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Influence of Aging Days and Age at Harvest on Meat Quality of Gannan Black Yak

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Abstract: Meat from yak (*Bos grunniens*) is a primary staple in diets of people in western China. Yak meat has low-fat content, high protein and good amino acid and fatty acid profiles. However, meat from yak may be less tender than meat from *Bos taurus* cattle. Gannan Black yaks (n = 181) were used to investigate the effects of age at harvest and aging days on meat quality characteristics of M. longissimus dorsi. Yaks were harvested at 2, 3 and 4 year of age and muscles of each yak carcass were aged for 0, 1, 3, 7, 14 or 21 days at 4°C and frozen at -20°C until analyzed. Age at harvest affected shear force and percentage fat, protein and moisture ($p<0.05$). Aging days affected shear force, retort cooking loss, pressing loss, moist cooking loss, pH, percentage fat, moisture ($p<0.01$) and protein ($p<0.10$). There were interactions between aging days and age at harvest for shear force, moisture and protein ($p<0.01$). Aging days appeared to have a greater effect on shear force than age at harvest and tended to moderate the age at harvest effect on shear force. When cooked in retortable bags, cooking loss decreased until 3 days postmortem after which it remained relatively constant. When steam cooked, meat aged 7 days had the lowest cooking loss ($p<0.05$). Pressing loss decreased until 3 days postmortem then remained relatively constant. After thawing, pH decreased during the 21 days period of postmortem aging with the greatest decline in the first 24 h (6.68-5.73 from 2-24 h postmortem). Results suggest that aging yak meat 7 days is sufficient for acceptable tenderness and meat quality.

Key words: Gannan Black yak, age at harvest, aging, meat quality, shear force, postmortem

INTRODUCTION

Consumers are increasingly concerned with the nutritional value of food consumed (Vandendriessche, 2008) and also are interested in information on origin of food (Revilla and Vivar-Quintana, 2006; Muchenje *et al*., 2008) with interest including system of production, environmental impacts and animal welfare (Andersen *et al*., 2005). The yak species (*Bos grunniens*), an important source of meat protein in China and is an economically important bovine species managed by herders and farmers on the Qinghai-Tibetan plateau of China at altitudes of 3,000 m or more above sea level (Wu *et al*., 2007).

The Chinese yak population is approximately 14 million, accounting for 92% of the global population and mainly distributed in Qinghai (4.97 million), Tibet (3.92 million), Sichuan (3.87 million), Gansu (1.05 million), Xinjiang (0.23 million) and Yunnan (0.06 million) provinces (Guo *et al*., 2008).

Yak is a unique food animal species because of its adaptation to challenging environments at high altitudes with low temperature and low concentration of oxygen. Yaks are used for meat, milk, draft and fiber and are a major economic resource for herders in this region (Wu *et al*., 2007; Zheng *et al*., 2008; Yin *et al*., 2009). Yak meat has recently gained additional acceptance because of its reputation for safety, good quality, high protein and low fat content and favorable amino acid and fatty acid profile compared with *Bos taurus* cattle (Xiaoling and Tinghua, 2004; Li *et al*., 2008; Yin *et al*., 2009). However, yaks are usually harvested at older ages and sold on the commercial market without any distinction being made relative to age at harvest.

Research involving several species has concluded that eating quality of meat and chemical composition of muscle change with increasing animal age at harvest independent of factors such as gender, breed or species (Hoffman and Fisher, 2001).

Because yaks are harvested at older ages and because of the relationship between age at harvest and tenderness, there is a perception that meat derived from yaks is less tender upon consumption after cooking. Production of meat with acceptable quality requires

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appropriate combinations of animal genetics and management and meat processing procedures (Short *et al*., 1999; Vieira *et al*., 2007). There is currently considerable interest in the meat processing industry in influence of aging after harvest on beef quality (Monson *et al*., 2005). It is currently accepted that favorable changes in meat characteristics are possible through aging but optimum aging time depends on many factors including breed and age at harvest (Sanudo *et al*., 2004; Revilla and Vivar-Quintana, 2006). However, limitations on cooler space in commercial packing plants make it difficult to hold product for any extended time, so aging time is often limited and it is important to determine minimum aging time required for acceptable tenderness.

Few studies, to date have been performed to assess how meat quality characteristics in yak are influenced by age at harvest and postmortem aging days. Therefore, this study was conducted to investigate the effects of age at harvest and aging days on meat quality characteristics of meat from Gannan Black yak.

