INFLUENCE OF GENOTYPE ON LAMB MEAT QUALITY. 1. CARCASS AND MEAT QUALITATIVE TRAITS

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Background

Consistent high quality is required in lamb meat production to maintain consumer confidence and consumption. Recently however, especially in the Southern of Europe (Italy, France, Spain, Portugal, Greece), the concept of 'quality' evolved in that of 'typicality', which combines the guaranteed quality of a product to its localization and origin (geographic and historic) (Rubino et al., 1999). The future of a lot of small ruminant productions depends from the capacity of research to explore and to find the scientific reasons of typicality. A great number of factors affects carcass and meat quality of lamb and, therefore, the consumer preference and the value of the product. Genotype is one of the most important to consider in planning lamb meat production and marketing system (Sarti, 1992; Sañudo et al., 1998; Beriain et al., 2000). Genotype, as a source of variation in meat quality, is a very complex factor since results vary depending on the criterion used for comparison. When making indeed the comparison at an equal live or carcass weight, lambs from precocious breeds, with a smaller adult format, and therefore with a lower growth rate, will be older and thus will have more fat (Pollott et al., 1994) than the lambs from larger and later-maturing breeds (Beermann et al., 1995). Differences in reaching mature size can produce important effects on carcass and meat quality in lamb (Hopkins et al., 1997; Sañudo et al., 1998).

Objective

The aim of the present research was to compare, at an equal live weight representing an Italian traditional commercial weight, lamb carcass and meat qualitative traits of Gentile di Puglia (GP) and Merinizzata Italiana (MI) breeds, mainly raised in the center and in the south of Italy for lamb meat production, and of Merinizzata Italiana × Pagliarola (MI×P) cross.

Methods

Thirty-three male lambs (11 GP, 11 MI, and 11 MI×P), born as single and naturally suckled, were weaned at a live weight of 10.3±0.1 kg (reached at a mean age of 35, 25, and 39 d for GP, MI, and MI×P lambs, respectively) and carried to the same farm, where they were *ad libitum* fed with a weaning diet (18% CP and 6.63 MJ NE/kg DM) for two weeks, and with a growing diet (16% CP and 5.94 MJ NE/kg DM) until slaughter. Lambs were slaughtered, according to the procedure described by the Italian Scientific Association of Animal Production (A.S.P.A., 1991), at a live weight of 21.6±0.3 kg, reached at a mean age of 93, 71, and 87 d for GP, MI, and MI×P lambs, respectively. Weight of carcass (with head and thoracic organs plus spleen and liver, particularly appreciated by Italian consumers) was recorded and dressing percentage calculated immediately after dressing and after chilling (24 h at 2-4°C). Carcass shrink losses, calculated as difference between hot and cold carcass weights, were expressed as a percentage of hot carcass weight. At slaughter, both eye lens weight and both testes weight were recorded, and loin eye area was measured between the 12th and 13th ribs. In addition, metacarpal and metatarsal bones were collected, cleaned of all connective tissue and measured for fresh weight and length. Dry weight of both bones was recorded after 7 d at 100°C in a drying oven. Metacarpal growth plate thickness was evaluated according to the procedure described in Maiorano et al. (1999). *Longissimus dorsi* pH was measured 45 min (pH_1) and 24 h (pH_u) after slaughter: rate of pH fall from 45 min to 24 h *post mortem* was expressed as pH change per 100 min assuming a linear decrease (Henckel et al., 2000). ANOVA was performed with General Linear Model procedure of SPSS (2000) including the animal effect. Differences among unadjusted means were tested by Scheffé's test.

