Meat quality traits of *longissimus thoracis*, *semitendinosus* and *triceps brachii* muscles from Chianina beef cattle slaughtered at two different ages

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ABSTRACT

The aim of this experiment was to study the effects of muscle and slaughtering age on some meat quality traits of forty-eight carcasses of Chianina beef cattle raised on the same farm and slaughtered at an age ranging between 18 and 21 months. After the usual commercial ageing period for Chianina carcasses, *longissimus thoracis*, *semitendinosus* and *triceps brachii* muscles were taken and analyzed instrumentally for pH, meat color, water holding capacity, tenderness and chemical composition. To compare the quality characteristics of the three muscles at different age, all data were subdivided in two groups: slaughtering age 18-19 months (n=25) and 20-21 months (n=23). Quality characteristics of meat derived from the three muscles analyzed were different: *semitendinosus* muscle showed higher values of Lightness (L*) and Hue (H*), thus lighter and paler meat, but was less tender and had a higher cooking loss. Meat derived from *triceps brachii* muscle had the lowest values of Lightness (L*) and Hue (H*) thus meat slightly darker; with regard to the other quality parameters, *longissimus thoracis* gave more tender meat with better water holding capacity than *triceps brachii*. The meat analyzed had a very low content of intramuscular fat (expressed as ether extract (%)), a very well-known characteristic of Chianina meat.

The comparison between meat derived from 18-19 month old beef and from 20-21 month old beef shows that only redness (a*) and Chroma (C*) increased significantly with the increase in slaughtering age, but these results do not induce differences in meat color appreciation, as shown by the similar values of Lightness (L*) and Hue (H*).

Water holding capacity, tenderness and chemical composition were not influenced by slaughtering age.

Key words: Chianina beef, Meat quality, Muscle, Slaughtering age.

RIASSUNTO

CARATTERISTICHE QUALITATIVE DELLA CARNE DERIVATA DAI MUSCOLI *LONGISSIMUS THORACIS*, *SEMITENDINOSUS* E *TRICEPS BRACHII* DI VITELLONI DI RAZZA CHIANINA MACELLATI A DIVERSE ETÀ

Scopo del lavoro è stato quello di valutare alcune caratteristiche qualitative della carne ottenuta da tre muscoli derivati dalle carcasse di 48 vitelloni Chianini, studiando l'effetto dell'età di macellazione su tali caratteristiche. Gli animali, allevati nella stessa azienda, sono stati macellati ad un'età compresa fra 18 e 21 mesi. Dopo il periodo di frollatura utilizzato per le carcasse Chianine, sono stati prelevati i muscoli longissimus thoracis*,* semitendinosus *e* triceps brachii*, sui quali sono stati determinati: pH, colore, potere di ritenzione idrica, tenerezza e composizione chimica.*

Per confrontare le caratteristiche qualitative dei tre muscoli ottenuti a diversa età di macellazione, i dati sono stati suddivisi in due gruppi: età 18-19 mesi e 20-21 mesi.

Il semitendinosus *ha fornito carne significativamente più luminosa e chiara, come si evince dai più alti valori di Luminosità*

(Età 18-19 mesi: L: 46.65; 42.24; 44.18; Età 20-21 mesi: L*: 45.80; 42.20; 43.25 rispettivamente nel* semitendinosus*, nel* triceps brachii *e nel* longissimus thoracis*) e di Tinta (Età 18-19 mesi: H*: 28.88; 25.02; 26.68; Età 20-21 mesi: H*: 28.05; 24.99; 26.34 rispettivamente nel* semitendinosus*, nel* triceps brachii *e nel* longissimus thoracis*). Il Drip loss è risultato piuttosto basso, confermando l'attitudine alla conservazione della carne Chianina (Età 18-19 mesi: 1.51; 1.62; 1.36%; Età 20-21 mesi: 1.72; 1.44; 1.50% rispettivamente per* triceps brachii, longissimus thoracis *e* semitendinosus*); per il muscolo* semitendinosus *è stato registrato il più elevato valore di cooking loss (Età 18-19 mesi: 34.21 vs. 30.38 e 31.37%; Età 20-21 mesi: 37.21 vs. 32.45 e 30.49% rispettivamente nel* triceps brachii *e nel* longissimus thoracis*). Lo sforzo di taglio è risultato significativamente diverso fra i tre muscoli (carne cruda: Età 18-19 mesi: 18.72; 10.88; 21.51 kg; Età 20-21 mesi: 18.82; 10.09; 19.16 kg rispettivamente per* triceps brachii, longissimus thoracis *e* semitendinosus*; carne cotta: Età 18-19 mesi: 8.72; 7.16; 9.70 kg; Età 20-21 mesi: 9.27; 7.95; 10.33 kg rispettivamente per* triceps brachii, longissimus thoracis *e* semitendinosus*). La carne derivata dai muscoli* longissimus thoracis *e* triceps brachii*, sebbene lievemente più scura, sembrerebbe più tenera e con un miglior potere di ritenzione idrica rispetto a quella fornita dal* semitendinosus*. L'analisi chimica ha evidenziato un ridotto contenuto in lipidi inframuscolari, caratteristica tipica della carne Chianina; fra i muscoli analizzati, il* longissimus thoracis *ha mostrato la maggior percentuale in estratto etereo (Età 18-19 mesi: 2.32%; Età 20-21 mesi: 2.48%) rispetto al* triceps brachii *(Età 18-19 mesi: 1.52%; Età 20-21 mesi: 1.74%) ed al* semitendinosus *(Età 18-19 mesi: 1.27%; Età 20-21 mesi: 1.31%).*

