Effect of ageing time on consumer-perceived quality of Italian Simmental beef

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ABSTRACT

The aim of the experiment was to provide an objective indication on the optimal ageing time of meat from Italian Simmental (IS) young bulls, the most important commercial category of the breed. The research was carried out on 10 young bulls slaughtered at the average weight of 688 kg (SE: 7.3 kg). The right side of each carcass was stored for 7 days and the left one for further 7 days, at normal refrigeration temperatures. At the end of the ageing period, the sides were sampled at the loin for meat pH, color, cooking loss and shear force measurement. A central location, affective test involving 74 consumers was carried out to measure the degree of liking for grilled beef aged 7 or 14 days. The pH and color parameters were not significantly affected by the duration of post-mortem storage, while cooking loss increased (31.4 vs 32.6 %; P<0.05) and shear force values diminished (56.7 vs 46.8 N; P< 0.01) when ageing time increased from 7 to 14 days. The degree of liking by the untrained respondents for the two types of cooked meat was different, considering that consumers gave the highest hedonistic scores to beef aged 14 days. Tenderness was the sensory attribute that allowed the best discrimination between beef stored for periods of different length. In fact, while the difference between 14-day-aged and 7-day-aged beef for flavour ratings (7.0 vs 6.9) did not reach the threshold of significance, the former meat was perceived as significantly finer than the latter regarding tenderness (6.5 vs 5.6; P= 0.01) and marginally preferred in overall terms (6.9 vs 6.5; P= 0.07). The classification test, carried out at the end of the quantitative test by asking consumers to select from a list the most appropriate attributes describing the stimuli associated with meat consumption, confirmed the effectiveness of texture attributes in ranking different-aged beef acceptability. In fact, the number of ticks reported for chewiness and juiciness descriptors were different for the two types of meat: the 14-day-aged beef was perceived as easier to chew (57 vs 34 ticks) and juicer (42 vs 24) than the shortest-aged beef. Ageing for 14 days should be recommended as a process control point for the beef industry to improve consumer acceptance of IS young bull beef.

Key words: Ageing, Italian Simmental bulls, Meat quality, Consumer test

RIASSUNTO

EFFETTO DELLA DURATA DELLA FROLLATURA SULLA PERCEZIONE DI QUALITÀ DEL CONSUMATORE NEI CONFRONTI DELLA CARNE DI PEZZATA ROSSA ITALIANA

Lo scopo della ricerca è fornire indicazioni oggettive sulla durata ottimale della frollatura della carne di vitellone di Pezzata Rossa Italiana, la più importante categoria commerciale della razza. Per cogliere il miglioramento complessivo della piacevolezza della carne all’aumentare della durata della frollatura, è stata effettuata un’analisi sensoriale di tipo edonistico che, esprimendo una valutazione di gradevolezza basata sul giudizio dei fruitori finali del prodotto, rappresenta un test attendibile e trasparente, affidabile sia per l’industria alimentare che per i consumatori. La prova è stata effettuata con 10 vitelloni di 540 giorni (ES: 8,5 giorni) e 688 kg (ES: 7,3 kg). La mezzina destra di
ciascuna carcassa è stata conservata per 7 giorni e quella sinistra per ulteriori 7 giorni, alla normale temperatura di refrigerazione. Al termine del periodo di frollatura, le mezzene sono state campionate in corrispondenza del muscolo longissimus thoracis, per le misure di pH, colore, perdite di cottura e resistenza al taglio. Inoltre è stato effettuato un test sensoriale di tipo affettivo, in locazione esterna, che ha coinvolto 74 consumatori, per misurare il grado di piacevolezza della carne grigliata, frollata 7 o 14 giorni.