MATERIALS AND METHODS

Animals and sampling: Management of yaks in the experiment conformed to care and use requirements of Gansu Agricultural University. Animals were harvested at a commercial facility that complied with state regulations governing humane processing of meat animals. A total of 181 Gannan Black yaks (steers) were used in this study. Yaks harvested were 2, 3 and 4 year of age (n = 51, 59 and 71, respectively) and of similar body condition. Age was determined through records of local producers and verified by observing number of permanent incisors for each yak.

All animals rotationally grazed cool-season native pasture under similar environmental conditions prior to harvest. On the day prior to harvest, animals were kept overnight in abattoir holding pens without food and water. After conventional commercial, humane harvest procedures, Longissimus dorsi muscles anterior to the mid-point carcass cut (1.5-2.0 kg samples) were collected within 2 h. Pre-rigor or hot muscle excision is conventional practice in yak and cattle processing in China (Tang, 2004; Liu *et al*., 2005).

There is some evidence that sarcomere shortening in meat excised before the onset of rigor mortis results in an increase in WBSF up to 24 h post-mortem (Wheeler and Koohmaraie, 1994). However, muscle proteolysis, not sarcomere shortening is the major factor in meat tenderness after 24 h post-mortem (Koohmaraie *et al*., 1996) and there is little evidence that pre-rigor sampling substantially differs from muscle sampled after rigor mortis onset in WBSF measurements after 24 h (Meade *et al*., 1992; Jenschke *et al*., 2008). A sample (about 50 g) was excised and immediately frozen in liquid nitrogen and stored at -80°C for measuring enzyme activities and mRNA expression in related studies. Each Longissimus dorsi sample was divided into six equally thick steaks. Most steaks were approximately 7.6 cm thick with the exception of 20 smaller muscles that allowed only six 5.1 cm steaks. Steaks were vacuum-packaged and randomly chosen for aging for one of six postmortem aging days. Samples at 0 aging days were immediately frozen and the remainder were kept at 4°C for 1, 3, 7, 14 or 21 days.

Following completion of the appropriate aging time, all muscles were stored at -20°C until further analysis. The meat quality attributes (shear force, cooking loss, pressing loss and pH) from all 181 animals with six postmortem aging days each were determined while the chemical composition (percent moisture, protein and fat) was only determined from 60 yaks (20 individuals per age at harvest) with 6 aging days each.

Meat quality attributes measurements: Steaks were thawed for 24 h at 4°C. After thawing, each steak was cut into slices; each slice was designated for a certain meat quality measure. The order and thickness or weight of slices were as follows: 2.54 cm thick samples of similar geometry for determination of Warner-Bratzler Shear Force (WBSF) and cooking loss from cooking in retortable bags (RCL); 1.0 cm thick sample for determination of pressing Loss (PL); approximately 30 g for evaluating Moist Cooking Loss (MCL) from steam cooking and approximately 10 g for pH measurements. The remainder of the muscle was used for analysis of percentage protein, fat and moisture from 60 of the 181 yaks.

Muscle shear force was tested using WBSF according to procedures described by Wheeler *et al*. (1994) and French *et al*. (2000). Each 2.54 cm thick sample was weighed and cooked individually in a retortable vacuum pack bag to an internal temperature of 70°C, monitored with core thermometer, by immersing in a water bath (HH-6, China) at 80°C.

At the final temperature, steaks were removed from the bath, taken from the bags and cooled to room temperature (20°C). Each steak was dried with filter paper and weight was determined after cooking to assess retort cooking loss. About 6-10, 1.27 cm diameter cores were removed from the cooked steaks parallel to the muscle fiber orientation.

Each core was sheared once through the center and perpendicular to muscle fiber orientation with a WBSF machine (C-LM3B, Patent number: 02153072.6, China) to determine shear force. The crosshead speed was 1 mm sec^{-1} and maximum peak force was recorded. Water Holding Capacity (WHC) was evaluated in three ways: retort scooking loss, moist cooking loss and pressing loss. Moist cooking loss is important because of the prevalence moist-cooking methods in food preparation in China. Moist cooking loss was determined by placing 30 g samples into a steam cooker for 30 min and cooling to room temperature (20°C); weight was determined before and after cooking. Both RCL and MCL were calculated by measuring the difference in weight between the cooked and raw samples as follows:

$$\text{RCL (\%) or MCL (\%)} = \frac{\left(\begin{array}{c}\text{Pre-cooking weight -}\\ \text{Post-cooking weight}\end{array}\right)}{\text{(Pre-cooking weight)}} \times 100$$

