# QUALITATIVE CHARACTERISTICS OF MEAT IN LAMBS BORN FROM EWES SUBJECTED TO HORMONAL SYNCHRONIZATION OF OESTRUS*

E. Cosentino[1], A. Girolami[1], A. Pelosi[2] and D. Matassino[1]

[1] Istituto di Produzione animale, Facoltà di Agraria, Università degli Studi di Napoli, 80055 Portici, Italy

[2] Istituto Sperimentale per la zootecnia, Sezione periferica operativa di Foggia, 71020 Segezia, Italy

* This work was supported by National Research Council of Italy (Progetto finalizzato: 'Incremento delle disponibilità alimentari di origine animale').

## INTRODUCTION

It is by now well established that oestrus synchronization can optimize sheep breeding. Several studies have considered the effects of this technique on productive and reproductive aspects (Colas et al.,1970; Newton et al., 1972; Robinson, 1977). On the contrary, very few studies are concerned with the cellular biochemistry (Matassino et al.,1978, Rubino et al.,1978, Barone et al.,1980) and none with the qualitative characteristics of lamb meat. The latter aspect seems particularly interesting since it has been shown (Pilla et al.,1976) that lambs conceived after 'induced' oestrus have lighter birth live weight than those conceived after 'physiological oestrus' /by 'induced' and 'physiological' oestrus it is meant here the heat manifestation between 2 and 4 and 16 and 18 days respectively after removal of sponges impregnated with FGA (Matassino et al.,1978)/.

## MATERIAL AND METHODS

The study was carried out on 133 'Gentile di Puglia' lambs (56 males and 77 females), born from ewes subjected to hormonal synchronization of oestrus which lambed following either 'induced' or 'physiological oestrus'. Rams (13 in total) where the same for both groups of ewes.The synchronization was obtained by using the technique of intravaginal insertion of polyurethane sponges impregnated with 30 mg of F G A (9 fluoro-11-hydroxy-17 acetoxy progesterone); after 14 days the sponges have been removed and each ewe received a subcutaneous injection of 400 I U of PMSG (pregnant mare serum gonadotropin).

Lambs suckled till 60-70 days of age and then received a diet of alfa alfa hay and cereal grain (barley, oat and maize) till the 120th day, when they were slaughtered. Lambs (51 from 'induced' and 82 from 'physiological' oestrus) were slaughtered after 12 hours of fasting by using three different slaughtering methods: (i) 42 lambs were stuck after electrical stunning (110 V for 10 s); (ii) 42 lambs were stuck after stunning with captive bolt pistol; (iii) 42 were stuck without stunning. The study of qualitative characteristics was carried out on the muscles (table 1) obtained from the right side aged 24 hours at 0-2°C and dissected according to the following commercial cuts: shoulder, neck, chop, loin, leg, flank and breast. Rheological (hardness, cohesiveness, springiness, adhesiveness, viscosity, gumminess,chewiness, water holding capacity), colour (spectrophotometer curves, brightness, dominant wavelenght, purity) and chemical variables (dry matter, protein, fat, ash) were evaluated on raw meat samples as suggested by Matassino et al. (1976a, 1976b and 1975 respectively). The model used for statistical analysis of data was:

$$y_{ijkln} = \mu + \alpha_i + \beta_j + \delta_k + \gamma_l + (\text{inter.}) + \varepsilon_{ijkln}$$

where $y_{ijkln}$ is the value of $i^{th}$ muscle of the $n^{th}$ lamb, born from the $j^{th}$ oestrus, slaughtered with the $l^{th}$ method. It has been assumed that:

$$\sum_{i=1}^{5} \alpha_i = \sum_{j=1}^{2} \beta_j = \sum_{k=1}^{2} \delta_k = \sum_{l=1}^{3} \gamma_l = \sum (\text{inter.}) = 0$$

Mean differences were evaluated according to the Duncan test.

