The effect of grazing on the quality of lamb meat

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Summary

The effect of grazing on the quality of lamb meat was analysed by considering the results of a study carried out on Bergamasca heavy lambs produced in two contrasting systems: transhumance utilizing permanent pasture (‘pasture finished’) and stabled, ‘concentrate-finished’. Bergamasca sheep, the most important breed in Italian Alpine regions, is reared for meat production, mainly on traditional transhumance systems. In recent years, this type of farming system has taken on a semi-sedentary nature. The flocks still use pasture and summer alpine grazing, but they remain in contact with the ‘home farm’. This allows more intensive feeding regimes to be imposed, involving supplementation with forage and concentrates.

The analyses were carried out on meat samples obtained from 120 lambs (42 kg liveweight on average) from each of the two production systems. Clear relationships were found between production systems and the quality of both carcass and meat. The more intensive production system, making use of feed supplementation, allowed the production of higher quality carcasses. Lambs from pasture yielded meat that was leaner and with a n-6/n-3 ratio more favourable for human health than meat from lambs fed on concentrate. In particular, in the muscle phospholipids, C18:2 was higher in concentrate finished lambs, while the transhumance animals had higher percentages of C18:3, C20:5, C22:5 and C22:6. The taste panel identified some differences between the lamb types in the odour and flavour profile. However, the expected relationships between C18:3 and ’sheepmeat flavour intensity’ and between high n-3 PUFA and ‘rancid’ were not found. It is postulated that the higher intake of antioxidants (in the grazed flora) by the transhumance lambs may account for the latter observation. The meat of the concentrate-finished lambs showed a better texture profile in comparison with the meat of the transhumance lambs: the first was, in fact, evaluated as more tender, more juicy and less fibrous than the latter by trained assessors. However, these differences between lamb types were not confirmed in the assessments made by family groups, whose hedonic ratings did not differ significantly between production systems.

Introduction

The society attributes to farmers and breeders, more and more explicitly, complementary functions to agricultural production and in particular landscape management and rural space protection functions. This positive image is strong especially in mountain areas, where livestock production represents an index of vitality and territory utilisation, and constitutes an element of equilibrium in naturalistic and landscape values of the pastoral environment. The general evolution of agriculture and rural context towards land abandonment threatens this equilibrium and suggests the definition of durable management systems for territory and animal resources, in order to achieve a new balance, acceptable by all, farmers, breeders, local communities and naturalists, in the frame of a more extensive use of pastoral habitats.

The durability of the agricultural management systems is an issue that interests and involves mainly the economic dimension of the enterprise, therefore it is very important to make use of all the opportunities available in order to add value to livestock products, to expand their market and to improve their competitiveness. Considering the consumers’ interest in typically, originality and authenticity of foods, the product quality may serve as a basis of a strategy for rural development, with the view of adding value to local resources by means of integrated programs aimed to connect the product with the territory, his traditions, cultural heritage and natural beauty. Research can contribute to this process by defining the objective basis of quality and identifying the properties and attributes that allow consumers to appreciate and distinguish local products from the standardized homologues offered by the market.

The present communication takes into account an example of this research contribution, applied to Bergamasca lamb meat from transhumance system, based on the exclusive use of permanent pasture, which was compared with a farming system more intensive in terms of feeding.

Bergamasca heavy lamb

The main product of sheep breeding in Italian Alpine regions is lamb meat. The most important breed is the Bergamasca, mainly reared in Lombardy. The transhumance production system is still of major importance in the Bergamasca breed (BOLLA and RIZZI, 1997). In Lombardy, 40,000 Bergamasca sheep belong to vagrant flocks which number from a few hundred to more than 1.000 head. The herds stay on the Alpine pastures from June to September and move around the Po Valley during the rest of the year. During this period the flocks graze on the crop remains, along the borders of rivers, ditches, fields and roads and on the no longer cultivated outskirts of human dwellings. The transhumance system can be thus considered both ecologically and economically sustainable. In fact, using land and forage resources which would otherwise be abandoned provides low cost food and contributes to landscape preservation and the maintenance of the outskirts (CORTI and FOPPA, 1999). The traditional product of the transhumance flocks is represented by the 70 - 80 kg

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castrate aged 14 - 18 months. In recent years, it has been substituted by the production of lighter wethers and heavy lambs. These are the most important products from the permanent and semi-permanent herds. In this type of farming system, which represents more than half of the Lombardy regional flock, the farmers have fewer sheep (generally fewer than 100 head; GIACOMELLI et al., 1997). As transhumance shepherds do, they still make use of - and preserve - pasture and summer alpine grazing but remain in contact with the 'home farm'. This allows better feeding regimes to be imposed, involving supplementation with forage and concentrates.