Results and discussion

During the post-weaning phase, MI and MI×P lambs grew faster than GP lambs (250±7 and 227±6 vs 198±9 g/d, respectively; $P < 0.05$), according with the Italian performance testing scheme for meat-producing sheep breeds (Roberti, 2001), and reached target slaughter weight earlier (-22 and -6 d, respectively) than GP lambs. Carcass traits and *longissimus dorsi* pH are presented in Table 1. Carcass weights and dressing percentages were not different ($P > 0.05$) among genotypes. However, carcass shrink losses in MI and MI×P lambs were markedly higher (+1.8 and +2.4%, respectively; $P < 0.001$) than in GP lambs. This is probably related to differences in carcass fatness and conformation among genotypes, which condition evaporative and essudative losses of water during the carcass chilling (Lawrie, 1983; Sañudo et al., 1998). GP lambs had a larger ($P < 0.05$) loin eye area than the MI purebred and crossbred genotype. Although, to our knowledge, a direct comparison between GP and MI lambs has not been reported in literature, differences in eye muscle area were previously found in lambs of different genotypes when values were carcass weight adjusted (Hopkins et al., 1997). Hopkins and coworkers reported also a positive correlation between *longissimus thoracis* cross-sectional area and the muscle:bone ratio and muscularity of carcass. In addition, Safari et al. (2001) showed how valuable *longissimus lumborum* area is in lamb to predict saleable meat yield in a diverse genotype population. Eye lens weight differed ($P < 0.001$) among genotypes with GP > MI×P > MI. This trend, however, was presumably not breed-related since eye lens weight increased in a quasi linear manner with increasing lamb age. In agreement with this hypothesis, Ho et al. (1989) found that the weight of lamb eye lens does not differ between breeds but increases with age, as observed also by Field et al. (1990a). The above-mentioned Authors indeed concluded that eye lens weight is a valid indicator of animal age in sheep as well as in other species. Testes weight, the best indicator for lamb testicular size (Matos et al., 1992), was approximately 50% lower ($P < 0.001$) in MI lambs than in GP and MI×P. It is stated that puberty begins in ram lambs when some morphological traits (for example testis size over 6 g), corresponding to the phase of accelerated testicular growth, are present (Courot, 1971). In addition, significant correlations between testis size and reproductive hormone levels have been previously reported in ram lambs, both in the pre-pubertal and post-pubertal phases (Courot and Ortavant, 1981; Yarney and Sanford, 1985; Langford et al., 1998). The onset of pubertal development in lamb markedly influences growth, muscling and fat deposition and, therefore, carcass composition and meat quality (Ford and Klindt, 1989; McCormick, 1989). The lambs in our study were generally handled under near optimum pre-slaughter conditions in the absence of acute stresses, but differences in *longissimus dorsi* pH_u were observed among genotypes. Ultimate pH of muscle is an important indicator of meat eating quality: higher pH results in meat that is darker, tougher, and has a reduced storage life (Chrystall and Daley, 1996). GP lamb muscle had a higher ($P < 0.05$) pH_u value than the purebred MI lambs, with the MI crossbred lambs being intermediate. On the contrary, differences among genotypes in pH_1 values and rate of pH fall were not significant ($P > 0.05$). The increase in ultimate pH with advancing age, possibly due to an increasing age-related susceptibility to stresses (Devine et al., 1993), has previously been shown in lamb by Failla et al. (1996). A breed effect was also reported by several researchers (Young et al., 1993; Hopkins and Fogarty, 1998; Fogarty et al., 2000), who suggested that some genotypes may differently respond to the stresses associated with slaughter, but it is unknown whether this is due to genotype effect on animal behaviour *per*

se or to differences in glycolytic potential. However, in our study the decreasing proportion of Merino gene was associated with a slight increase in ultimate pH. Bone characteristics are listed in Table 2. The weight and length of the metacarpal bone, related to the total quantity of bone in the carcass (Velasco et al., 2000), were genotype-conditioned as reported also by Ho et al. (1989). Metacarpal bone of MI×P lambs was 13 and 18% lighter ($P < 0.05$) than that of GP and MI lambs, respectively. However, it was longer (about 5%, $P < 0.05$) than that of the other two genotypes. The same trend was observed also for metatarsal weight and length, even if differences between genotypes only approached statistical significance ($P = 0.08$). Furthermore, both bones of crossbred lambs had a higher ($P < 0.001$) moisture content than those of GP and MI lambs. Since bone moisture is an indication of their chemical maturity (Field et al., 1974), bones of MI×P crossbred lambs would be expected to be less mature than those of GP and MI. Metacarpal growth plate, the site of the longitudinal bone growth, was wider ($P < 0.05$) in MI (younger) lambs than in GP and MI×P (older) lambs. Besides being due to different lamb age however, as reported also by Ho et al. (1989) and Field et al. (1990a), the difference in growth plate width may be even related to breed. In fact, Oberbauer et al. (1989) observed that a difference in cartilage thickness between Dorset and Suffolk rams was present just at birth. The ossification process of metacarpal growth plate condition carcass and meat quality because the extent of skeletal development plays a significant role in muscle growth and composition of gain at a given weight (Thonney, 1987; Field et al., 1990b).

