Productive performances of Maremmana young bulls reared following organic rules and slaughtered at 18 and 24 months of age

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Abstract

Fourteen Maremmana young bulls fed on pastures supplemented with mixed hay and concentrates, according to an organic method, were slaughtered at 18 and 24 months of age to evaluate in vita and post-mortem performances. At slaughter, carcass yield was determined and carcass evaluation according to EU rules was made. Physico-chemical characteristics of Longissimus thoracis (LT) and Caput longum triceps brachii (TB) muscles were determined. No differences for both carcass yield and quality were found between the two age groups. Animals of 24 months of age presented lighter and more yellow meat as well as higher hue angle and drip loss. TB muscle showed lower protein content and higher shear force, moisture, total lipids and ash than LT. The latter presented a higher percentage of C15:0iso, C20:3n6, C20:4n6, C18:3n3 and C22:5n3. Maremmana animals, irrespective of age, showed a low percentage of saturated fatty acids, good PUFA:SFA ratio and a great amount of unsaturated fatty acids of the n3 and n6 series, as well as a favorable atherogenicity and thrombogenicity indexes.

Introduction

Tuscany possesses 16 autochthonous breeds belonging to various livestock species (cattle, horse, donkeys, pigs, goats, sheep). Four of them are considered endangered and 6 are threatened with extinction (ARSLA, 2006). The recovery and the safeguard of the biodiversity were recognized as a priority from both the EU (European Council, 1992) and the Tuscany regional authorities (Regione Toscana, 1997; Regione Toscana, 2004). The project to re-evaluate and promote the Maremmana cattle breed is integrated in this framework. At present, the breed is in a phase of numerical stabilization after being, in recent years, on the threshold of extinction because of uncontrolled crossbreeding with other beef cattle breeds.

The Maremmana breed, rustic, frugal and perfectly adapted to the difficult environment of the area from which it takes its name, has been used over the past centuries as a draught animal. From the mid sixties, with mechanization, the breed was used for the production of low cost pure or crossed calves.

Even if crossbreeding with the most prestigious national and foreign breeds (mainly Chianina, Charolaise and Limousine) improved its performance (Catalano and Russo, 1967; Romita and Borghese, 1982; Biagioli et al., 1987; Biagioli et al., 1989; Lucifero et al., 1997), the repeated and uncontrolled crossing determined a lack of the ethnic characteristics and the numerical contraction of the breed (Lucifero and Sargentini, 1997).

Moreover, although F1 or F2 animals have a higher dressing percentage at slaughter than purebred animals, they don’t seem to have better meat characteristics (Romita, 1972, 1976; Mazziotto di Celso et al., 1981). The heads enrolled in the Herd Book, distributed in 184 farms currently number 9,682, divided into 5,347 cows, 2,051 heifers and first-calf heifers, 2,126 young cattle and 158 bulls. The heads reared in Tuscany are approximately 19% of the total and are distributed over 26 farms.

Various authors have carried out studies concerning the productive characteristics of Maremmana breed reared on pasture and/or in feedlot, slaughtered at various ages (Poli et al., 1996a; Sargentini et al., 1996; Bozzi et al., 1998; Sargentini et al., 2000) but attention has been focussed on early slaughter ages (up to 16 months) whereas no recent data are available for older slaughter ages (over 18 months). In the present study, in agreement with the “Comunità Montana delle Colline Metallifere” (the “Metal Hills” Mountain Community), two different slaughter ages, 18 and 24 months, were considered. Despite the fact that slaughtering ages could be considered quite high, they allow animals to be produced in various periods of the year. In fact, deliveries in this breed are concentrated in Spring, and the sole production of animals of 15-16 months of age, considered the optimum for this breed, would mean reducing market availability over a restricted period of time. The production of young bulls up to two years of age could be considered an attempt to create greater continuity of supply through the year. This paper aims to verify whether these relatively high slaughter ages could lead to a quantitative and qualitative decline in production, which is usually good at lower ages (Poli et al., 1996a; Sargentini et al., 1996; Bozzi et al., 1998; Sargentini et al., 2000).