Table 1 - Cuts and muscles considered.

| Cut | Muscle | Symbol (*) |
|---|---|---|
| Shoulder | Caput longum Tricipitis Brachii | CLoTB |
| Shoulder | Caput laterale Tricipitis Brachii | CLaTB |
| Chops | Longissimus dorsi | LDt |
| Loin | Longissimus dorsi | LDl |
| Leg | Gluteobiceps | Gb |
| Leg | Vastus intermedius | VI |
| Leg | Vastus lateralis | VL |
| Leg | Vastus medialis | VM |
| Leg | Rectus femoris | RF |
| Leg | Semimembranosus | Sm |
| Leg | Adductor | Ad |
| Leg | Semitendinosus | St |

(*) LDt: 6th-12th thoracic vertebra
LDl: 13th thoracic-5th lumbar vertebra

## RESULTS AND DISCUSSION

Studies of factors effecting organoleptic characteristics of lamb meat reported in the literature refer to parameters others than the synchronization, sex, slaughtering method and muscle, considered in the present study. Therefore, the comparison of our results with those in the literature is not possible. The mean value and the variability (CV %) of some traits at slaughter and of qualitative characteristics are reported in tables 2-5.

1. Muscle

The difference among muscles result always highly significant for all studied characteristics, except springiness, dominant wavelenght and ash (table 6). The meat from Sm muscle is the hardest, most gummy, requiring more chewing energy, darkest and with the least water holding capacity; the reverse applies to meat from RF for the

first four variables and from LDl for the last (table 5). The Gb muscle shows the highest content of dry matter, protein, fat and ash; the opposite is true for the first three fractions of VM muscle (table 3). The other muscles tend to have intermediate values. In conclusion, also sheep muscles display their own individuality, a finding which presumably reflects the structural and physiological homologies existing among muscles from different species.

Table 2 - Results of some traits at slaughter.

| | N | Weight, kg | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | live | | | | cold carcass with head | | cold side whithout head | |
| | | fasted | | net (*) | | | | | |
| | | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % |
| Males | 56 | 17.7 | 17 | 14.6 | 17 | 9.15 | 18 | 3.67 | 19 |
| Females | 77 | 16.2 | 16 | 13.5 | 16 | 8.50 | 17 | 3.43 | 19 |
| Induced oestrus | 51 | 16.7 | 17 | 13.9 | 17 | 8.66 | 17 | 3.51 | 19 |
| Physiological oestrus | 82 | 16.9 | 17 | 14.0 | 17 | 8.85 | 18 | 3.54 | 19 |
| Slaughtered by sticking | 49 | 16.4 | 17 | 13.6 | 17 | 8.59 | 19 | 3.43 | 19 |
| Slaughtered by electricity | 42 | 17.4 | 17 | 14.4 | 17 | 9.05 | 18 | 3.65 | 20 |
| Slaughtered by pistol | 42 | 16.8 | 15 | 13.8 | 16 | 8.75 | 17 | 3.51 | 18 |
| Total | 133 | 16.9 | 17 | 13.9 | 17 | 8.78 | 18 | 3.53 | 19 |

(*) Fasted live weight without the gastro-intestinal content

Table 3 - Mean values of chemical characteristics, at muscular level (for meaning of symbols see table 1).

| Muscle (*) | Dry matter | | Protein | | Fat | | Ash | |
|---|---|---|---|---|---|---|---|---|
| | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % |
| TB | 23.8 | 3 | 20.0 | 5 | 2.6 | 25 | 1.2 | 12 |
| QF | 23.7 | 3 | 20.0 | 4 | 2.5 | 23 | 1.2 | 13 |
| Gb | 25.6 | 4 | 20.3 | 5 | 4.0 | 23 | 1.2 | 13 |
| St | 23.6 | 4 | 19.9 | 5 | 2.5 | 30 | 1.2 | 12 |
| SA | 23.7 | 4 | 20.0 | 5 | 2.5 | 24 | 1.2 | 13 |
| LD | 24.1 | 4 | 20.1 | 5 | 2.5 | 27 | 1.2 | 13 |

(*) TB = pool of CLaTB and CLoTB; QF = pool of VI, VL and VM; SA = pool of Sm and Ad; LD = pool of LDt and LDl.