Il confronto fra le caratteristiche qualitative della carne derivata da vitelloni macellati a diversa età ha evidenziato soltanto un aumento significativo dell'indice del rosso (a) e del Croma (C*) con l'aumentare dell'età di macellazione; tuttavia tali risultati non hanno indotto modificazioni sulla percezione del colore della carne, restando inalterati i parametri di Luminosità (L*), indice del giallo (b*) e Tinta (H*). La capacità di ritenzione idrica, la tenerezza e la composizione chimica non sono stati influenzati significativamente dall'età di macellazione.*

Parole chiave: Vitelloni Chianini, Qualità della carne, Muscoli, Età di macellazione.

Introduction

Consumers decide to purchase meat based, first of all, on the perception of quality, i. e. in terms of appearance, organoleptic and dietetic properties (Savell *et al.*, 1987; Abril *et al.*, 2001; Alcalde and Negueruela, 2001; Gonzales *et al.*, 2001).

Beef quality is determined by various intrinsic (breed, gender and slaughtering age) and extrinsic factors (rearing technique, transport, slaughter and post-slaughter conditions, etc.) (Klont *et al.*, 1998; Renand *et al.*, 2001).

Meat quality even depends on the histochemical traits of the muscles from which it originates and therefore various commercial cuts, derived from different anatomical locations, give meat with different quality characteristics (Ouali, 1990; Monin and Ouali, 1991; Klont *et al.*, 1998; Vestergaard *et al.*, 2000).

Because most studies on meat quality have focused on the loin (*longissimus dorsi* muscle) and only limited information is available on inter-muscle variation in the Chianina breed, the main breed reared in the Central Italy (Acciaioli *et al.*, 1995; Funghi *et al.*, 1994; Pugliese *et al.*, 1994), the aim of this study was to compare color, shear force, water holding capacity and some chemical properties of three muscles of Chianina beef, slaughtered at different ages.

Material and methods

Forty-eight carcasses of male Chianina beef cattle, reared on the same farm in multiple pens, fed with the same diet, based on maize silage and concentrate, and slaughtered at an age ranging between 18 and 21 months, were used. After 24 h post-mortem, the right sides of the carcasses were quartered between the 6th and the 7th thoracic vertebra;: the forequarters were aged for 10 days, while hindquarters were aged for 20 days, according to the usual commercial ageing period for Chianina meat.

After ageing, the *triceps brachii* muscle was removed from the forequarters, while the *longissimus thoracis* and *semitendinosus* muscles were excised from the hindquarters. To evaluate meat quality characteristics, 10-cm-thick slices of *longissimus thoracis* (7th-8th thoracic vertebrae), *semitendinosus* and *triceps brachii* (collected approximately in the central part of the muscles) were taken and analyzed.

Meat color and pH

The pH of all muscles was determined using a Hanna pH211 pH-meter provided with a Hanna FC 200B electrode and an automatic temperature compensator (Hanna Instruments, Padua, Italy).

Meat color was evaluated on a 2.5-cm-thick slice of meat, using a Minolta CR300 colourmeter (Illuminant D 65) (Minolta Camera Co. Ltd, Osaka, Japan), calibrated against a standard white tile in the CIEL*a*b* system, which measures the values of coordinates Lightness (L*), redness (a*), yellowness (b*), Chroma (C*) and Hue (H*) (Renerre, 1982). Prior to color evaluation, each sample was allowed to oxygenate at 4°C for 45 min covered with an oxygen permeable polyethylene film. After removing the polyethylene film, meat color was determined making three readings for each sample.

