Effects of initial fattening age on carcass characteristics and meat quality in Simmental bulls imported from Austria to Turkey

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Abstract

The aim of this study was to determine the effects of initial fattening age on carcass and meat quality of Simmental bulls imported from Austria to Turkey. These animals were allocated to two initial ages of fattening groups, namely young (n = 74) and old group (n = 61) at 5.5 and 7.5 months old, respectively. After reaching the target final weights, the animals were slaughtered and the carcass characteristics, area and circumference of the *longissimus thoracis et lumborum* (LTL) muscle, marbling score, and meat quality, including cooking loss, water-holding capacity (WHC), shear force (WBSF), and colour parameters were evaluated in six animals per group. A comparison of hot and cold carcass weights and dressing percentages, LTL circumference, fat thickness values and marbling score indicated no significant differences between young and old groups. However, the LTL area was significantly affected by the initial age. There were no significant differences between groups in WHC, cooking loss, and WBSF values and meat colour parameters. The results of this study showed that the initial fattening age of bulls showed no significant effect on carcass and meat quality parameters, except the LTL area. The LTL area was significantly higher in young group than the old group. Further studies are needed to improve carcass and meat quality of imported Simmental bulls through modifying the initial fattening age.

Keywords: Age, beef, carcass quality, Simmental
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Introduction

Beef is an important component of the human diet and a source of valuable nutrients such as proteins, essential fatty acids, fat soluble vitamins, and minerals (Williamson *et al*., 2005). Thus, beef cattle production occupies an important place in meeting the nutrient requirements of the population in sufficient quantities. Livestock and beef production have gradually declined in Turkey as a result of several factors such as reducing the number of livestock, obtaining meat from slaughtered dairy cows, and lower carcass weights. Yet population growth has led to increased demand for meat products (Demirbas & Tosun, 2005; Kirmizibayrak *et al*., 2011). Because of this increased demand and the decrease in beef production in Turkey, the price of meat is rising. Because of high meat prices, Turkish ministries have allowed the import of animals to regulate supply and demand and, in return, the price of red meat. However, importing red meat could not prevent price increases in red meat (23.6 % price increase). On the contrary, it has caused a lower native domestic supply (Cevger & Sakarya, 2002; TSI, 2016). The Simmental steer is the preferred import, as it could adapt easily to Turkish conditions, is resistant to diseases, and produces high-quality beef at minimum cost (Akosman *et al*., 2013).

Improving fattening performance, carcass characteristics, and meat quality traits are the objectives of most research in beef production. Meat quality can be described as 'the attractiveness' of meat to consumers (Warner *et al*, 2010). The visual appearance of intramuscular fat content, commonly called marbling, is the primary criterion for quality grading of beef in the United States and Canada (Dubeski *et al*.,

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1997). Meat quality, which refers to compositional quality and palatability of meat, is also an important criterion that influences the consumer's decision to purchase beef (Sami *et al*., 2004). The major parameters that are considered in the assessment of meat quality are appearance, juiciness, and tenderness (Lawrie & Ledward, 2006). Tenderness has been identified as the most important palatability attribute of meat and the primary determinant of meat quality (Huffman *et al*., 1996).

Many factors affect ruminant carcass and meat quality. They may be divided into two categories: endogenous factors that are linked directly with the animal (breed, age, sex) and exogenous factors (diet, weather, slaughtering procedures, etc.), also called 'environmental factors' (Cross *et al*., 1984; Dannenberger *et al*., 2006).

Carcass and meat quality of beef breeds have been measured and compared in numerous studies. These comparisons have concentrated on the effects of fattening, fattening or slaughter age on carcass and meat quality characteristics (Chambaz *et al*., 2003; Özlütürk *et al*., 2004; Ekiz *et al*., 2005; Ugarković *et al*., 2013; Modika *et al*., 2015). There is limited information about the effect of initial fattening age on carcass, meat quality, and marbling score of imported Simmental bulls in Turkish conditions. The present study was therefore intended to determine the effects of initial fattening age on carcass and meat quality of Simmental bulls.

Materials and Methods

All procedures conducted for this research were done according to worldwide ethical considerations to ensure maximum animal welfare. The research protocol was approved by the Ethics Committee of Uludag University (Approval Number 2012-05/04).