2. Sex

Sex causes significant differences of adhesiveness, viscosity, water holding capacity, fat and reflectance percentage at wavelenghts from 470 to 600 nm (table 6). Females, in comparison to males, give meat harder (3%), more springy (4%) and gummy, requiring more chewing energy (7%) and slightly darker, but with better water holding capacity (4%) and less fat (4%) (table 4). In conclusion, males seems to give meat of higher quality, in contrast with what observed for bovine and turkey meat (Matassino et al., 1979; Cosentino et al., 1978).

3. Oestrus

The type of oestrus which brought about conception in the ewes determined significant differences (table 6) in the meat quality of the lambs (cohesiveness, springiness, gumminess,water holding capacity and all colour characteristics except purity). Lambs born from ewes which lambed following 'physiological' oestrus, in comparison to those born from 'induced' oestrus give meat whith more cohesiveness (6%),

Table 4 - Mean values of qualitative characteristics within sex, oestrus and slaughtering method.

| Variable (*) | Sex | | | | Oestrus | | | | Slaughtering method | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | male | | female | | induced | | physiolog. | | sticking | | pistol | | electricity | |
| | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % |
| Rheological: | | | | | | | | | | | | | | |
| Hardness, kg | 4.23 | 26 | 4.38 | 26 | 4.27 | 26 | 4.35 | 27 | 4.31 | 25 | 4.25 | 28 | 4.41 | 27 |
| Cohesiveness | 0.435 | 17 | 0.426 | 19 | 0.416 | 18 | 0.439 | 18 | 0.434 | 19 | 0.431 | 17 | 0.425 | 18 |
| Springiness, mm | 14.2 | 33 | 14.8 | 31 | 15.4 | 32 | 14.0 | 31 | 14.6 | 30 | 15.0 | 32 | 13.9 | 33 |
| Adhesiveness | 27.6 | 69 | 33.6 | 68 | 30.2 | 70 | 31.6 | 69 | 31.3 | 70 | 31.8 | 69 | 30.2 | 69 |
| Viscosity, kg | 0.071 | 80 | 0.091 | 69 | 0.088 | 79 | 0.080 | 70 | 0.084 | 74 | 0.086 | 71 | 0.078 | 77 |
| Gumminess | 185 | 33 | 188 | 35 | 178 | 34 | 191 | 34 | 187 | 33 | 185 | 37 | 188 | 34 |
| Chewiness | 2593 | 43 | 2770 | 49 | 2765 | 50 | 2652 | 44 | 2722 | 43 | 2775 | 51 | 2585 | 46 |
| Water holding capacity, $cm^2$ | 97.08 | 21 | 93.78 | 23 | 89.49 | 23 | 98.71 | 21 | 94.70 | 22 | 97.99 | 22 | 92.90 | 23 |
| Colour: | | | | | | | | | | | | | | |
| Brightness, % | 24.6 | 11 | 24.3 | 10 | 24.0 | 10 | 24.6 | 11 | 24.6 | 10 | 23.8 | 10 | 24.8 | 10 |
| Dominant wavelenght, nm | 505 | 1 | 504 | 1 | 504 | 1 | 505 | 1 | 505 | 1 | 504 | 1 | 505 | 1 |
| Purity, % | 24.2 | 21 | 23.9 | 22 | 23.7 | 19 | 24.3 | 23 | 23.9 | 23 | 24.2 | 20 | 24.1 | 20 |
| Chemical: | | | | | | | | | | | | | | |
| Dry matter, % | 24.1 | 5 | 24.0 | 4 | 24.0 | 5 | 24.1 | 5 | 24.0 | 5 | 24.2 | 5 | 24.0 | 4 |
| Protein, % | 20.0 | 5 | 20.1 | 5 | 20.1 | 5 | 20.0 | 5 | 20.0 | 5 | 20.2 | 4 | 20.0 | 5 |
| Fat, % | 2.9 | 31 | 2.7 | 33 | 2.8 | 32 | 2.8 | 32 | 2.8 | 33 | 2.8 | 30 | 2.8 | 33 |
| Ash, % | 1.2 | 13 | 1.2 | 13 | 1.2 | 12 | 1.2 | 13 | 1.2 | 13 | 1.2 | 12 | 1.2 | 13 |