Pressing loss was determined using an approximate 10 g, 1.0 cm thick raw sample. The sample was weighed to 0.001 g and sandwiched between 18 medium-porosity qualitative filter papers, top and bottom. A weight of 35 kg was applied for 5 min and weight was recorded after press. The percentage water loss was calculated as:

$$\text{PL (\%)} = \frac{\text{(Initial weight - Post pressing weight)}}{\text{(Initial weight)}} \times 100$$

Meat pH was measured using 2 g of muscle tissue homogenized with 10 mL of neutralized 5 mM sodium chloride at 0-4°C using a calibrated (standard buffers of pH 4.01 and 6.86) pH-meter (HI221, Hanna Instruments) equipped with a pH and temperature probe.

Chemical composition: Chemical analysis of muscle samples were conducted in duplicate according to procedures outlined by AOAC (1990). About 2 g of sample were dried at 105°C for 24 h, desiccated for 1 h and reweighed to determine Dry Matter (DM). Following DM determination, each sample was placed in a Soxhlet extractor for 16 h for ether extraction of lipids followed by drying at 105°C for no >12 h. Samples were then desiccated and reweighed to calculate lipid content. Nitrogen was determined using Kjeldahl procedures (AOAC, 1990) from a 0.5 g sample and CP was estimated as N×6.25.

Statistical methods: Data were analyzed using SAS® PROC MIXED, consistent with a repeated measures design using a linear model that include age at harvest (fixed), steer nested in age at harvest (random), aging days (fixed repeated), age at harvest x aging days (fixed) and steer x aging days nested in age at harvest (random). A heterogeneous first order autoregressive covariance structure was determined to be most appropriate for each dependent variable. Means separations were conducted using t statistics associated with linear contrasts of the least squares means when observed significance levels of F tests in the analyses of variance were <0.10.

RESULTS AND DISCUSSION

Tests of fixed main effects and interactions from the analysis of variance for shear force, pH, moisture loss, percentage moisture, protein and fat are shown in Table 1. There was evidence ($p<0.01$) of an age at harvest x aging days interaction for shear force, percentage moisture and protein but not for other traits. Aging days was important for moisture loss traits and pH ($p<0.01$) but there was little evidence ($p>0.05$) of age at harvest or age at harvest x aging days effects for these traits. Percentage fat was affected by age at harvest ($p<0.01$) and aging days ($p<0.01$).

Warner-Bratzler shear force: There were differences in age at harvest for WBSF but these differences were dependent on aging days (Table 2). There were shear force differences among all ages at harvest at 0 day of aging ($p<0.05$) and 2 year old yaks had lower shear force than 3 and 4 year old yaks at 1 and 3 days of aging ($p<0.05$). There was no evidence of age at harvest differences at 7, 14 or 21 days of aging ($p>0.05$). Age at harvest x aging days interaction for shear force is shown in Fig. 1. Before aging, there were clear differences among

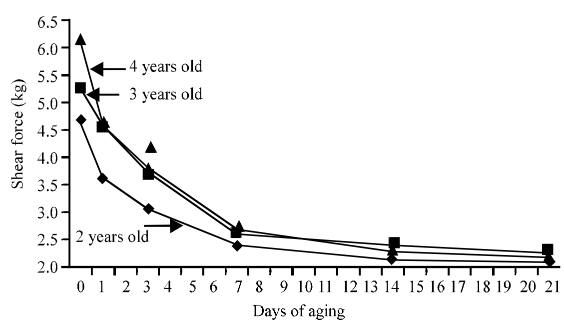

Fig. 1: Temporal changes in Warner Bratzler shear force during the postmortem aging period for three ages of yak (kg)

Table 1: F tests of age at harvest, aging days and age at harvest x aging days on meat quality attributes

Items	Age at harvest	Aging days	Age at harvest x aging days
Warner-Bratzler shear force	15.43**	386.48**	7.41**
Retort cooking loss	1.99	14.40**	0.79
35 kg pressing loss	2.33	6.44**	0.57
Moist cooking loss	1.61	5.45**	0.84
pH	1.12	74.96**	0.88
Moisture	11.62**	7.81**	3.50**
Protein	12.98**	1.97†	3.68**
Fat	4.58*	4.71**	1.35

†$p<0.10$, *$p<0.05$, **$p<0.01$

Table 2: Age at harvest x aging days least squares means and standard errors for Warner-Bratzler Shear Force (WBSF) (kg)