The present study was carried out with Simmental bulls (n = 135) in the same commercial farm (Tabiat Agriculture Farm). The cattle were transported from Austria to Tabiat Agricultural Farm/Yenisehir/Bursa (40°15'28.04"N 29°30'50.18"E) in Turkey. The animals were taken to holding paddocks (approximately 60 animals per truck, 1.3–1.5 m^2 space per animal) based on similar live weights (± 50 kg) from the same herd. The duration of total transport was approximately 32 hours with an additional 24-hour rest period. After reaching the farm, these animals were allocated to the two initial ages of fattening groups, namely Group 1 (young) at 5.5 months old (n = 74) and Group 2 (older) at 7.5 months old (n = 61). Both groups had been fattened in the same semi-open barn and feeding conditions in different pens (approximately 20 bulls in a paddock, 10 m^2 per animal). The animals were adapted to rations for about two weeks. All animals were fed *ad libitum* with the same diet (Table 1). The bulls had *ad libitum* access to water during the whole fattening period. Initial bodyweights of the groups were similar (Table 2).

Table 1 Components of total mix ration

Ingredient	Concentration (%)
Corn silage	28
Wheat straw	27
Macaroni pellets	12
Corn bran	11
Corn gluten feed	10.5
Sunflower meal	6.5
Vitamin and minerals	5

The animals that reached the target slaughter weight (Table 2) at monthly weighings were transported to an abattoir and slaughtered according to standard handling procedures. After being kept for 12 hours in paddocks, deprived of feed, but with full access to water, pre-slaughter live weights were recorded. Carcasses were weighed and chilled for 24 hours at 5 ºC and weighed again. Carcass and meat quality characteristics were evaluated using six randomly selected animals per group.

Meat quality characteristics were evaluated in samples of LTL, which were taken from the region of the 9^{th} and10^{th} ribs at 24 hours post mortem. Samples were stored in refrigerators at 4 ºC until the next analysis. The LTL area and fat thickness were measured by planimeter (Ushikata 380d III, X Plan, Tokyo-Japan).

The level of marbling in the present study was evaluated by looking at the prevalence of fat droplets on the cross-section surface of LTL. Marbling scores were evaluated by comparing them with photographic templates according to USDA standards. Marbling scores were described from least to most as follows: practically devoid (1), traces (2), slight (3), small (4), modest (5), moderate (6), slightly abundant (7), moderately abundant (8), and abundant (9).

To assess meat quality characteristics, 9-cm thick steaks (3.5 cm for cooking loss and Warner–Bratzler shear force, 3 cm for colour and 2.5 for WHC) were taken from the LTL. These samples were packaged in vacuum bags and then kept at 4 °C for seven days before testing.

The WHC (%) was measured with the modified Grau and Hamm method described by Beriain *et al.* (2000). To determine cooking loss, meat samples were first weighed, and then cooked in a water bath at 80 °C for 45 min, as described by Honikel (1998). Cooking loss (%) was estimated by means of percentage weight loss of the cooked sample compared with initial sample weight. After the measurement of cooking loss, cooked samples were used to determine the shear force. The procedure described by Ekiz *et al*. (2012) was used to prepare samples for shear force analysis. Briefly, six sub-samples, cut parallel to the muscle fibres and with a cross-section of 1 × 1 cm, were removed from each cooked sample. An Instron Universal Testing Machine (Model 3343, Norwood, MA, USA) equipped with Warner–Bratzler shear force (WBSF) apparatus was used to determine shear force values. The crosshead speed was 150 mm/min and the force applied to the meat was set to 50 kg. An average of the values for four sub-samples was accepted as the WBSF value for that sample.

Meat colour was measured at 0 hours, 1 hour, 24 hours and 7 days after storage on the cut surface of 2.5-cm thick samples from a fat-free area. During the storage period, samples were kept at 4 °C in a polystyrene tray wrapped with oxygen-permeable PVC film to allow blooming. Nine colour measurements were performed on each sample. The colour coordinate value was determined by calculating the average of those nine measurements. Colour was evaluated with the CIELAB colour space system. L* (lightness), a* (redness) and b* (yellowness) values were obtained with a Minolta CR 400 colorimeter (Minolta Camera Co., Osaka, Japan), with an 8 mm aperture size, 2 ° observation angle and the illuminant D65 as the light source.