(*) Cohesiveness, adhesiveness, gumminess and chewiness are expressed by Texturometric Units obtained from used apparatus.

Table 5 - Mean values of qualitative characteristics at muscular level (for meaning of symbols see table 1).

| Variable | Muscle | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RF | | Gb | | Sm | | LDt | | LDl | |
| | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % | $\bar{x}$ | CV % |
| Rheological: | | | | | | | | | | |
| Hardness, kg | 3.71 | 30 | 4.45 | 23 | 5.22 | 21 | 3.99 | 23 | 4.22 | 22 |
| Cohesiveness | 0.407 | 17 | 0.481 | 14 | 0.452 | 19 | 0.416 | 13 | 0.393 | 19 |
| Springiness, mm | 15.1 | 31 | 14.3 | 34 | 14.3 | 29 | 15.0 | 25 | 13.9 | 29 |
| Adhesiveness | 38.6 | 59 | 20.4 | 75 | 25.5 | 66 | 33.0 | 73 | 37.8 | 58 |
| Viscosity, kg | 0.100 | 66 | 0.056 | 98 | 0.075 | 68 | 0.081 | 76 | 0.101 | 60 |
| Gumminess | 151.0 | 36 | 214.0 | 29 | 235.0 | 28 | 165.0 | 26 | 155.0 | 30 |
| Chewiness | 2260.0 | 47 | 3099.0 | 47 | 3337.0 | 40 | 2467.0 | 42 | 2314.0 | 41 |
| Water holding capacity, $cm^2$ | 92.67 | 25 | 92.67 | 21 | 109.68 | 16 | 30.62 | 22 | 90.22 | 21 |
| Colour: | | | | | | | | | | |
| Brightness, % | 26.4 | 10 | 23.8 | 10 | 23.2 | 10 | 24.3 | 9 | 24.3 | 8 |
| Dominant wavelenght, nm | 504.0 | 1 | 505.0 | 1 | 505.0 | 1 | 505.0 | 1 | 505.0 | 1 |
| Purity, % | 22.9 | 22 | 23.7 | 20 | 25.3 | 19 | 24.3 | 24 | 24.0 | 20 |

less springy (10%), more gummy (7%) with less water holding capacity (9%) but lighter (i.e. with larger area of neutral colour and higher brightness; see table 4 and fig. 1). In the future we plan to extend the study of meat quality of lambs born following oestrus synchronization of ewes also to additional parameters (such as hormones, enzymes, serum proteins etc.) which may allow a better understanding of the biochemical processes responsable for the observed differences. It already possible to say at this stage that lambs born from ewes which lambed following 'induced' oestrus have a lighter birth live weight and give meat of higher quality. This finding may possibly be due to the hormonal treatment, known to cause temporary enzyme (Matassino et al., 1978) and serum protein (Rubino et al., 1978) disequilibrium in the mothers. Recent results suggest that hormonal synchronization of oestrus influences the morphological organization of the gonads and the level of some sexual hormones (Barone et al., 1980).