Il pH e il colore della carne frollata 7 o 14 giorni non sono risultati significativamente diversi, mentre durante la seconda settimana di conservazione sono aumentate le perdite di cottura (31,4 vs 32,6 %; P<0,05) ed è diminuita la resistenza al taglio (56,7 vs 46,8 N; P< 0,01) della carne. Il grado di soddisfazione espresso dai consumatori non addestra
ti mangiando i due tipi di carne è stato diverso, avendo ricevuto quella frollata più a lungo i punteggi edonistici più elevati. La tenerezza è stato l’attributo sensoriale che meglio ha consentito di discriminare le carni con diversa lunghezza di frollatura. Infatti, mentre la differenza di sapore fra carne frollata 14 e 7 giorni non ha raggiunto la significatività statistica (7,0 vs 6,9 punti), la carne conservata più a lungo è stata percepita come più tenera (6,5 vs 6,5; P=0,07), e leggermente migliore in termini di piacevolezza generale (6,9 vs 6,5; P= 0,07). Il test di classificazione, condotto al termine di quello quantitativo chiedendo ai consumatori di selezionare da una lista gli attributi più appropriati per descrive
gli stimoli associati al consumo della carne, ha confermato l’efficacia degli attributi strutturali nella valutazione del
taccettabilità della carne a diversa frollatura. Infatti, il numero di scelte ottenuto dagli attributi di masticabilità e succu
lenza è risultato statisticamente diverso per i due tipi di carne: quella frollata per 14 giorni è stata percepita come più facile da masticare (57 vs 34 scelte) e più succulenta (42 vs 24 scelte).

Pertanto, si può concludere raccomandando l’adozione di un periodo di frollatura di 14 giorni, per esaltare l’accettabilità dei consumatori nei confronti della carne di vitellone Pezzato Rosso Italiano.

Parole chiave: Frollatura, Vitellone Pezzato Rosso Italiano, Qualità della carne, Test di consumo

**Introduction**

The processes that affect tenderness, which is an important part of meat acceptability, are as well known as the variability of tenderness post-mortem evolution (Zamora et al., 1996). Ageing, i.e. the practice of storing meat at normal refrigeration temperatures for some time after slaughter, is the simplest and best documented method of improving the inconsistency of meat tenderness at the consumer level (Koohmaraie, 1996). In spite of this, owing to the costs of storage and refrigeration and the weight losses for water evaporation and exudation, the majority of beef produced is aged only for the duration of distribution and retailing, which may be as short as three days after slaughter.

The Italian Simmental (IS) Breeders’ Association (ANAPRI), with the purpose of promoting IS beef on the basis of quality, is examining a quality assurance system which manages quality along the entire production chain. One of the critical points is ageing, the duration of which should suffice for the meat to reach an acceptable tenderness, according to consumer expectations, in a commercially reasonable period of time.

The aim of the experiment is to provide objective indication on the optimal ageing time of meat from IS young bulls, the most important commercial category of the breed. To account for all the improvement in beef palatability when ageing time increased it was decided to use the consumer testing, which allowed a reliable, transparent, system of testing meat that would engender confidence in both the beef industry and consumers. The same would also allow the final assessment of palatability to be determined by the target consumer market for the product (Thompson, 2002).

**Material and methods**

**Animals**

The research was carried out on 10 young bulls of IS breed, randomly chosen among the bulls subjected to performance test at the IS National Association Genetic Centre and destined to slaughter. The animals were reared on slatted-floor multiple boxes and slaughtered at the age of 16-20 months. The mean values of age and live weight, individually recorded the day before slaughter, are summarized in Table 1.
Slaughtering conditions and carcass characteristics

All bulls underwent similar transport (approx. 1.5 hours) and waiting conditions (1-2 hours) before slaughtering at an EU-licensed abattoir, using conventional commercial procedures, without carcass electrical stimulation. After chilling at 4°C for 24 hours, the carcasses were weighed and scored for conformation and fatness, following the EUROP standardized classification (EEC, 1981a; 1981b; 1991). At the same time, the ultimate pH (pHu) was measured three times, on the longissimus thoracis muscle, between the 11th and 12th thoracic vertebrae by a glass piercing electrode (Crison 52-32) connected to a pH-meter. As summarized in Table 1, the carcass weight and its incidence on the weight at slaughter, the carcass conformation grade (between U and R) and fatness score (between 2 and 3) of the 18-month-old IS bulls were in accordance with those previously reported for the same category of animals, produced under the same conditions (Piasentier et al., 2003). The mean pH at 24 hours after slaughtering was 5.48, which is a value comprised in the normal commercial range, the same as 5.65, the highest pHu recorded.

Meat ageing and sampling

The right side of each carcass was then stored for 6 days and the left one for further 7 days, at normal refrigeration temperatures (0-4°C), all the time hanging by the Achilles tendon. At the end of the ageing period, i.e. respectively 7 and 14 days after slaughtering, both sides were quartered by pistol style cut yield and their hind quarter sampled at the loin (muscle longissimus thoracis, 9th - 11th rib section, LT), by cutting three (right side, 7 days of ageing) or two (left side, 14 days of ageing) three-centimeter thick chops.