The Shapiro-Wilk (SW) test was performed to evaluate the normality of the data. The parametric analysis for initial and final weights and age was carried out by the T test. Data were expressed as means and standard errors. In addition, carcass and meat quality characteristics were compared by the Mann-Whitney U test for the evaluation of non-parametric distribution in the mentioned traits. Data were expressed as median with minimum and maximum values. Differences were considered significant at a probability level of $P < 0.05$ in all analyses. Statistical analyses were performed using SPSS software (SPSS 20.0).

Results

The mean initial and final ages and weights of young and old groups are presented in Table 2. Differences between groups in terms of initial and final ages were significant ($P < 0.01$). Initial and final weights of the young group were not statistically different from those of the old group ($P > 0.05$).

Table 2 Means and standard errors of live weights, initial and final age of experimental groups

Parameters	Young Group (n = 74)		Old Group (n = 61)		Significance
	Mean	SE	Mean	SE	
Initial weight (kg)	220.75	8.67	222.75	8.84	NS
Final weight (kg)	615.83	7.16	615.58	3.92	NS
Initial age (day)	167.58[a]	5.45	224.26[b]	6.37	**
Final age (day)	433.33[a]	4.59	490.00[b]	8.65	**

[SE] Standard error; [NS] Not significant ($P > 0.05$); [a,b] Row means with different superscripts differ significantly (** $P < 0.01$)

Descriptive statistics of carcass characteristics for young and old groups are given in Table 3. There were no significant differences between young and old groups regarding to the weights of hot and cold carcass (kg), hot and cold dressing percentages (%), LTL circumference (cm), fat thickness (mm) values, and marbling score. However, the LTL area (cm^2) was significantly affected by the initial age ($P < 0.05$).

Table 3 Descriptive statistics of carcass characteristics of experimental groups

Parameters	Young Group (n = 74)			Old Group (n = 61)			Significance
	Median	Max	Min	Median	Max	Min	
Hot carcass weight (kg)	344.50	353.00	334.00	337.50	352.00	330.00	NS
Cold carcass weight (kg)	338.75	347.50	329.00	332.50	346.50	324.50	NS
Hot dressing percentage (%)	56.50	57.00	54.00	55.50	57.00	53.00	NS
Cold dressing percentage (%)	55.38	56.05	53.02	54.67	55.89	51.92	NS
LTL area (cm^2)	124.43[a]	146.40	109.73	110.69[b]	114.27	85.35	*
LTL circumference (cm)	54.35	59.74	44.98	47.23	51.80	44.58	NS
Fat thickness (mm)	0.36	0.45	0.24	0.36	0.87	0.22	NS
Marbling score	2.00	1.00	2.00	2.00	3.00	2.00	NS

[NS] Not significant (*P* >0.05); LTL: *longissimus thoracis et lumborum*;
[a, b] Row values with different superscripts differ significantly (* *P* <0.05)

There was no significant difference between young and older groups in terms of WHC, cooking loss and WBSF value (Table 4).

Table 4 Descriptive statistics of cooking loss, water holding capacity and Warner-Bratzler shear force values of *longissimus thoracis et lumborum*

Parameters	Young group (n = 74)			Old group (n = 61)			Significance
	Median	Max	Min	Median	Max	Min	
CL (%)	31.57	33.55	20.18	33.88	35.31	29.42	NS
WHC (%)	8.01	9.42	6.15	9.52	12.00	6.41	NS
WBSF (kg)	7.53	10.76	4.17	7.13	9.60	5.29	NS

[CL] Cooking loss; [WHC] Water holding capacity; [WBSF] Warner-Bratzler shear force
[NS] Not significant (*P* >0.05)

Descriptive statistics of meat colour characteristics of LTL are presented in Table 5. No differences were observed in terms of meat lightness (L*), redness (a*) and yellowness (b*) values for the two groups at 0 hours, 1 hour, 24 hours and 7 days after cutting (*P* >0.05).