Materials and methods

Fourteen young Maremmana bulls, born and weaned on pastures, were used in the trial (“Il Filetto” farm, regional property managed by the “Comunità Montana delle Colline Metallifere”), following the Organic rules (European Council, 1991, 1999). Animals, starting from ten months of age (L.W. = kg 249.9±43.4) and up to 15 months of age, were fed on pastures supplemented with mixed hay ad libitum and concentrate (1 meat E.U./kg d.m. and 170 gr/kg)

Key words: Maremmana cattle breed, Organic husbandry, Meat quality, Fatty acids.

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d.m. of crude protein), in the proportion of 0.5 kg/100 kg of body weight. Concentrate was increased to 0.7 kg/100 kg of body weight starting from 15 months of age up to slaughtering at the age of 18 months for 7 animals and at the age of 24 months for the other 7 animals. Young bulls were weighed and measured every two months recording height at withers, height at rump, and thorax circumference (ASPA, 1991). The animals were slaughtered according to the EU Regulation (European Parliament and Council, 2001). Dressing percentage was calculated. Carcasses were then refrigerated at 4°C for 15 days and after that they were evaluated for conformation and fat score following EU grid rules (15 points scale, ASPA, 1991). Immediately after the conformation evaluation, samples of Longissimus thoracis (LT) and Caput longum triceps brachii (TB) muscles were taken and the following parameters were determined: water holding capacity, determined either as drip loss or as cooking loss in water bath (ASPA, 1996) and in oven (Poli et al., 1994); meat colour was determined (ASPA, 1996) with a Minolta Chromometer CR 200 (CIE L, a*, b*). Chroma (color saturation – (a*+ b*)2) and Hue angle (arc tan b/a) were also calculated. Shear force was performed on raw and cooked meat with a Warner Bratzler Instron apparatus (ASPA, 1996). Chemical analyses were carried out on each sample of muscle determining dry matter, ether extract, crude protein and ash (AOAC, 1990). The samples were also analyzed for total lipid concentration by gravimetric determination of total lipid extract according to Folch et al. (1957) and for quantitative fatty acid composition of total lipids by gas chromatographic separation of methyl esters – comprising C19 as internal standard – on capillary column oven temperature ranging from 164°C and 200°C with 3°C/min heat increment. Atherogenicity (AI) and Thrombogenicity (TI) indexes were calculated according to Ulbricht and Southgate (1991). Growth performances (weight and measures/age) were described by cubic equations (Sargentini et al., 1996; Rondina et al., 2000). This is probably related to the breeding system that is, according to the traditional breeding system and with the EU regulation on organic husbandry, mainly based on pasture. This system, with integration of hays and concentrates as described in the Materials and methods section, allowed a growth rate higher than 1 kg/d. In this situation, there is continuous constant growth also at ages higher than those usually recorded in intensive breeding (Sargentini et al., 1996). There was no difference in slaughtering parameters (Table 2) between the two groups: the dressing percentage was about 52%, similar or slightly higher than the values recorded in other trials with Maremmana cattle (Sargentini et al., 1996; Sargentini et al., 2000). The qualitative characteristics of the carcasses were comparable with those of Chianina young bulls slaughtered at 600 and 650 kg (Giorgetti et al., 1990, 1991): the conformation score, R class, and the adiposity, class 2+ of the UE grid rules, indicated mature and well conformed carcasses.