		Aging days					
Items	Age (years)	0	1	3	7	14	21
WBSF (kg)	2	$4.64\pm0.13^{z,a}$	$3.62\pm0.18^{y,b}$	$3.07\pm0.17^{y,c}$	$2.40\pm0.11^{x,d}$	$2.12\pm0.11^{x,e}$	$2.09\pm0.09^{x,e}$
	3	$5.25\pm0.14^{y,a}$	$4.57\pm0.20^{x,b}$	$3.72\pm0.18^{x,c}$	$2.60\pm0.12^{x,d}$	$2.41\pm0.12^{x,de}$	$2.25\pm0.10^{x,e}$
	4	$6.10\pm0.12^{x,a}$	$4.61\pm0.17^{x,b}$	$3.81\pm0.15^{x,c}$	$2.69\pm0.10^{x,d}$	$2.30\pm0.10^{x,e}$	$2.18\pm0.09^{x,e}$

$^{a-e}$Means with different letters in the same row differ (p<0.05); ^{xyz}Means with different letters in the same column differ (p<0.05)

all ages at harvest with greater age associated with higher shear force (p<0.05). After 24 h, there was little evidence of difference between 3 and 4 year old age at harvest (p>0.05) but both ages had greater shear force than that of 2 year old age at harvest at 1 and 3 days of aging (p<0.05).

At and beyond day 7 of aging, there was little age at harvest differences (p>0.05). The results are generally consistent with other research that have concluded that older animals at harvest require longer aging periods to improve tenderness (Koohmaraie *et al*., 2002; Kolczak *et al*., 2003) but the research suggests that all ages are fairly homogeneous in tenderness on or past 7 days of aging. Wulf *et al*. (1996) and Campo *et al*. (2000) reported that breed differences in tenderness tended to disappear with longer aging times.

Monson *et al*. (2005) further reported that aging time tended to minimize differences in meat shear force between breeds and individuals within the same breed at the same age at harvest. In the present study, aging to and over 7 days tended to moderate the age at harvest effect on WBSF within the yak species.

The results also indicated that the greatest reduction in shear force was during the 1st week of aging for all ages at harvest. Of the total reduction in shear force that occurred after 21 days of aging, 87.7% occurred during the first 7 days of aging. Other researchers also reported that the greatest improvement in shear force occurred during the 1st week (Campo *et al*., 2000; Monson *et al*., 2005).

The extent of reduction in shear force due to aging observed in this study was greater (with 2.55, 2.99 and 3.92 kg for 2, 3 and 4 year old group, respectively) than those reported by Campo *et al*. (2000) for breeds that were double-muscled (little effect), fast growth (0.04 kg), dual purpose (0.22 kg) and unimproved (0.32 kg) and for those reported by Monson *et al*. (2005) for Holstein (1.29 kg), Brown Swiss (1.06 kg), Limousin (0.61 kg) and Blonde d'Aquitaine (0.70 kg). Miller *et al*. (2001) defined tender, intermediate and tough steaks as having <3.0 kg between 3.0 and 4.6 kg and >4.6 kg of shear force, respectively. Using these intervals and based on the estimates of WBSF, yak beef of 0 day of aging may be regarded as tough meat, 1 day to 3 days of aging as intermediate meat and from 7 days of aging as tender meat. This conclusion is at variance with Vieira *et al*. (2007) who stated that an aging period of 28 days or longer was needed for adult oxen meat to reach a desirable degree of tenderness. However, King *et al*. (2003) used Warner-Bratzler shear force tests to compare meat previously cooked at 90°C (slow) and 260°C (fast) and reported that greater tenderness was associated with slower cooking rates.

Also Vieira *et al*. (2007) stated that in mature oxen, slower cooking rates are likely associated with more favorable meat tenderness. Given the cooking temperature (80°C) (French *et al*., 2000) used in the study, cooking rate was slow. Consequently, the relatively low Warner-Bratzler shear force values observed in the study might be partially explained by the cooking process used in preparing samples for Warner-Bratzler tests.

Water Holding Capacity (WHC): The term Water Holding Capacity (WHC) has been used to define the ability of muscle to bind water under a given set of conditions and is related to sensory characteristics of meat including juiciness and flavor (Pena *et al*., 2009). The mechanism of water-holding capacity is related to myofibrillar protein that binds moisture (Huff-Lonergan and Lonergan, 2005). For retort cooking loss, pressing loss or moist cooking loss percentage, there was no strong evidence of differences (p>0.05) among age at harvest groups.