4. Slaughtering methods

The slaughtering method causes statistically significant differences in springiness, water holding capacity, co-

Table 6 - F values of considered factors.

| Variable | F ([1]) among | | | |
|---|---|---|---|---|
| | muscle | sex | oestrus | slaughtering method |
| Rheological: | | | | |
| Hardness | 42.5*** | 3.4 | 0.8 | 1.4 |
| Cohesiveness | 34.9*** | 2.5 | 16.7*** | 0.8 |
| Springiness | 1.6 | 2.7 | 16.4*** | 3.4* |
| Adhesiveness | 20.3*** | 14.1*** | 0.7 | 0.2 |
| Viscosity | 14.1*** | 18.3*** | 3.6 | 0.7 |
| Gumminess | 56.9*** | 0.5 | 8.2** | 0.1 |
| Chewiness | 23.2*** | 3.7 | 1.5 | 1.3 |
| Water holding capacity | 23.3*** | 4.6* | 35.4*** | 4.3* |
| Colour: | | | | |
| % Reflectance: 426 nm (violet) | 23.8*** | 3.2 | 26.6*** | 10.0*** |
| 470 nm (blue) | 42.6 | 5.9* | 52.4*** | 7.7*** |
| 490 nm (blue-green) | 39.2*** | 3.8* | 36.2*** | 6.3** |
| 520 nm (green) | 43.1*** | 4.7* | 29.8*** | 7.0*** |
| 550 nm (yellow-green) | 36.8*** | 8.3* | 21.9*** | 8.2*** |
| 580 nm (yellow) | 30.2*** | 4.5* | 17.9*** | 9.0*** |
| 600 nm (red-orange) | 33.5*** | 3.3 | 15.1*** | 4.6** |
| 660 nm (red) | 23.0*** | 2.1 | 15.4*** | 3.7* |
| 684 nm (deep-red) | 21.7*** | 0.1 | 19.3*** | 7.2*** |
| Brightness | 37.2*** | 2.9 | 10.2** | 10.9*** |
| Dominant wavelenght | 1.4 | 3.3 | 5.2* | 1.9 |
| Purity | 3.9** | 0.6 | 2.3 | 0.2 |
| Chemical: | | | | |
| Dry matter | 97.9*** | 0.7 | 1.1 | 5.7** |
| Protein | 2.5* | 0.8 | 0.1 | 3.7* |
| Fat | 96.3*** | 6.7** | 1.6 | 0.5 |
| Ash | 1.4 | 2.6 | 0.2 | 1.4 |

([1]) * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$. The interactions are not significant.

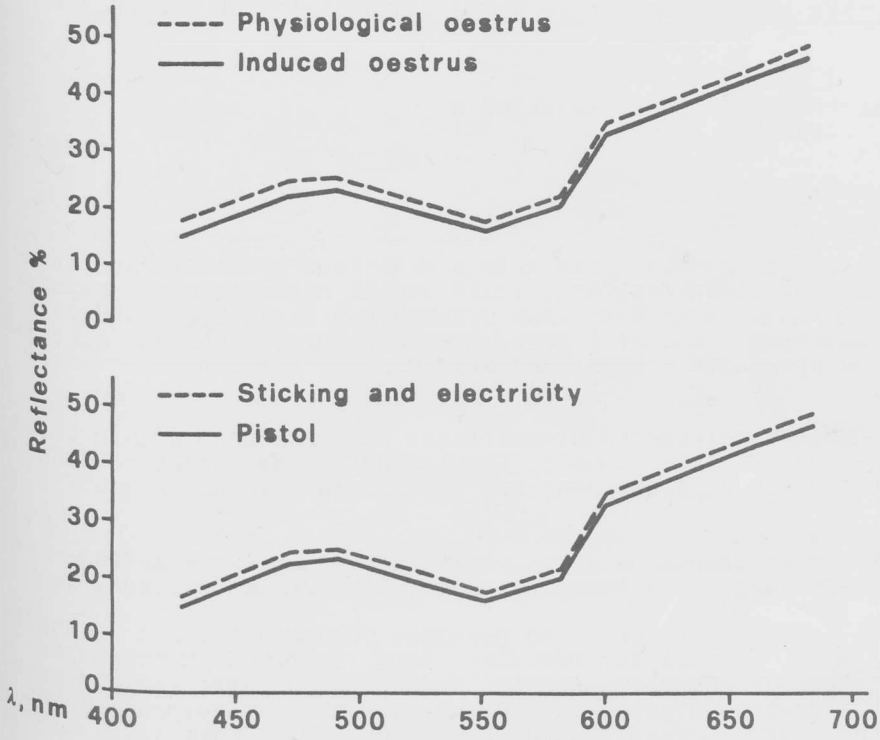


Figure 1 - Spectrophotometric curves.