Among the large range of lamb types produced in Italy, from many different breeds reared in a wide variety of farming systems, the meat of the Alpine Bergamasca lamb has distinctive properties especially when compared with the small, young, milk-fed lambs slaughtered at light carcass weights in the Mediterranean regions. The aim of this study, as part of an EC financed program of research aimed at evaluating the sensory qualities of lamb meat obtained from different European regional production systems, was to analyse the meat quality of the heavy lamb type from two finishing systems, considering that the traditional heavy castrate type was already described (PIASENTIER et al., 1999).

Materials and methods

Animals

120 lambs per type were obtained from three transhumance flocks. The 'pasture finished' lambs were kept on pasture of grass and crop residues from mid-November when they were born. At the end of May, the day before slaughter, male lambs between 40 and 48 kg LW were selected from the flocks. The 'concentrate finished' lambs were purchased in November, at an average age of 2,5 months and transported to a farm for the finishing period. There the animals received a fixed quantity (1.42 kg DM/day on average) of a complete diet formulated from dried, pelleted lucerne (35 % DM basis), whole maize (57 %), flaked soybean (6 %) and mineral and vitamins (2 %). The lambs were slaughtered 75 days after weaning, between 36 and 52 kg LW.

Carcass and meat quality

The procedures for evaluating and dissecting carcass, as well as the methodology used to sample *longissimus dorsi* muscle and measure physical, chemical and sensory, both descriptive and hedonistic, properties of meat were already described in detail in previous papers (BERGE et al., 2000; PIASENTIER et al., 2002), from which the results presented in this communication were obtained.

Results and discussion

Pre-slaughter live weight was not different between the two lamb types but, because of a higher killing-out in the concentrate finished lambs, they had a higher carcass weight than the pasture finished ones (*table 1*).

As shown in *table 2*, which reports the carcass distribution in the various classes of the European scale of ovine evaluation, the use of concentrates improved both carcass conformation and fatness, in agreement with the results of carcass dissection (*table 3*).

In fact, the less intensively reared lambs were characterised by both, a lesser muscle to bone ratio and a minor level of separable carcass fat in comparison with the grazing lambs.

The pH (*table 4*) varied within the normal range accepted for commercial meats and was slightly higher in grazing lambs. This difference may be due to a variation in glycogen content in muscle. IMMONEN et al., 2000 showed that high-energy diets protect from potentially glycogen-depleting stressors.

In accordance with their lesser carcass fatness, pasture-finished lambs produced leaner meat than concentrate-finished

Table 1: **Weights and killing out percentage; 120 lambs per type.** (a, b: P ≤ 0.05)

	Concentrate finished	Pasture finished	s.e.d.
Pre-slaughter live weight (kg)	42.2	41.5	2.77
Killing Out Percentage (%)	48.9 [b]	46.3 [a]	1.65
Cold Carcass Weight (kg)	20.1 [b]	18.7 [a]	1.56

Table 2: **Distribution of the carcasses in the various classes of conformation and fatness in relationship with feeding system** (EC Regulations no.2137/92 and no, 461/93; 120 lambs per type)**.**

	Concentrate finished			Pasture finished			
	mean	SD	frequency %	mean	SD	frequency %	significativity
Conformation	3.4	0.59		2.7	0.56		0.000[1]
E (5)			1.7			0.0	0.000[2]
U (4)			37.5			2.5	
R (3)			56.7			61.7	
O (2)			4.2			34.2	
P (1)			0.0			1.7	
Fatness	2.9	0.24		2.1	0.28		0.000[1]
2			5.8			91.7	0.000[2]
3			94.2			8.3	

[1] Significativity of the difference between lamb type means, by F test.
[2] Significativity of the difference between lamb type frequencies, by Chi square test.

Table 3: **Tissue composition of the carcasses; 10 lambs per type** (a, b: P≤0.05)**.**

	Concentrate finished	Pasture finished	s.e.d.
Left side weight (kg)	9.76 [b]	9.19[a]	0.595
Left side muscle weight (g)	5587	5622	310.9
Muscle (% of fresh weight)	20.1[a]	23.7[b]	1.49
Bone (% of fresh weight)	20.1[a]	23.7[b]	1.49
fat (% of fresh weight)	14.4[b]	6.2[a]	3.48
Muscle/bone	2.92[b]	2.65[a]	0.182

Table 4: **Chemical characteristics of m.l. dorsi, 20 lambs per type** (a, b: P≤0.05).