### Results and discussion

As shown in Table 1 weight and zoometric measurements increased linearly with age. This trend of body growth seems to differ from those recorded in previous trials, where they were described by cubic equations (Sargentini et al., 1996; Rondina et al., 2000). This is probably related to the breeding system that is, according to the traditional breeding system and with the EU regulation on organic husbandry, mainly based on pasture. This system, with integration of hays and concentrates as described in the Materials and methods section, allowed a growth rate higher than 1 kg/d. In this situation, there is continuous constant growth also at ages higher than those usually recorded in intensive breeding (Sargentini et al., 1996). There was no difference in slaughtering parameters (Table 2) between the two groups: the dressing percentage was about 52%, similar or slightly higher than the values recorded in other trials with Maremmana cattle (Sargentini et al., 1996; Sargentini et al., 2000). The qualitative characteristics of the carcasses were comparable with those of Chianina young bulls slaughtered at 600 and 650 kg (Giorgetti et al., 1990, 1991): the conformation score, R class, and the adiposity, class 2+ of the UE grid rules, indicated mature and well conformed carcasses. The meat showed higher values of brightness, yellow index and Hue angle in older animals compared to younger ones (P = 0.036, P < 0.0001, P < 0.0001, respectively) (Table 3). The lightness (L) was comparable to that found in a previous trial on animals of 18 months of age, while the red index (a+) appeared higher (Bozzi et al., 1998). The b* index found in the older animals was remarkably higher than that showed by the younger ones, as already found in a previous trial (Bozzi et al., 1998). Hue angle and Chroma of the older group were higher when compared with the values found for Maremmana males and females of previous trials (Bozzi et al., 1998; Sargentini et al., 2000). Muscle effect resulted significant only for shear force of raw meat, remarkably higher in TB muscle (P = 0.0002) probably due to the higher presence of connective tissue in the latter. Meat tenderness, both raw and oven cooked, was similar to that found in males (Bozzi et al., 1998) and females (Sargentini et al., 2000) of 18 months of age reared in feedlot. Overall the results of the physical analyses were comparable to those found in Chianina (Funghi et al., 1994) specialized in the production of high quality meat, while other studies showed that Maremmana meat was lighter and more tender than Chianina meat (Pugliese et al., 1994; Preziuso and Russo, 2004).

### Chemical composition of the meat is shown

| Table 1. Regression equations of weight and measurements according to age (days). |
|----------------------------------|-----------------|-------|--------|
| Equation                        | Significance    | RSD   | R²     |
| Weight, kg                      | y= -89.226 + 1.064x | **   | 0.83  |
| Height at withers, cm           | y= 90.081 + 0.072x | **   | 0.66  |
| Height at rump, cm              | y= 96.916 + 0.066x | **   | 0.61  |
| Thorax circumference, cm        | y= 97.914 + 0.161x | **   | 0.73  |
| Thorax circumference/height at withers | y= 1.161 + 0.0005x | **   | 0.48  |

**P<0.01.**

| Table 2. Slaughtering performances. |
|--------------------------------------|-----------------|-------|
| Slaughter age                        | Significance    |
| 18 mo.                               | 24 mo.          |
| Live weight, kg                      | 529.0           | 568.1 |
| Warm carcass, kg                     | 272.6           | 301.8 |
| Cold carcass, kg                     | 267.1           | 295.7 |
| Cooling loss, %                      | 1.99            | 2.05  |
| Dressing percentage, %               | 51.40           | 52.80 |
| Conformation score*                  | 7.6             | 8.3   |
| Adiposity score*                     | 5.8             | 5.8   |

ns: not significant. ** (15 points scale - ASPA, 1991).
in Table 4. No differences in chemical composition were found between the two groups. The animals of this trial, irrespective of age, showed a low level of intramuscular lipids compared to those found in animals of the same breed reared in intensive conditions (Poli et al., 1996a; Bozzi et al., 1998; Sargentini et al., 2000). Muscle effect was always significant for the chemical parameters, with higher values in TB than in LT, except for protein content which was higher in LT.