The first steaks from both, the 7- and 14-day-aged LT muscle, were immediately vacuum frozen and stored at -20°C for an average period of 6 months prior to consumer test.

Beef pH and physical properties

On the second section of both, the 7- and 14-day-aged LT muscle, meat pH was measured as above and color was evaluated, according to CIE L*, a*, b* color system, after a 1-hour blooming period at normal refrigeration temperatures, by a Minolta CM-2600d Spectrophotometer (Minolta Camera, Osaka, Japan) with D65 illuminant.

The same sections were then used to measure water loss (in a 75°C-water bath for 20 min.; ASPA, 1996) and shear force, on the cooked sample, using a Warner-Bratzler device with a triangular shaped hole in the shear blade, mounted on an Instron 4301 (Instron Ltd., High Wycombe, United Kingdom) universal testing machine; the measurement was recorded as the peak yield force in N, required to shear, at a 100 mm/min crosshead speed, perpendicularly to the direction of the fibers, three cylindrical cross-section, 10 mm diameter x 30 mm length, replicates from each sample.

Table 1. In vivo and carcass characteristics of Italian Simmental young bulls.

| Item                  | mean | SE  |
|-----------------------|------|-----|
| Age days              | 540  | 8.5 |
| Live weight kg        | 687.5| 7.29|
| Carcass weight "      | 395.2| 3.90|
| Dressing percentage % | 57.5 | 0.63|
| Conformation score1   | 3.7  | 0.16|
| Fatness score2        | 2.5  | 0.18|
| pHu                   | 5.48 | 0.028|

1 Community scale for the classification of carcasses of bovine animals (ECC, 1981a; 1981b; 1991).
Conformation score: from S (superior)=6 to P (poor)=1.
2 As above. Fatness score: from 5 (very abundant) to 1 (very low).
Beef chemical composition

The third steak from the right side was quickly frozen under vacuum and stored at -20°C to be analyzed for its proximate composition (ASPA, 1996). The chemical composition of beef, as summarized in Table 2, was in accordance with that previously reported for the same category of animals, produced under the same conditions (Piasentier et al., 2003).

Consumer test

A central location, quantitative affective test was carried out to measure the consumer degree of liking for grilled beef aged either 7 or 14 days, by examining three sensory attributes: flavour, tenderness and overall liking (Meilgaard et al., 1991). Every untrained respondent was requested to score each attribute on an intensity scale, with values ranging from 1 (very bad) to 9 (excellent).

At the end of the quantitative test, the consumers were involved in a classification test (Meilgaard et al., 1991). The respondents were asked to select, by ticking from a provided list, the most appropriate attributes describing the stimuli associated with meat consumption. Descriptors were previously selected looking at a few simple, widely understood attributes, useful in getting consumers to explain the organoleptic basis of their preference for beef aged for periods of different length. The proposed word list included alternatives that are mutually exclusive and exhaustive - beefy odour and barnyard odour, juicy and dry, easy to chew and difficult to chew- without the introduction of any relationship between the attributes faced on the same parameter. The results were reported for each attribute as the number of consumers that ticked it.

Statistical analysis

Beef physical data and consumer responses for each sensory attribute were compared using a paired t-test, while the frequency of selection of each attribute were analyzed by using a χ² test.

Table 2. Proximate analysis of beef from longissimus thoracis muscle of Italian Simmental young bulls.

| Item          | Mean | SE  |
|---------------|------|-----|
| Moisture % wet weight | 72.6 | 1.25 |
| Crude protein " | 21.9 | 0.42 |
| Ether extract " | 4.35 | 0.920 |
| Ash "         | 1.07 | 0.011 |
Results and discussion

**pH and physical characteristics of aged meat**

The effects of ageing time on pH and physical characteristics of beef are reported in Table 3. Comparing the values of pHu given in Table 1 with those of Table 3, a significant (P<0.01) and expected (Gašperlin et al., 2001) increase of pH can be observed between aged and non aged meat, likely due to hydrolysis of proteins to amino acids. However, after the first week of ageing, the pH showed a steady state around 5.65.

