It clearly indicated that steers and bulls had a better meat performance than females. Although meat performance differed by age, when determining the optimum slaughter rates, stocking capacity of pasture and reproductive rates (Zi, 2003) should also be considered.

Yak meat is scarlet in color and intramuscular marbling is poor. LD pH was higher than those reported in pigs.

Table 2. Carcass characteristics of Jiulong-yak (means±SE)[1]

Age (yr)	Bull		Female	Steer
	2.5-3.5 (n=9)	4.5-5.5 (n=11)	4.5 (n=7)	4.5-5.5 (n=11)
Slaughter wt, kg	218.4±8.1^a	319.0±8.7^b	236.3±15.0^a	379.9±31.2^b
Carcass wt, kg	106.0±4.3^a	169.2±6.5^b	112.9±8.4^a	205.9±16.4^b
Dressing, %	48.53±1.25^a	53.25±0.76^b	47.58±0.85^a	55.04±0.52^b
Meat, %[2]	37.96±0.76^a	42.56±0.83^b	37.34±0.88^a	45.32±0.49^c
Backfat thickness, cm	0.20±0.04^a	0.75±0.16^b	0.74±0.11^b	0.58±0.10^b
Ribeye area, cm^2	48.02±2.01^a	61.53±2.55^b	52.50±2.73^a	68.56±3.76^b
Meat: bone ratio	3.38±0.09^a	3.80±0.11^b	3.55±0.12^{a,b}	4.44±0.11^c
Marbling score of LD[3]	1.75±0.03^a	2.14±0.09^b	1.75±0.13^a	2.39±0.03^c
Color[4]	3.42±0.10^a	3.53±0.02^a	3.54±0.11^a	3.79±0.03^b
pH (1 h)	6.49±0.07^{a,b}	6.34±0.03^a	6.48±0.03^b	6.40±0.03^b
pH (24 h)	6.10±0.07^a	5.84±0.10^{a,b}	6.02±0.05^a	6.11±0.05^a

[1] Means in rows without a common superscript letter are significantly different ($p<0.05$). [2] Meat percentage=(meat wt/slaughter wt)×100.
[3] 1=very poor, 5=very good. [4] 1=very light, 5=very dark.

Table 3. Proximate composition of 10th/12th rib-cut of Jiulong-yak (means±SE)[1]

Age (yr)	Bull		Female	Steer
	2.5-3.5 (n=9)	4.5-5.5 (n=11)	4.5 (n=7)	4.5-5.5 (n=11)
Dry matter, %	24.99±0.18^{a}	26.54±0.20^{b}	31.93±0.69^{c}	29.71±1.03^{c}
Protein, %	21.42±0.18^{a}	22.58±0.27^{b}	19.98±0.36^{c}	21.55±0.52^{a,b}
Fat, %	2.52±0.22^{a}	2.97±0.33^{a}	10.86±1.14^{b}	7.26±1.43^{b}
Ash, %	0.94±0.02^{a}	1.00±0.03^{a}	1.00±0.06^{a}	0.93±0.03^{a}

[1] Means in rows without a common superscript are significantly different ($p<0.05$).

Table 4. Amino-acid composition of 10th/12th rib-cut (g/100 g meat) of Jiulong-yak (means±SE)[1]

Age (yr)	Bull		Female	Steer
	2.5-3.5 (n=9)	4.5-5.5 (n=11)	4.5 (n=7)	4.5-5.5 (n=11)
Aspartic acid	8.57±0.10^{a}	8.41±0.08^{a}	7.80±0.01^{b}	8.01±0.14^{a,b}
Threonine	3.65±0.05^{a}	3.68±0.06^{a}	3.79±0.03^{a}	3.52±0.11^{a}
Serine	3.44±0.06^{a}	3.57±0.08^{a,b}	3.73±0.07^{b,c}	3.36±0.02^{a,c}
Glutamic acid	16.47±0.45^{a}	16.28±0.33^{a}	14.10±0.11^{b}	15.33±0.33^{a,b}
Proline	3.84±0.34^{a}	3.83±0.28^{a}	2.12±0.06^{b}	4.26±0.36^{a}
Glycine	5.18±0.27^{a}	5.83±0.32^{a}	3.83±0.09^{b}	4.13±0.15^{b}
Alanine	5.16±0.25^{a}	5.14±0.19^{a}	5.55±0.06^{a}	5.87±0.41^{a}
Valine	4.01±0.11^{a}	4.02±0.14^{a}	4.28±0.00^{a}	3.54±0.17^{b}
Methionine	1.18±0.11^{a}	1.10±0.02^{a}	1.43±0.04^{b}	1.36±0.13^{a,b}
Iso-leucine	3.70±0.07^{a}	3.67±0.11^{a}	4.01±0.00^{b}	3.55±0.18^{a}
Leucine	7.61±0.10^{a}	7.58±0.05^{a}	7.28±0.09^{a}	7.76±0.17^{a}
Tyrosine	3.22±0.13^{a}	3.11±0.07^{a}	2.59±0.03^{b}	2.96±0.05^{a}
Phenylalanine	4.04±0.07^{a}	4.02±0.06^{a}	3.40±0.01^{b}	3.82±0.08^{a}
Histidine	2.88±0.01^{a}	2.87±0.05^{a}	2.80±0.02^{a}	2.76±0.01^{a}
Lysine	5.83±0.04^{a}	5.71±0.03^{a}	6.65±0.08^{b}	5.90±0.07^{a}
Arginine	6.93±0.06^{a}	6.83±0.23^{a}	6.48±0.02^{a}	6.72±0.01^{a}