lour characteristics, dry matter and protein content (table 6). The lambs stunned by electrical shock before of sticking fournish meat less springy (8%), requiring less chewing energy (7%), with more water holding capacity (5%), lighter (4%) than lambs slaughtered with pistol; the latter have a meat with more dry matter and protein content (table 4 and figure 1). When lambs are stuck without stunning we observe an intermediate behaviour. It is possible that the observed differences are due to the more or less complete bleeding. In fact, according to Lawrie (1975), the phenomenon which takes place in muscle 'post mortem' can be referred to the stoppage of circulation that produces: nervous and hormonal regulation cease; supply of vitamins, antioxidant etc. cease; oxygen supply fail; osmotic equilibrium destroying and reticulo-endothelial scavenging cease.

## CONCLUSION

The results show that the rank of muscle tends to be invariant in relation to the factors (oestrus, sex, slaughtering method) taken into consideration and that lambs born from 'induced' oestrus give first quality cuts with better myorheological characteristics (less hardness, less chewiness and gumminess), with the exception of water holding capacity and colour characteristics that are better in lambs born from 'physiological' oestrus. Moreover, it is surprising that males, in contrast with what observed for other species, tend to fournish meat of higher quality than females.

In conclusion, the results available at present suggest that it is necessary to re-examine the effects of hormonal sinchronization of oestrus in sheep which, contrary to what was believed till some years ago, influences profoundly not only the ewes but also the meat quality of the offspring. To stress this point we mention that in the farm where the experiment was carried out the annual and continuous use of hormonal synchronization has decreased sheep fertility.

## REFERENCES

Barone, C., Cosentino, E., Botte, V., Pelosi, A. and Matassino, D. (1980). Prod. Anim. (1975), 14, 85. (In print)
Colas, G. and Brice, G. (1970). Ann. Zoot., 19, 353.
Cosentino, E., Carena, A., Colatruglio, P. and Matassino, D. (1978). Genetica Agraria, 32, 139.
Lawrie, R.A. (1975). In Hawthorn, J. and Leitch, J. (ED). Recent Advances in Food Science, Butterworths, London, 68.
Matassino, D., Cosentino, E., Bordi, A. and Colatruglio, P. (1975). Genetica Agraria, 29, 23.
Matassino, D., Romita, A., Colatruglio, P. and Bordi, A. (1976a). Atti II Conv. Naz. ASPA, Bari, 373.
Matassino, D., Girolami, A., Colatruglio, P., Cosentino, E., Votino, D. and Bordi, A. (1976b). EEC Agric. Res. Seminar Crit. Meth. Assess. Carcass Meat Charact. Beef Prod. Exp., Zeist 1975. EUR 5489, 285.
Matassino, D., Rubino, R., Pilla, A.M., Pelosi, A., Grasso, F. and Cosentino, E. (1978). Prod. Anim. (1975), 14, 7.
Matassino, D., Girolami, A. and Cosentino, E. (1979). 3ª Conf. Mond. della Carne, Firenze 1978. 4 Razze, 6, 3.
Newton, J., Denehy, H.L. and Betts, J.E. (1972). Br. Vet. J., 128, 35.
Pilla, A.M., Pelosi, A., Di Taranto, F.P. and Dell'Aquila, S. (1976). Ann. Ist. Sper. Zootec., 9, 15.
Robinson, J.J. (1977). Feed Grain Council, Roma.
Rubino, R., Dell'Aquila, S., Bordi, A., Di Taranto, F.P. and Matassino, D. (1978). Prod. Anim. (1975), 14, 41.