Color parameters (L*, a*, b*) were not significantly changed by ageing time, even if color was slightly lighter and redder in the most aged samples. These results were in accordance with those of Gašperlin et al. (2001) but disagree with Boakye and Mittal’s (1996) conclusion that time of ageing affects all the instrumental parameters of beef color. The time of blooming may have been insufficient for a deeper oxygenation of the most aged meat, which would have allowed easier accessibility of oxygen to myoglobin (Gašperlin et al., 2001).

By contrast, the duration of post-mortem storage affected both meat cooking loss and shear force values. The cooking loss increased (31.4 vs 32.6 %) and the shear force values diminished (56.7 vs 46.8 N) in meat when ageing time increased from 7 to 14 days. An increase in cooking loss upon ageing has also been reported by other authors (Boakye and Mittal, 1993; Purchas et al., 1999). Bertram et al. (2004) found that this rise was determined by changes in the water-holding properties of cooked meat during ageing, due to an alteration towards a more homogeneous matrix of the morphology of macromolecules, which is responsible for the binding of water.

The decrease in the resistance to shear in cooked meat with ageing has been extensively documented (Dransfield, 1996; Geesink et al., 1995; Hwang and Thompson, 2001; Jung et al. 2000; Palka, 2003; Silva et al., 1999; Wheeler and Koohmaraie, 1994) and it is known that the post-mortem storage changes in shear force values of cooked meat vary greatly from individual to individual (Koohmaraie et al., 2002).

**Sensory analysis**

The sensory ratings from consumer testing, aimed at evaluating the effect of ageing length on beef palatability, are reported in Table 4. The degree of liking by the untrained respondents for the two types of cooked meat was different, since consumers gave the highest hedonistic scores to beef aged 14 days. Tenderness was the sensory attribute which allowed the best discrimination between beef stored for periods of different length. In fact, while the difference between 14-day-aged and 7-day-aged beef for flavour ratings (7.0 vs 6.9) did not reach the threshold of significance, the former meat was perceived as significantly finer than...
Table 4. Consumer preferences for beef from *longissimus thoracis* muscle of Italian Simmental young bulls, as affected by ageing time.

| Ageing time | 7 days | 14 days | SE<sup>1</sup> |
|-------------|--------|---------|---------------|
| Flavour     | 6.9    | 7.0     | 0.26          |
| Tenderness  | 5.6<sup>a</sup> | 6.5<sup>b</sup> | 0.35          |
| Overall liking | 6.5<sup>a</sup> | 6.9<sup>b</sup> | 0.26          |

<sup>1</sup> SE of the paired difference.

<sup>a,b</sup> Means in the same row with different superscripts differ significantly (P ≤0.01).

Means in the same row with different superscripts differ at the significance of P = 0.07.

The results of attribute selection, carried out as a part of the consumer test in the endeavor to better understand the reasons of meat preference, are reported in Figure 1. There, the number of ticks for the mutually exclusive attributes regarding the same parameter are plotted on the opposite halves of the same line, to allow an easy evaluation of consumers’ answers consistency. The classification test confirmed the effectiveness of texture attributes in ranking beef acceptability. In fact, the number of ticks for chewiness and juiciness descriptors were different for the two types of meat, which were both appreciated because they had a normal beefy odour (45 vs 48 ticks, respectively for 7-day-aged and 14-day-aged beef) and no barnyard odour off-note (8 vs 8). The 14-day-aged beef, preferred for its tenderness and characterized by lower shear values, was also perceived as easier to chew (57 vs 34 ticks) than the shortest-aged beef, which, in turn, was confirmed as more difficult to masticate (11 vs 33).

Moreover, the longest-aged meat obtained a higher frequency of selection for juiciness (42 vs 24 ticks), confirmed by a lesser frequency of dryness (20 vs 38), than the 7-day beef. These texture attributes were in accordance with the higher cooking loss observed in the 14-day beef and the related changes of the water-holding properties hypothesized for the cooked meat. An improvement in juiciness was also observed by Miller et al. (1997) who found that ageing steaks for 14 days enhanced both initial and sustained juiciness, compared with steaks aged 7 days, while Campo et al. (1999) showed a different evolution of this...
attribute along ageing, depending on the breed group.

**Conclusions**

The textural improvement of beef throughout ageing, objectively measured by shear force, was clearly perceived by target consumers, who preferred beef when aged for 14 days instead of 7 days in terms of both tenderness and overall liking, since it was classified easier to chew and juicier. Thus ageing for 14 days should be recommended as a process control point for the beef industry to improve consumer acceptance of IS young bull beef.

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