Conclusions

Based on the results of this study it is concluded that, although there are no apparent variations in dressing yield, substantial differences exist in carcass and meat qualitative traits among lambs of different genotypes when raised under similar conditions and slaughtered at the same weight. Purebred and crossbred MI lambs grow faster and reach target slaughter weight (representing an Italian traditional commercial weight) earlier than GP lambs. However, these later-maturing genotypes show the evidence for an excessive carcass immaturity, suggesting to slaughter them at a live weight higher than that in this study. Moreover, the genotype-related differences in rate of lamb growth and/or physiological maturation, and the different age at slaughter affect muscle growth and fat deposition and, therefore, commercially important carcass and meat properties but, above all, determine a production with no consistent qualitative characteristics, which is one of the major problem for Italian lamb meat market.

Pertinent literature

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Table 1. Carcass traits and *longissimus dorsi* (LD) pH of GP, MI and MI×P lambs (mean values ± standard errors)

	Genotype		
	GP	MI	MI×P
Hot carcass wt, kg	13.01 ± 0.2	13.5 ± 0.2	13.2 ± 0.2
Hot dressing, %	60.3 ± 0.6	62.7 ± 1.1	61.1 ± 0.8
Cold carcass wt, kg	12.5 ± 0.2	12.8 ± 0.2	12.4 ± 0.2
Cold dressing, %	58.0 ± 0.7	59.2 ± 1.0	57.2 ± 0.7
Shrink losses, %	3.9^{A} ± 0.3	5.7^{B} ± 0.4	6.3^{B} ± 0.3
Loin eye area, cm^2	13.6^{a} ± 1.4	10.7^{b} ± 0.6	10.0^{b} ± 0.4
Eye lens wt, g	1.30^{A} ± 0.02	0.90^{C} ± 0.04	1.09^{B} ± 0.02
Testes wt, g	17.1^{A} ± 1.2	9.0^{B} ± 1.6	17.3^{A} ± 1.4
LD pH_1	6.55 ± 0.12	6.33 ± 0.09	6.45 ± 0.10
LD pH_u	5.83^{a} ± 0.05	5.61^{b} ± 0.07	5.78^{ab} ± 0.06
Rate of pH fall	-0.052 ± 0.009	-0.053 ± 0.007	-0.047 ± 0.006

Different superscripts, within a raw, stand for significant differences (a, b: $P < 0.05$; A, B, C: $P < 0.001$)

Table 2. Bone characteristics of GP, MI and MI×P lambs (mean values ± standard errors)

	Genotype		
	GP	MI	MI×P
Metacarpal			
fresh wt, g	36.5^{a} ± 0.9	39.0^{a} ± 1.5	31.9^{b} ± 1.6
length, cm	11.6^{a} ± 0.1	11.7^{a} ± 0.1	12.2^{b} ± 0.2
moisture, %	19.9^{A} ± 0.4	22.0^{A} ± 0.9	27.6^{B} ± 1.0
growth plate width, mm	0.42^{a} ± 0.02	0.52^{b} ± 0.01	0.38^{a} ± 0.02
Metatarsal			
fresh wt, g	35.8 ± 0.9	37.0 ± 1.5	32.0 ± 2.1
length, cm	12.2 ± 0.1	12.4 ± 0.1	12.8 ± 0.2
moisture, %	17.2^{A} ± 0.4	21.2^{A} ± 0. 9	26.0^{B} ± 1.1

Different superscripts, within a raw, stand for significant differences (a, b: $P < 0.05$; A, B: $P < 0.001$)