The acidic composition of the intramuscular lipids has a high value for human health, both for the nutritional functions of the fatty acids and for the influence on functionality of several organs and apparatuses, like the cardio-circulatory apparatus. Table 5 reports the percentage composition of total fatty acids. Saturated fatty acids were similar between the two investigated slaughtering ages. TB muscle showed a lower percentage compared to LD, as well as a higher monounsaturated/saturated ratio (P = 0.019). This latter result was also found in other studies (Bozzi et al., 1998; Sargentini et al., 2000) of Maremmana animals of 18 months of age, both males and females, as well as by Poli et al. (1996b) who found comparable results in young 16 and 24 month old Chianina bulls. Special attention should be given to the saturated fatty acids. In fact, they are considered harmful for human health and the cause of obesity, inflammatory states and insulin resistance (Bray et al., 2002; German and Dillard, 2004), as well as stimulating the hypercholesterolemic processes and the insurgence of cardiovascular diseases (Keys et al., 1955; Dietzchy, 1998; Fernandez and West, 2005). Overall, the percentage of saturated fatty acids appeared similar to that found by Poli et al. (1996a) in young 18 month old Maremmana bulls whereas it was lower than the values reported for young Chianina (Poli et al., 1996b) and Piemontese bulls (Russo and Prezioso, 2002), widely recognized as breeds with optimal dietetic and nutritional characteristics. The level of myristic plus palmitic saturated fatty acids (C14:0 and C16:0), considered potentially harmful due to their ability to increase the plasmatic content of LDL cholesterol (Keys et al., 1995), was lower than 21% on average and no difference was seen in either between slaughter age or muscle. This value was in the same range of data reported by Poli et al. (1996a) in young 18 month old Maremmana bulls, and it was lower than values found in previous trials with 18 month old females of the same breed (Sargentini et al., 2000) reared in feedlot or in Chianina young bulls (Poli et al., 1996b) reared in intensive conditions. The sum of monounsaturated fatty acids did not appear to differ, either between ages or muscles, and the better MUFA:SFA ratio for TB seemed to be due to the lower incidence of saturated fatty acids (P = 0.019).

Table 3. Physical characteristics of the meat.

| Age (A) | Muscle (M) | Significance | RSD |
|--------|------------|--------------|-----|
| 18 mo. | 24 mo. | LT | TB | A | M |
| Colour | L | 38.40 | 41.10 | 40.70 | 38.80 | * | ns | 2.67 |
|       | a* | 21.55 | 22.28 | 22.00 | 21.83 | ns | ns | 2.27 |
|       | b* | 6.65 | 10.78 | 8.68 | 8.75 | ** | ns | 1.73 |
|       | ns | 0.30 | 0.45 | 0.37 | 0.57 | * | ns | 0.67 |
| Chroma | 22.63 | 24.76 | 23.76 | 23.62 | ns | ns | 2.45 |
| Shear force on raw meat, kg | 11.81 | 11.98 | 9.39 | 14.40 | ns | ** | 2.22 |
| Shear force on water bath cooked meat, kg | 7.81 | 8.16 | 7.89 | 8.08 | ns | ns | 1.60 |
| Shear force on oven cooked meat, kg | 7.41 | 8.38 | 8.04 | 7.75 | ns | ns | 1.93 |
| Drip loss, % | 0.91 | 1.81 | 1.40 | 1.31 | ** | ns | 0.57 |

Table 4. Chemical characteristics of the meat.

| Age (A) | Muscle (M) | Significance | RSD |
|--------|------------|--------------|-----|
| 18 mo. | 24 mo. | LT | TB | A | M |
| Moisture, % | 75.42 | 75.40 | 75.20 | 75.60 | ns | * | 0.46 |
| Protein, % | 22.37 | 22.64 | 22.96 | 22.08 | ns | ** | 0.68 |
| Fat, % | 1.01 | 0.75 | 0.71 | 1.04 | ns | * | 0.33 |
| Ash, % | 1.20 | 1.21 | 1.13 | 1.28 | ns | ** | 0.08 |

The muscle showed a higher incidence of C15:0:0 (P = 0.034) (Table 5). Significant interactions between age and muscle have also been found for branched chain fatty acids C15:0:0 (P = 0.026), C17:0:0 (P = 0.002) and C17:1 (P = 0.002). The C15:0:0 resulted higher in TB at 18 months of age than at 24 months of age (0.26 vs 0.15), whereas LT resulted higher at 24 months of age (0.22 vs 0.18); C17:0:0 presented the same trend: higher in TB at 18 months of age (0.64 vs 0.49) and in LT at 24 months of age (0.63 vs 0.44). The C17:1 resulted higher in LT of animals of 18 months of age (2.84 vs 1.83) and in TB of the young bulls of 24 months of age (3.31 vs 1.37).