Discussion

Optimum slaughter age to achieve maximum net return and improved meat quality may differ depending on breed, castration age, gender, nutrition, and genetics, along with economic factors such as feed costs and carcass prices (Pyatt *et al*., 2005; Marti *et al*., 2013). Hence, an adequate evaluation of fattening performance in different cattle breeds may be a crucial point for beef production. Accordingly, in the current study, the effects of initial weight on carcass and meat quality traits were evaluated.

Carcass characteristics of beef cattle vary due to the genetic background, age and sex of the animal, and nutritional and environmental effects (Cross *et al*., 1984; Dannenberger *et al*., 2006). The results for the carcass weight (kg) and dressing percentage (%) were in accordance with the results reported by Chambaz *et al*. (2003), Sochor *et al*. (2005) and Schmutz *et al*. (2014) for Simmental bulls.

Litwińczuk *et al*. (2006) reported that dressing percentage rose with increasing slaughter weights of bulls. In the current study, there was no significant difference between groups in terms of hot and cold dressing percentage, probably because of similar slaughter weights in young and old groups.

The LTL area increases in parallel with slaughtering at a higher age (Sami *et al*., 2004). In contrast to Sami *et al*. (2004), the LTL area of the young group was higher (*P* <0.05) than the old group, but the difference between groups in terms of LTL circumference was not significant (P >0.05) in the current study. Crouse *et al*. (1986) noted that increased slaughter weight causes an increase in the LTL area. The existence of contrary results revealed in the present study might be caused by the genetic background of the animals. Thus, carcass traits, such as the LTL area, are under the control of the polygenic inheritance (Warner *et al*., 2010). However, more studies should be carried out to confirm the present results in larger Simmental populations. The LTL area values obtained in the study were similar with those reported by Arevalo-Turrubiarte *et al*. (2012), but higher than Sami *et al*. (2004) and Ozluturk *et al*. (2004).

Table 5 Descriptive statistics of meat colour characteristics of *longissimus thoracis et lumborum* muscles

Parameters	Young group (n = 74)			Old group (n = 61)			Significance
	Median	Max	Min	Median	Max	Min	
Colour parameters at 0 hours							
$(L^*)^{0\ h}$	35.28	38.31	30.28	33.23	36.14	30.58	NS
$(a^*)^{0\ h}$	15.47	19.99	13.78	16.57	18.81	15.53	NS
$(b^*)^{0\ h}$	-0.46	1.54	-2.46	-0.98	0.59	-1.84	NS
Colour parameters at 1 hour							
$(L^*)^{1\ h}$	35.80	39.56	30.84	34.15	36.33	31.32	NS
$(a^*)^{1\ h}$	18.66	23.76	16.09	20.30	23.75	17.78	NS
$(b^*)^{1\ h}$	4.09	7.03	0.58	3.76	5.66	2.74	NS
Colour parameters at 24 hours							
$(L^*)^{24\ h}$	37.01	42.41	33.09	36.29	39.39	32.91	NS
$(a^*)^{24\ h}$	22.29	24.87	17.05	22.96	27.14	21.32	NS
$(b^*)^{24\ h}$	6.64	8.78	3.41	6.70	8.12	5.03	NS
Colour parameters at 7 days							
$(L^*)^{7d}$	34.31	39.87	27.70	33.61	35.72	28.44	NS
$(a^*)^{7d}$	15.92	17.65	13.39	16.13	23.02	14.36	NS
$(b^*)^{7d}$	4.19	5.81	1.39	4.10	4.58	2.88	NS

^{NS} Not significant (P >0.05); L* (lightness), a* (redness), b* (yellowness): meat colour parameters

Fatness level and carcass composition of various species might differ because of carcass weight and slaughter age. As animals become older, the proportion of fat in their carcasses increases and the proportion of muscles and bones decreases (Crouse *et al*., 1986; Irshad *et al*., 2013). In contrast to these reports, subcutaneous fat thickness was similar in carcasses from both young and old groups in the current study. Ugarković *et al*. (2013) reported that slaughter age (14 months and 19 months) had no significant effect on thickness of subcutaneous fat. Fat thickness (6.42 mm) was measured in Simmental beef bulls slaughtered at 15 months of age in the study performed by Ozluturk *et al*. (2004) had higher values than that of the old group (16.3 month–4.60 mm) in the current study.