			Concentrate finished	Pasture finished	s.e.d.
pH			5,58[a]	5,69[b]	0,17
Fat		g/100 g muscle	8,5[b]	5,3[a]	2,9
Pigment		µm eminic iron/g	24[a]	30[b]	4
Collagen:	total	mg hydrossi prolin/g	2,4[a]	2,9[b]	0,3
	soluble	% total	36[b]	29[a]	6

Table 5: **Fatty acids total concentration** (mg/100g) **and % contribution of each fatty acid to the total content in longissimus thoracis muscle, 20 lambs per type** (a, b: P≤0.05)**.**

		Neutral lipid			Phospholipid		
		Concentrate finished	Pasture finished	s.e.d.	Concentrate finished	Pasture finished	s.e.d
total	(mg/100g)	1794.0[b]	997.0[a]	584.18	603.9[b]	531.4[a]	59.07
	%						
C12:0		0.16[a]	0.38[b]	0.156	0.01[a]	0.06[b]	0.051
C14:0		2.98[a]	4.26[b]	0.869	0.32	0.38	0.188
C16:0		25.82[b]	23.14[a]	1.659	12.89[b]	12.25[a]	0.798
C16:11		2.32	2.54	0.378	1.02[a]	1.40[b]	0.232
C18:0		15.98[a]	20.10[b]	1.474	12.36	12.35	0.792
C18:1	trans	4.14	3.94	0.872	1.60[b]	0.99[a]	0.345
C18:1	n-9	37.88[b]	32.91[a]	2.787	18.39	19.94	3.336
C18:1	n-7	1.22[b]	0.85[a]	0.166	2.40[b]	1.72[a]	0.482
C18:2	n-6	3.42[b]	2.70[a]	1.048	22.70[b]	15.54[a]	2.967
C18:3	n-3	0.65[a]	0.99[b]	0.161	1.64[a]	3.56[b]	0.459
CLA	cis 9, trans-11	0.71[a]	1.11[b]	0.197	0.36[a]	0.49[b]	0.124
C20:3	n-6	0.01	0.04	0.059	0.80	0.73	0.140
C20:3	n-3	0.00	0.00	---	0.01[a]	0.05[b]	0.035
C20:4	n-6	0.16	0.46	0.592	8.40	8.44	0.861
C20:5	n-3	0.00	0.07	0.113	1.40[a]	2.62[b]	0.405
C22:4	n-6	0.00	0.01	0.035	0.56[b]	0.43[a]	0.153
C22:5	n-3	0.06[a]	0.26[b]	0.187	2.20[a]	3.19[b]	0.295
C22:6	n-3	0.00	0.02	0.53	0.67[a]	0.84[b]	0.183
total	n-6	3.58	3.21	1.648	32.48[b]	25.15[a]	3.391
total	n-3	0.71[a]	1.34[b]	0.448	5.92[a]	10.25[b]	1.092
n-6/n-3		5.14[b]	2.30[a]	0.820	5.57[b]	2.48[a]	0.771
C18:2/C18:3		5.37[b]	2.67[a]	1.023	14.16[b]	4.44[a]	2.205

lambs. However, the collagen content of their meat was less favourable in terms of tenderness, as the total concentration of the connective protein was higher, and the proportion of its soluble fraction, lesser than in the more intensively fed lamb type.

Lamb meat from transhumance system also showed a higher pigment content, as a result of the greater physical activity of lambs reared at pasture. Moreover, as for collagen, meat pigmentation was probably influenced by animals age, considering that the pasture-finished were lambs older than the concentrate-finished ones. In fact, because of a slower rate of growth, the former achieved the planned slaughter weight one month later than stabled lambs.

As expected, the muscle lipid content, i.e. the total weight of phospholipids and, mainly, neutral lipids, was higher in the concentrate-fed lambs, as shown in *table 5*, moreover, the phospholipids of the muscle membranes were very rich in polyunsaturated fatty acids (PUFA), while intramuscular neutral lipids contained less than 5 % PUFA, as shown in *table 5*, which presents the percentage contribution of each FA to the total.