The monounsaturated fatty acid content, considered important in the prevention of atherosclerotic processes and cardiovascular diseases (Grundy, 1986; Grundy et al., 1988; Mensink and Katan, 1987), was similar to the value found in young Maremmana and Chianina bulls, 18 and 16 months of age, respectively (Poli et al., 1996b). Among the MUFA, the percentage of C16:1 and C18:1 were exactly comparable to the result reported by Poli et al. (1996a) in 18 month old Maremmana animals, while the content of C17:1 was higher.

The percentage of polyunsaturated fatty acids, widely known for their favorable role in the prevention and treatment of arterial hypertension, LDL hypercholesterolemic syndrome (Frenoux et al., 2001) and cardiac arrhythmias (Sudheera et al., 1997), didn’t appear to differ from the values found in 18 month old Maremmana calves (Poli et al., 1996a), as well as the MUFA:SFA and PUFA:SFA ratios. The level of polyunsaturated fatty acids of the n6 and n3 series were higher than that found in Chianina of 20 and 24 months of age (Poli et al., 1996b) and the ratio n3:n6 (Table 5) was close to the current diets of 1:10 (French et al., 2003) or even better with a high level of n3, probably due to the use of pasture throughout the growth period. In fact, it is well known that plants with green leaves and forages contain a good level of the polyunsaturated fatty acids of the n3 series, especially the C18:3 that cannot be synthesized from the animal organism (French et al., 2003; Ciaccio, 2006).

Table 6 reports the fatty acid composition of the meat expressed as quantitative value
(mg/100 g). Also in this case, no significant differences were found between the two ages whereas LT and TB were different for some polyunsaturated fatty acids favorable to human health with positive effects on the cardiovascular apparatus. TB muscle showed a higher level of n6 and n3 series polyunsaturated fatty acids, namely the C18:2n6 (P=0.014), very important for the health of the cardiovascular apparatus because of its hypcholesterolemic action on the LDL fraction (Calder, 2004), the C20:3n6 (P= 0.022) and the C20:4n6 (0.009) derived from C18:2n6, that plays a controversial role in the diet (Bartolí et al., 2000; Moreno et al., 2001; Ciaccio, 2006).

The most represented fatty acids of the n3 series in TB muscle were C18:3 and C22:5. The former (linolenic acid) is an EPA and it is a precursor of EPA (C20:5n3) and DHA (C22:6n3) which are important for the optimal function of the brain, of the hairnet and of the gonads (Ciaccio, 2006) with their protective action against the atherosclerotic process and cardiovascular diseases (Calder, 2004; Ciaccio, 2006). The Atherogenicity Index (AI), significantly lower in TB than in LT, presented values comparable to those found by Poli et al. (1996a) in LT of 12 month old Marammana calves and by Poli et al. (1996b) in young Chianina bulls of 16, 20 and 24 months of age. However, the AI values found in this work, both for TB and LT, were lower than those reported by Ulbricht and Southgate (1991) for sheep (1.00), beef (0.78) and pig meats (0.60) and they were lower than the AI reported by Palmegiano et al. (2000) for trout meat fed with different nutritional plans. Thrombogenicity Index (TI) followed the same trend, with values lower than the unit for TB. The same values of TI were found by Poli et al. (1996a) in LT muscle of 12 month old Marammana calves. Our animals, of 18 and 24 months of age, showed an average value of TI of 1.06, similar to that found for 16 month old Chianina and lower than values found in 20 and 24 month old Chianina (Poli et al., 1996b). Only the C17:1 (P<0.0001) showed significant interaction between age and muscle; the fatty acid was higher in LT at 18 months of age than at 24 months of age (26.2 vs 16.5), whereas it showed the opposite in TB muscle (34.2 at 24 months of age vs 13.9 at 18 months of age).