Water holding capacity

The water holding capacity of meat was determined using three different methods:

- Drip loss, as the weight loss of the meat sample used for color determination, kept at 4°C for 48 h in a plastic container with a double bottom (Lundström and Malmfors, 1985).
- Cooking loss on the meat sample used for drip loss, as the percentage of weight loss during cooking in a ventilated oven at 180°C to an internal temperature of 75°; the sample temperature was detected using a thermocouple thermometer HANNA HI92704C (Hanna Instruments, Padua, Italy).
- Filter paper press method (Grau and Hamm, 1957), expressed as the ratio M/T where M is the area (cm^2) of the meat and T is the total area (cm^2) of a Whatman filter paper impregnated by the juice loss of 300 mg meat under a pressure of 50 kg/cm^2 during 5 min. The areas were measured using an Uchida Planimeter (Uchida, Japan). Therefore, a larger value of M/T ratio indicates a higher water holding capacity (Hofmann *et al.*, 1982).

Tenderness

Tenderness was measured as the shear force (kg) using Warner-Bratzler Shear applied to an Instron 1011 (Instron Ltd, High Wycombe, UK), on 1-inch-diameter cylinders of row and cooked meat, following a modified method of Joseph (1979).

For each muscle a minimum of 4 cylinders of about 2.5 cm long were taken in parallel to muscular fibers and placed inside the Warner-Bratzler to be sheared perpendicularly to the long axis of the muscle fibers.

Chemical analysis

Dry matter, ether extract, crude protein and ash in each sample were determined, according to AOAC methods (Association of Official Analytical Chemists, 1990).

Statistical analysis

To compare the quality characteristics of the three muscles at different ages, all data were subdivided in two groups: slaughtering age 18-19 months (n=25) and slaughtering age 20-21 months (n=23). The following linear model was fitting by the statistical package JMP (SAS, 1995):

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$$

where: Y_{ijk} = dependent variable; μ = overall mean; α_i = muscle effect; β_j = slaughtering age effect; $(\alpha\beta)_{ij}$ = effect of the interaction (muscle, slaughtering age); ε_{ijk} = residual error.

Results and discussion

Data of meat pH and color are reported in Table 1. It is possible to note that no significant interactions between type of muscle and age of slaughter were detected for these traits. Moreover, no differences were found among muscles and between slaughtering age groups for pH. Meat derived from *semitendinosus* muscle appears significantly lighter (L*) and paler (H*), while the *triceps brachii* muscle shows the lowest values of L* and H*, thus darker meat; *longissimus thoracis* has intermediate meat color characteristics. Similar results found by Acciaioli *et al.* (1995) on Chianina beef showed that meat derived from *semitendinosus* muscle always appears to have color characteristics which are more desirable for the Italian consumer. These results were also con-

Table 1. Effect of slaughtering age and type of muscle on pH and meat color.

	Slaughter age: 18-19 months			Slaughter age: 20-21 months			Significance			Error
	T. brachii	*L. thoracis*	*Semitendinosus*	*T. brachii*	*L. thoracis*	*Semitendinosus*	Muscle	Slaughtering age	Interaction	Mean Square
n	25	25	25	23	23	23				
pH	5.48	5.45	5.45	5.46	5.47	5.44	ns	ns	ns	0.01
Meat color:										
L*	42.24	44.18	46.65	42.20	43.25	45.80	≤ 0.001	ns	ns	5.79
a*	26.80	25.43	26.39	27.55	26.21	27.74	0.010	0.017	ns	5.48
b*	12.60	12.78	14.6012.98	13.03	14.79	≤ 0.001	ns	ns		2.53
C*	29.62	28.47	30.17	30.47	29.25	31.45	0.004	0.040	ns	7.63
H*	25.02	26.68	28.88	24.99	26.34	28.05	≤ 0.001	ns	ns	2.24

ns: not significant

Table 2. Effect of slaughtering age and type of muscle on water holding capacity and shear force of meat.

		Slaughter age: 18-19 months			Slaughter age: 20-21 months			Significance			Error
		T. brachii	*L. thoracis*	*Semitendinosus*	*T. brachii*	*L. thoracis*	*Semitendinosus*	Muscle	Slaughtering age	Interaction	Mean Square
n		25	25	25	23	23	23				
Water holding capacity:											
Drip loss	%	1.51	1.62	1.36	1.72	1.44	1.50	ns	ns	ns	0.35
Cooking loss	"	30.38	31.37	34.21	32.45	30.49	37.21	≤ 0.001	ns	ns	20.95
M/T		0.40	0.40	0.39	0.41	0.43	0.39	ns	ns	ns	0.01
Shear force:											
on raw meat	kg	18.72	10.88	21.51	18.82	10.09	19.16	≤ 0.001	ns	ns	19.92
on cooked meat	"	8.72	7.16	9.70	9.27	7.95	10.33	≤ 0.001	ns	ns	4.22

ns: not significant

Table 3. Effect of slaughtering age and type of muscle on chemical composition of meat.