[1] Means in rows without a common superscript are significantly different ($p<0.05$) in each group.

steers and Hanwoo cattle (French et al., 2001; Nilzen et al., 2001; Baik et al., 2003). Muir et al. (1998) indicated that grass-fed steers had higher ultimate pH values than grain-fed steers. Bidner et al. (1981) and Reagan et al. (1977) reported darker lean in forage-fed animals in comparison with concentrate-fed animals. Bidner et al. (1986) attributed the darker lean in forage-fed animals to higher myoglobin concentrations due to more activity pre-slaughter. Improved lean color is sometimes associated with increased intramuscular fat concentration (Muir et al., 1998), however, lean color for steers and females were not improved in the present study, though they had a higher fat content.

The proximate composition of 10th/12th rib-cut obtained from yak carcasses at different ages and for different sexes is given in Table 3. In general, dry matter (DM) content of rib-cut was 24-31%. The DM content of meat differed ($p<0.05$) by age and sex. Meat from older animals had a higher DM content than younger-animal meat. Female meat had the greatest ($p<0.05$) DM content, followed by steer and bull, respectively. The DM content of meat for 4.5-5.5 yr old steers of Jiulong-yak (29.7%) was slightly lower than the values (33.8%) reported by Pu et al. (1987) for steers of Tianzhu White yak.

The protein content of the meat differed ($p<0.05$) by age and by sex. Values were higher ($p<0.05$) in bulls and steers than in females. Percentage of protein (22.58%) was highest for 4.5-5.5 yr old bulls, followed by steers and 2.5-3.5 yr old bulls, and females with the lowest content (19.98%). Ash content did not differ ($p>0.05$) by either by age or by sex. In general, the protein content and ash content of yak meat appeared to be similar to that reported for beef, lamb, veal and camel meat (Abouheif et al., 1990; Dawood and Alkanhal, 1995; French et al., 2001; Nilzen et al., 2001). Fat content of yak meat obtained from females and steers was higher ($p<0.05$) than that of bulls, however, it did not differ ($p>0.05$) by age. Fat content is lower in yak meat than for meat of other domestic animal species reported by Kempster et al. (1986). This might be attributed to both genetic ("primitive" type) and environmental (lower nutrition or malnutrition) factors.

Results given in Table 4 show the amino-acid content (g/100 g meat) in 10th/12th rib-cut of Jiulong-yak. The amino-acid composition of the yak meat did not differ significantly ($p>0.05$) by age. According to Rice (1978), the amino-acid content of meat protein is quite constant, regardless of the species or the type of cut from which the meat is obtained. Some amino-acids differed significantly between sexes ($p<0.05$) in the present study. This was most likely caused by the variation in the protein content, i.e. a higher proportion of dry matter is fat in the meat of steers

and females as shown in Table 2.

Compared with beef, pork and lamb (Paul and Southgate, 1978; Pellet and Young, 1990), yak meat is higher in glutamic acid (15.65 g/100 g meat) and slightly lower in aspartic acid, threonine, serine, alanine, phenylalanine, proline, glycine, valine, iso-leucine and lysine, but it is dramatically lower in the content of methionine (1.26 g/100 g meat). Similarly, Pu et al. (1987) also reported that most amino-acid data in the meat of Tianzhu White Yak are comparable with those for other domestic animal species, but methionine is dramatically lower (0.34 g/100 g protein). Because there has been very little work carried out in the area, the measurements of amino acids in the yak meat need further investigation.

It appears that Jiulong-yak have a better meat performance in terms of growth rate, liveweights (or size) at maturity than other breeds of the yak. Meat quality and chemical composition are similar to red meat from other species, except for a lower fat content, but it has a scarlet color and intramuscular marbling is poor.

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