Weller *et al*. (1962) reported that there was no practical influence of age on cooking loss of Columbia lambs. However, Wismer-Pedersen stated that water holding capacity decreased as cattle age at harvest increased. The results consistently showed that postmortem aging affected (p<0.01) retort cooking loss, pressing loss and moist cooking loss and there was no strong evidence of interaction (p>0.05) between postmortem aging and age at harvest, indicating that percentage moisture loss was dependent on the length of postmortem aging.

Retort cooking loss at 0 days postmortem was greater than at 1 days postmortem (p<0.01) and 1 days postmortem was <3 days postmortem (p<0.01). After 3 days of aging, retort cooking loss remained relatively constant (Table 3). Pressing loss also decreased until 3 days postmortem after which it remained relatively constant. Moist cooking loss was least for 7 days aging compared to other aging days ($p<0.05$). These results agree with Yanar and Yetim (2001) and Abdullah and Qudsieh (2009) who reported that cooking loss decreased from 1-7 days of aging. Also, Revilla and Vivar-Quintana (2006) reported that retort cooking loss in a retortable bag remained constant from 3-7 days of aging. However, De Huidobro *et al*. (2003) reported that no effect of aging on cooking loss was observed and Zamora *et al*. (1996) reported that water holding capacity decreased until 24 h then remained constant.

pH after thawing: There was an effect of aging on pH but the most significant decline occurred within 24 h (Table 3). Yak meat pH declined from an average value of 6.68 at 2 h postmortem to 5.73 at 24 h postmortem ($p<0.05$) and then remained stable until day 3 of aging. There was a slight decline in pH from 3-7 days of aging ($p<0.05$). However, the difference was practically unimportant, therefore it is reasonable to conclude that the pH declined primarily during the first 24 h postmortem and remained relatively constant thereafter. The effect of aging on pH in this study was generally within values reported in the literature for bovine species (Zamora *et al*., 1996; Beltran *et al*., 1997; Silva *et al*., 1999; Byrne *et al*., 2000; Revilla and Vivar-Quintana, 2006).

Table 3: Age at harvest and aging days least squares means and standard errors for percent retort cooking loss, pressing loss, moist cooking loss and pH

Items[1]	RCL (%)	PL (%)	MCL (%)	pH
Aging days				
0	21.20±0.27^{a}	28.80±0.23^{a}	44.25±0.13^{a}	6.68±0.06^{a}
1	20.07±0.23^{b}	28.65±0.25^{a}	43.83±0.13^{b}	5.73±0.02^{b}
3	19.09±0.20^{c}	27.75±0.23^{b}	43.79±0.16^{b}	5.74±0.01^{b}
7	18.84±0.23^{c}	27.23±0.24^{b}	43.27±0.18^{c}	5.66±0.02^{c}
14	19.09±0.25^{c}	27.73±0.25^{b}	43.95±0.21^{ab}	5.67±0.02^{c}
21	18.87±0.20^{c}	27.92±0.28^{b}	44.24±0.17^{a}	5.64±0.02^{c}
Age (year)				
2	19.20±0.20	27.65±0.21	43.67±0.15	5.82±0.03
3	19.77±0.22	28.18±0.23	44.04±0.16	5.87±0.03
4	19.62±0.19	28.21±0.19	43.96±0.14	5.87±0.02

[1]RCL = Retort Cooking Loss, PL = Pressing Loss, MCL = Moist Cooking Loss; [a-c]Means with different letters in the same column differ ($p<0.05$)

Chemical composition: The age at harvest x aging days for percent moisture (Table 4) was primarily a function of a general increase in 2 year old yak from 3-21 days postharvest while percent moisture decreased or was in 3 and 4 year old yak. Numerically, moisture was lowest at 3 days of aging in 2 year old yak, 14 and 21 days of aging in 3 year old yak and 3 and 14 days of aging in 4 year old yak, respectively. Averaged over aging days, meat of older animals generally showed a lesser moisture content than that of younger animals. Once muscle is harvested, moisture percentage and location in meat can vary depending on numerous factors such as the physical characteristics of the meat itself and handling. The ability of meat to bind water is influenced by rate and extent of pH decline, proteolysis and protein oxidation (Honikel and Kim, 1986; Honikel, 2004; Huff-Lonergan and Lonergan, 2005). Results from this study reflected the complexity of water holding capacity in harvested meat products.