		Slaughter age: 18-19 months			Slaughter age: 20-21 months			Significance			Error
		T. brachii	*L. thoracis*	*Semitendinosus*	*T. brachii*	*L. thoracis*	*Semitendinosus*	Muscle	Slaughtering age	Interaction	Mean Square
n		25	25	25	23	23	23				
Dry matter	%	23.62	25.49	24.47	23.78	25.83	24.33	≤ 0.001	ns	ns	0.98
Ether extract	"	1.52	2.32	1.27	1.74	2.48	1.31	≤ 0.001	ns	ns	0.79
Crude protein	"	21.10	22.16	22.20	21.04	22.33	22.01	≤ 0.001	ns	ns	0.56
Ash	"	1.01	1.01	1.00	1.00	1.01	1.01	ns	ns	ns	0.00

ns: not significant

firmed by Torrescano *et al.* (2003) who, while evaluating some quality traits of 14 Swiss Brown beef muscles, found that *semitendinosus* was significantly lighter than *longissimus lumborum* and *triceps brachii*.

The different age of slaughter of the animals had some effect on meat color (Table 1). Prolonging the rearing period from 18-19 months up to 20-21 months induced significantly higher values of redness (a*) and Chroma (C*), while Lightness (L*), yellowness (b*) and Hue (H*) were not influenced by age. These results are not completely in agreement with Funghi *et al.* (1994), who found that even Lightness (L*) decreased with the increase in slaughtering age.

Table 2 shows the meat's water holding capacity expressed as drip loss, cooking loss and meat/total ratio (M/T). Also for these traits there was no significant interaction between slaughtering age of the animals and type of muscle. It is possible to note that drip loss and meat/total ratio (M/T) are not significantly different among muscles; moreover, percentage of drip loss is rather low, thereby reflecting the good aptitude for domestic storage of Chianina meat, since drip loss is strictly related to meat appearance (Warriss, 2000).

Consistent with Monin and Ouali (1991), there were significant differences among muscles for cooking loss. The highest losses were observed for *semitendinosus* muscle, while l*ongissimus thoracis* and *triceps brachii* show the lowest values, indicating a better water holding capacity. Similar differences were also found by Acciaioli *et al.* (1995) on the same muscles from Chianina cattle. Water holding capacity expressed as drip loss, cooking loss and meat/total ratio (M/T), was not influenced by slaughtering age (Table 2).

Meat tenderness values measured in both raw and cooked meat and expressed as shear force (kg) are also reported in Table 2. *Longissimus thoracis* gave more tender meat, as shown by lowest shear force before and after the cooking process. Meat derived from *triceps brachii* muscle, even if aged only for 10 days, has tenderness similar to *semitendinosus* muscle after 20 days of ageing and both muscles were always tougher than the *longissimus thoracis*. The greatest tenderness of *longissimus* meat observed in the present study is consistent with the results reported by Dransfield and Jones (1981), Funghi *et al.* (1994), Acciaioli *et al.* (1995) and Torrescano *et al.* (2003), in previous studies in which different muscles of beef cattle were compared.

It is also interesting to note that the increased age of slaughter did not induce any significant differences on shear force measured on raw and cooked meat, and this result is in agreement with the findings of Funghi *et al.* (1994) with respect to Chianina meat.

The chemical composition of the meat derived from the three muscles is reported in Table 3. Once again no interaction between type of muscle and age of slaughter was noticed. *Longissimus thoracis* muscle has significantly more dry matter content, due to the higher percentage of ether extract. The significantly higher intramuscular fat content of *longissimus thoracis* muscle, could partially explain its greater tenderness in both raw and cooked meat. It is known, in fact, that intramuscular fat may positively influence some organoleptic properties of meat such as tenderness, juiciness, flavor, etc. (Seideman *et al.*, 1987; Fiems *et al.*, 2000; Savell and Cross, 1988 quoted in Fiems *et al.*, 2000; Renand *et al.*, 2001).

Delaying the slaughter from 18-19 months to 20-21 months of age had no effect on the chemical composition of meat (Table 3), and particularly on the content of intramuscular fat, which remained steady agreeing with the results of Poli *et al.*, (1994).

Regardless of the type of muscle, the meat analyzed had a very low content of intramuscular fat, expressed as ether extract (%). This is a very well-known characteristic of Chianina meat (Funghi *et al.*, 1994, Poli *et al.*, 1996) that may increase its dietetic value for health reasons (Ulbricht and Southgate, 1991).

Conclusions

Some variations in meat quality characteristics among different muscles are shown. It would be interesting to more thoroughly investigate this subject by studying some factors which are proba-

bly implicated in the different quality of muscles, such as myoglobin content, fiber type composition and collagen content and its structure, that are associated with meat quality traits.

As regards the slaughtering age, it was noticed that a delay from 18 to 21 months of age had only little differences in meat characteristics and this may suggest that is possible to increase the slaughtering age of Chianina beef without a relevant worsening of its meat quality.

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