FA composition of the *longissimus* neutral lipids and phospholipids varied according to production system. The percentage of saturated and monounsaturated *cis*-FA in muscle phospholipids varied little between lamb types, while in the neutral lipids lambs fed concentrates had lower percentages of C12:0, C14:0, C18:0 and higher C16:0 and C18:1 than lambs fed pasture.

The most striking differences when comparing percentages of fatty acids in the phospholipid fraction in the two lamb types were in the relative amounts of the n-3 and n-6 series. In particular, the meat from pasture-finished lambs had a higher content of linolenic acid and its long chain n-3 derivatives (C20:5 n-3; C22:5 n-3 and C22:6 n-3) and a lower content of linoleic acid and its major product, arachidonic acid, than that from concentrate-finished lambs. As a consequence, the lambs fed on pasture yielded meat with a n-6/n-3 ratio more favourable for human health than that from lambs fed on concentrate. The observed differences between levels of these PUFA series are in agreement with results from the literature concerning the effect of feeding grass or grain diets to ruminants on meat FA composition (ENSER et al., 1998; NUERNBERG et al., 1998; ROWE et al., 1999; WOOD et al., 1999; FISHER et al., 2000; SAÑUDO et al., 2000).

Trans C18:1 concentration was higher in phospholipids of lambs fed concentrates whereas pasture resulted in higher CLA proportions in both neutral lipids and phospholipids.

The production system influenced some aspects of the odour and flavour profile of lamb meat (*Figure 1*); most of the descriptors, in particular abnormal flavours and odours, and rancidity, received low scores for both the lamb types. The transhumance lambs will have ingested more antioxidants, e.g. vitamin E, than the concentrate-fed lambs and this may be the reason that there was no evidence of greater rancidity in the meat with high levels of long chain PUFA. 'Sheep meat' odour and flavour received the highest scores, but were not significantly different between production systems in spite of the higher C18:3 content in the meat from pasture (SANUDO et al., 2000). However, fatty, dairy and lamb odour in both lean and fat were significantly higher for concentrate fed lamb than for those fed on pasture whereas livery flavour was higher for pasture-finished lamb, matching the relative levels of C18:3 and C18:2.

Fishy showed no clear relationship to diet.

The production system had a strong effect on the texture profile. In fact, the meat of the concentrate fed, stabled ani-

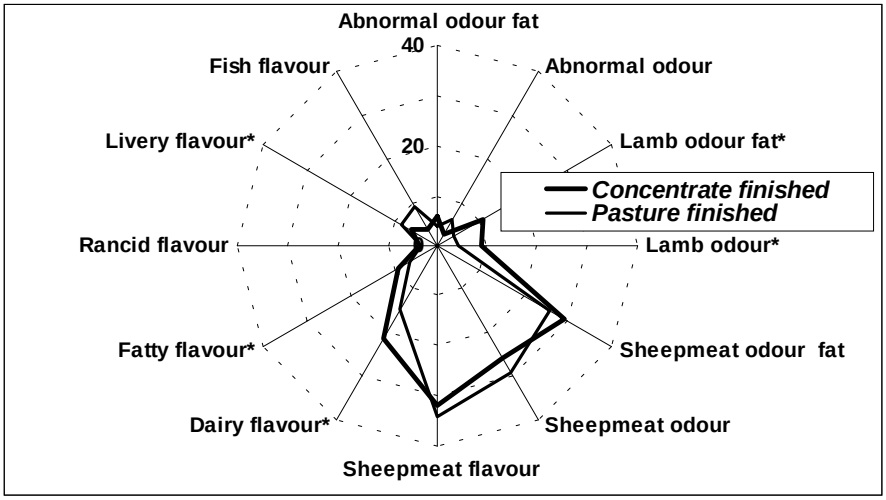

Figure 1: **Flavour and odour profile assessed by taste panel; 18 lambs per type and 10 assessors** (*: P≤ 0.05)**.**