Crude protein percentage showed a different trend during aging depending on the age at harvest ($p<0.01$). In 3 year old yak there was no effect of aging days. However, aging days affected crude protein in 2 and 4 year old yak, 1 and 3 aging days being generally greatest in 2 year old yak and 7 and 14 aging days being generally greatest in 4 year old yak. Generally, the percentage protein in the meat of 4 year old animals was greater than that of 3 year old animals but did not reach statistical significance ($p>0.05$) and both contained greater percentage protein than 2 year old animals ($p<0.05$). Additionally, the aging days x age at harvest interaction in crude protein appeared to be primarily a

Table 4: Age at harvest x aging days least squares means and standard errors for muscle moisture, crude protein and crude fat (%)

		Aging days						
Items	Age (years)	0	1	3	7	14	21	Avg.
Moisture (%)	2	74.39^{ab,x}	75.12^{a,x}	72.88^{c,y}	73.35^{bc,x}	74.26^{ab,x}	74.39^{ab,x}	74.06^{x}
	3	74.11^{a,x}	73.81^{a,y}	74.46^{a,x}	72.91^{ab,x}	72.40^{b,y}	72.33^{b,y}	73.34^{x}
	4	72.83^{ab,x}	72.81^{a,y}	71.28^{c,z}	71.47^{abc,x}	71.29^{c,y}	71.60^{bc,y}	71.88^{y}
	SE	0.68	0.37	0.47	0.82	0.42	0.38	0.33
Protein (%)	2	20.85^{c,y}	21.60^{a,x}	21.93^{a,x}	21.05^{bc,z}	21.08^{bc,z}	21.50^{ab,y}	21.34^{y}
	3	21.80^{a,x}	21.67^{a,x}	21.58^{a,x}	21.90^{a,y}	21.81^{a,y}	22.13^{a,xy}	21.81^{x}
	4	21.82^{bc,x}	21.40^{c,x}	22.06^{ab,x}	22.57^{a,x}	22.48^{a,x}	22.24^{ab,x}	22.10^{x}
	SE	0.23	0.21	0.22	0.20	0.17	0.24	0.11
Fat (%)	2	1.25^{a,xy}	0.97^{ab,y}	1.09^{ab,x}	0.89^{b,x}	0.91^{b,y}	1.06^{ab,x}	1.03^{y}
	3	1.06^{bc,y}	1.49^{a,x}	1.19^{ab,x}	0.96^{bc,x}	0.86^{c,y}	0.88^{c,x}	1.08^{y}
	4	1.46^{a,x}	1.25^{abc,xy}	1.28^{ab,x}	1.11^{bc,x}	1.19^{abc,x}	1.04^{c,x}	1.22^{x}
	SE	0.12	0.17	0.07	0.11	0.09	0.08	0.05
	Avg	1.26±0.07^{a}	1.24±0.10^{a}	1.19±0.04^{a}	0.99±0.06^{b}	0.99±0.05^{b}	0.99±0.05^{b}	-

[a-c]Means with different letters in the same row differ ($p<0.05$); [x-z]Means with different letters in the same column differ ($p<0.05$)

function of a decrease in crude protein between 14 and 21 days of aging in 4 years old yak whereas percentage crude protein increased during this time period in 2 and 3 year old yak. Percent intramuscular fat was greatest in 4 years old yak compared to 2 and 3 year old yak ($p<0.05$). Although yaks of similar body condition were used in this study, perhaps with increasing of age at harvest the intramuscular fat deposits accumulated in the M. longissimus dorsi. Wulf *et al.* (1996) reported that animal age was positively correlated with marbling score. The values found at 0, 1 and 3 aging days in this study were greater than at 7, 14 and 21 aging days ($p<0.05$). This outcome was not expected given that the process of aging under vacuum conditions protects the meat from oxygen and light.

Therefore, it is unlikely that the Intramuscular Fat content (IMF) underwent lipid oxidation in this study. Franco *et al.* (2009) reported no evidence of lipid oxidation in meat from Holstein-Friesian for any storage time. Abdullah and Qudsieh (2009) reported that there was no effect of aging on chemical composition of the M. longissimus from Awassi ram lambs ($p>0.05$) in contrast to results of this study with yak.

CONCLUSION

Aging days appeared to be more influential on shear force than age at harvest and tended to moderate the age at harvest effect on shear force within the yak species. Consequently, aging may be a valuable tool for making a more consistently tender product in yak for the consumer and increasing its market value.

About 7 days of aging appear to be sufficient for production of tender meat and other quality parameters seem to be similar or better than other postmortem aging days.

RECOMMENDATIONS

Further studies should focus on the genetics of calpain and calpastatin in yak and the relationships of these genes to tenderness in yak species.

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