Jennings *et al*. (1978) reported that increases in marbling above modest (score 5) were associated with improvements in tenderness, while the opposite was true of marbling scores of slight (3) and below. In this study, marbling scores seemed to be low for both groups of Simmental bulls. Accordingly, increased shear force values were observed. The distribution of intra-muscular fat and connective tissue affects the tenderness and marbling (Oliveira *et al*., 2011). Therefore, the findings of the current study indicated that the marbling level obtained for both groups (about 2 traces) might have resulted in tough meat.

The WHC is defined as the ability of meat to retain water during the application of external forces, such as cutting, heating, grinding and pressing (Zhang *et al*., 2005). It can be influenced by various, factors such as post-mortem glycolysis, rate of carcass temperature (Oliveira *et al*., 2011), and carcass fatness level (Lawrie & Ledward, 2006). Meat WHC increases with intramuscular fat content, probably because the fat loosens up the myofibril microstructure, which allows more water to be entrapped (Lawrie & Ledward, 2006). The non-significant difference between young and old groups in the current study might be related to similar fatness levels (carcass fat thickness and marbling score) of the groups. The WHC values obtained in the present study were similar to those of values reported by Teke *et al*. (2014) for Simmental bulls.

High quality meat loses less water during cooking (Lawrie & Ledward, 2006). No differences in cooking loss were found between the young and old groups, but the young group lost 3.3% less water than the older group. The cooking loss values in this study were consistent with those reported by Sochor *et al*. (2005), Crouse *et al*. (1986), and Oliveira *et al*. (2011), but higher than those reported by Chambaz *et al*. (2003) and Schmutz *et al*. (2014). The variation in cooking loss from various reports could be attributed to the different durations and temperature of cooking and the type of muscle (Simela, 2005).

Oliveira *et al*. (2011) and Frylinck *et al.* (2015) indicated that beef from younger groups presents less tenderness owing to lower levels of intra-muscular fat and greater amounts of connective tissue. However, in the current study, the WBSF values of the young and old groups were similar, which might be attributed to similar fatness level in the two groups. Revilla & Vivar-Quintana (2006) reported that WBSF values ranging between 2.67 and 7.31 kg for Limousin and Charolais young bulls and heifers were acceptable by consumers. Shear force values for young and old groups in the current study were similar to results reported by Revilla & Vivar-Quintana (2006). Therefore, the meat of young and old groups might be considered to be within the acceptable range in terms of tenderness.

Meat colour is one of the most important factors that affect consumers' acceptance, purchasing decisions, and satisfaction of meat products (Muchenje *et al*., 2009). In this study, initial ages of the animals did not affect the lightness (L*), redness (a*) or yellowness (b*) values measured at 0 hours, 1 hour, 24 hours and 7 days after cutting (P >0.05). The results of the current study were in agreement with the findings of Marenčić *et al*. (2012), who reported that slaughter age (13 to 14 months and 17 to 18 months) did not affect the L*, a* and b* values at 24 hours after cutting in Simmental bulls. Consumers appear to prefer beef that is neither extremely pale nor dark, with a range of values between 34 and 40 being considered normal (Ender & Augustini, 1998). L* values of young and old groups were consistent with this data up to 24 hours but slightly decreased after the seventh day. Pigment concentration of diet, slaughter weight, fatness level of carcass (Beriain *et al*., 2000) and level of pre-slaughter stress (Teke *et al*., 2014) might influence the meat colour characteristics. Hence, these factors might be reasons for the similar colour values of young and old groups in the current study.

Conclusion

This study focused on the effects of the initial fattening age on carcass and meat quality of Simmental bulls. The present results showed that although initial fattening age of Simmental bulls showed no significant effect on most of the carcass and meat quality parameters, the LTL area of the young group was significantly higher than the old group. Further studies are needed to improve the carcass and meat quality of imported Simmental bulls, which are well adapted to conditions in Turkey, through modifying the initial fattening age or diet.

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Authors' Contributions

HU conducted the research and was responsible for drafting and submitting the manuscript. HY, SA, BE critically analysed and interpreted results and assisted in the revision of the original and revised manuscripts. AO was responsible for statistical analyses and HG, together with OK, assisted in animal husbandry.

Conflict of Interest Declaration

There are no conflicts of interest.

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