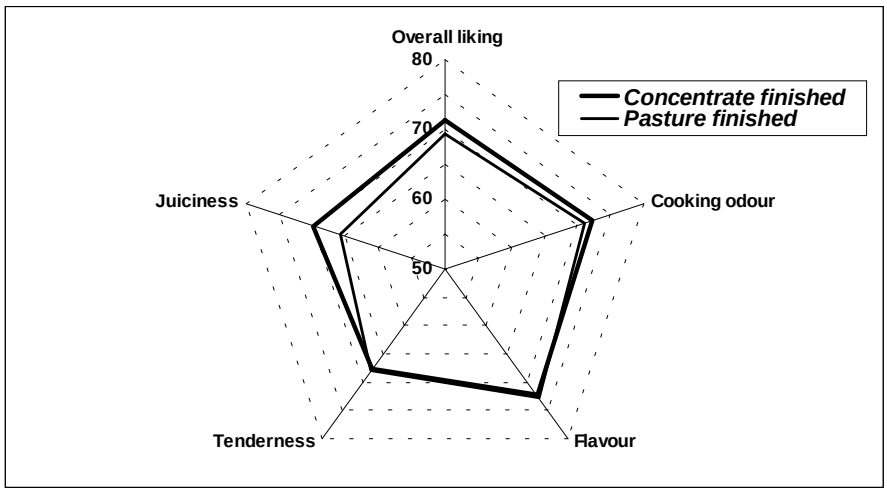

Figure 2: **Consumer preferences; 36 family groups of at least 3 components over 16.**

Table 6: **Texture profile assessed by taste panel; 18 lambs per type and 10 assessors** (a, b: P≤0.05)**.**

Item	Concentrate finished	Pasture finished	s.e.d.
Tenderness	48.9b	40.9ab	9.70
Juiciness	53.6b	49.1a	16.38
Fibrosity	50.5a	55.7b	9.34

mals was more tender, more juicy and less fibrous than that of the pasture fed lambs (*Table 6*).

Other authors have studied the variability of meat tenderness related to the intensity of the ruminant production system. Differences due to feeding system, when found, were not considered direct effects of dietary constituents and their intrinsic properties, but were associated with differences in animal growth rate and carcass composition. A reduced rate of growth could lower the extent of *post-mortem* tenderisation (VESTERGAARD et al., 2000) and a carcass with a thin fat cover could be more susceptible to cold shortening (BOWLING et al., 1978). Furthermore, in real production situations, where animals are free to move, are restricted in feedlots, or tie-stalled, the effect of feeding may be confounded by a different level of physical activity or housing condition (SCHROEDER et al., 1980). VESTERGAARD et al., 2000 suggested a major influence of physical activity to explain the lower tenderness observed in bulls raised on pasture compared with bulls tie-stalled and fed a concentrate-based diet.

Juiciness, as is known, depends on the amount of liquid released during mastication, both from the food and saliva. The higher lipid content of meat from the more intense feeding system might have affected perception of juiciness through stimulating saliva flow (WOOD, 1990).

The hedonic ratings in the consumer tests did not differ significantly between production systems (*Figure 2*). The overall liking was quite good, as demonstrated by the score, around 70, obtained by both the lamb types. Differences between lamb types may be greater than those observed here (MILLS et al., 1998, PIASENTIER et al., 1999). It is likely that the comparable intensity of 'sheep meat' and 'rancid' flavours (*Figure 1*), which are considered important descriptors in determining the intense flavours of lamb disliked in some markets (ROUSSET-AKRIM et al., 1997 and YOUNG et al., 1997), could be the basis for a comparable score in cooking odour and flavour preference (*Figure 2*).

Conclusions

The knowledge of carcass and meat characteristics is useful in order to qualify and value the output of ovine production chains that meet different technical, economic and environmental needs. Production and meat quality data are also important to develop marketing strategies, which in turn enable individual farmers, farmer groups, small scale processors and local authorities to promote their products on the basis of objective measurements. The extensive production system, based on pasture from semi-natural grasslands, while satisfying ecological and countryside conservation goals, produced lamb meat that contains an emotional value of "nature", as well as distinctive intrinsic qualities, which are mainly due to the favourable n3-/n-6 ratio of meat with its positive effect on human health.

Clear relationships between production system and fatty acid composition of muscle were found, and the taste panel identified some differences in the odour

and flavour profile between the lamb types. However, the expected relationships between C18:3 and 'sheepmeat flavour intensity' and between high n-3 PUFA and 'rancidity' were not found. It is postulated that the higher intake of antioxidants (in the grazed flora) by the transhumance lambs may account for the latter observation.

The more intensive production system, making use of feed supplementation, achieved a quicker finishing of lambs, having higher quality carcasses and producing meat less pigmented and characterised by a better texture profile, when evaluated by trained assessors. However, these differences between lamb types were not confirmed in the assessments made by family groups, whose hedonic ratings did not differ significantly between production systems.

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