The TI values found were comparable to those reported by Ulbricht and Southgate (1991) for bovine meat.

| Age (A) | Muscle (M) | Significance |
|---------|------------|--------------|
| LT      | TB         | A            | M       | A x M |
| 18 mo.  | 21.5       | 21.6         | 21.3     | 18.8   | ns     | ns     | ns     | 10.48  |
| 24 mo.  | 2.1        | 2.9          | 2.9      | 2.7    | ns     | ns     | ns     | 2.10   |
| C18:0   | 1.6        | 1.4          | 1.7      | 1.2    | ns     | ns     | ns     | 0.90   |
| C18:1   | 2.3        | 2.0          | 2.3      | 2.0    | ns     | ns     | ns     | 1.05   |
| C18:2   | 5.2        | 4.6          | 4.9      | 4.9    | ns     | ns     | ns     | 2.26   |
| C18:3   | 2.3        | 2.2          | 2.3      | 2.2    | ns     | ns     | ns     | 0.84   |
| C18:4   | 214.0      | 210.7        | 219.4    | 214.3  | ns     | ns     | ns     | 21.16  |
| C18:5   | 21.5       | 19.6          | 20.4    | 20.7   | ns     | ns     | ns     | 9.60   |
| C18:6   | 5.7        | 5.9          | 5.3      | 6.3    | ns     | ns     | ns     | 2.21   |
| C19:0   | 20.1       | 25.3          | 21.3    | 24.1   | ns     | ns     | ns     | 6.06   |
| C19:1   | 165.2      | 174.8        | 163.5    | 176.4  | ns     | ns     | ns     | 49.30  |
| C19:2   | 290.2      | 302.1        | 277.0    | 315.3  | ns     | ns     | ns     | 106.62 |
| C19:3   | 140.2      | 156.5        | 131.1    | 165.6  | ns     | ** ns | ns     | 27.15  |
| C19:4   | 14.0       | 15.9          | 13.0    | 16.8   | ns     | ** ns | ns     | 2.79   |
| C19:5   | 4.5        | 4.2          | 3.7      | 5.0    | ns     | ns     | ns     | 1.86   |
| C19:6   | 2.5        | 2.5          | 2.8      | 2.2    | ns     | ns     | ns     | 1.57   |
| C20:3   | 8.2        | 8.4          | 8.7      | 9.7    | ns     | * ns  | ns     | 1.60   |
| C20:4   | 42.7       | 50.6          | 39.5    | 53.5   | ns     | ** ns | ns     | 10.27  |
| C20:5   | 3.9        | 3.8          | 3.9      | 3.8    | ns     | ns     | ns     | 1.42   |
| C20:6   | 3.1        | 2.8          | 2.7      | 3.2    | ns     | ns     | ns     | 0.62   |
| C22:5   | 11.4       | 11.0          | 9.8     | 12.6   | ns     | ** ns | ns     | 2.58   |
| C22:6   | 0.6        | 0.7          | 0.6      | 0.7    | ns     | ns     | ns     | 0.37   |
| AI      | 0.5        | 0.5          | 0.5      | 0.4    | ns     | * ns  | ns     | 0.09   |
| TI      | 1.1        | 1.1          | 1.1      | 0.9    | ns     | * ns  | ns     | 0.16   |

ns: not significant; *: P< 0.05; **: P< 0.01.
Conclusions

The results obtained in this trial show that the Maremmana breed reared on pasture could provide meat of good quality. Both physical and chemical characteristics do not seem to be worse than those of animals of specialized beef breeds like Chianina slaughtered at the traditional ages of 16-18 months. TB muscle seems to show a better composition of the lipid fraction as well as a lower percentage of saturated fatty acids, a better PUFA/SFA ratio, a great amount of unsaturated fatty acids of the n3 series, and favorable values of AI and TI. However, the values concerning acidic composition of the meat are also completely favorable in LT. The relative stability of the favorable characteristic of the meat, irrespective of the age, could contribute to extend market availability through the year.

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