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# Effects of early maternal separation of lambs and rearing with minimal and maximal human contact on meat quality

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**Abstract**

The present study aims to assess the effect of gentling on behaviour and meat quality of lambs. Thirty-two Comisana lambs were divided into four groups of eight animals: ER (ewe reared), AR (artificially reared) and the corresponding gentled groups ERG and ARG. The provision of human contacts stimulated gentled subjects to explore, whereas the proportion of idling subjects was reduced ($P < 0.10$). At increasing age the number of subjects contacting the person increased in the gentled groups ($P < 0.05$). Lambs left with their dams showed higher warm and cold carcass yields compared to artificially reared animals, although animals benefiting from both maternal care and gentling, had the highest dressing percentage ($P < 0.05$). Values of pH declined more rapidly in meat from gentled animals than from ungentled subjects ($P < 0.05$), $b^*$ and $h$ values were higher in ARG than in AR group ($P < 0.05$), whereas Warner-Bratzler shear force and hardness tended to be lower in gentled lambs ($P < 0.15$). We conclude that human–animal relationship can play an important role in affecting welfare, productive performances and meat quality of lambs, in particular when young subjects are prematurely separated from mothers.


*Keywords:* Lambs; Artificial rearing; Gentling; Behaviour; Meat quality

## 1. Introduction

Within a few hours of parturition lambs develop a strong and selective relationship with their mothers (Poindron & Le Neindre, 1980). In order to increase the amount of milk available for transformation, lambs often are prematurely separated from the ewes, thus inducing an early disruption of the mother–young relationship. A number of authors demonstrated that the lack of the maternal bond can inhibit the welfare state of the lambs (e.g., Sevi et al., 2003) and poor animal welfare can have detrimental effects on meat quality in many animals species as well as in sheep (Napolitano, Cifuni, Pacelli, Riviezzi, & Girolami, 2002). Many different factors may contribute to define meat quality. Apart from those which are not physically part of it and are related to the image of the product (extrinsic quality cues), such as the welfare of the animals used for meat production, other components are directly linked to the muscle (e.g., texture, which is linked to the pH fall, and colour, which supplies the most important first impression stimulus). Both sets of factors can affect consumer perception and preference for meat products.

Positive human–animal interactions can have beneficial effects on both animals and humans (Hemsworth, 2003). In lambs, separation from the mothers promotes the development of substitutive social bonds, at least with pen-mates (Napolitano et al., 2003). A possible recovery from conditions of poor animal welfare may be attained through the administration of gentle contacts by humans (Boivin, Tournadre, & Le Neindre, 2000) which may supply an additional social bond with subjects of a different species. In sheep the establishment of social relationship with members of other species has been observed (Cairns, 1966).

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Although the effect of gentle contacts on veal meat production has been studied (e.g., Lensink, Veissier, & Florands, 2001), little is known of the effect of human behaviour towards animals on meat quality of lambs.

The present study aims (i) to verify the effect of artificial rearing on lamb welfare and meat quality, and (ii) to assess the possibility to increase both by providing a substitutive social bond soon after birth (gentling).

## 2. Materials and methods

### 2.1. Experimental design

The experiment lasted 7 weeks and involved 32 Comisana twin-lambs, divided into four groups of eight animals, and housed separately in 3 m × 8 m straw bedded pens in the same building. The ewe reared lambs (ER and ERG) were kept with their dams throughout the experimental period. The artificially reared lambs (AR and ARG) were maintained with their dams 24–30 h after parturition to receive maternal colostrum and then separated from them, and offered a milk substitute. The ERG and ARG animals were subjected to gentling treatment by trained stockmen. Groups were balanced for age, weight and sex of lambs.

Gentling treatment consisted of gently handling the lambs for 5 min each, once a day. Two stockpersons were involved in the gentling treatment: daily, one of the two stockmen randomly carried out the treatment in each pen in order not to identify the treatment with a specific human character. In particular, the stockman entered the pen, sat down and caught each lamb between his legs gently stroking the animal with his hand resting on the subject while talking to it. The lambs in the groups not subjected to the gentling treatment (ER and AR groups) received minimal contact with stockmen except for the routine management and testing procedures, which were consistent for all the experimental groups.

In AR and ARG groups, animals were trained to suck from the artificial teat during the first three days of life using a standard procedure (Sevi et al., 2003). Milk was available from two 10 l buckets fitted with six 50 mm long latex teats. The lambs had free access to milk, which was administered twice daily (0800 and 1800). Starting from d 30 of the trial, all the groups were supplemented ad libitum with an oath/vetch hay and a pelletted concentrate for weaning lambs.

### 2.2. Behavioural activities

At 13, 23, 33 and 43 days of age, behavioural activities of lambs were monitored to assess the effect of gentling treatment at different ages. Behavioural observations were video-recorded for 4 h (from 1000 to 1400) and scan samples were taken every 5 min. At each observation period the number was recorded of lambs engaged in each of two postures (standing or lying) and of the following behaviour categories: idling, walking, investigation (object licking or smelling), eating (both milk and solid food). Behavioural variables were expressed as the proportion of subjects observed in each category of posture and activity calculated as: number of animals displaying each posture and activity/8 (number of animals per pen). Locomotor playing (galloping, bucking or kicking) and object playing (butting or rubbing water bowls, bars and straw) are short lasting events; therefore, their frequency of presentation was measured by continuous recording for the whole 4-h periods and expressed as the number of lambs involved in each activity.

### 2.3. Stationary human tests

The lambs of all the experimental groups were tested for their responses to two stationary human tests performed at 10 and 30 days of age according to Markowitz, Dally, Gursky, and Price (1998). The test was conducted into a runway of 5 m: the human stimulus was sat at one end of the runway and presented his hands to the lamb waiting for it to reach his fingers and to come into contact with him; the lamb entered the alley from the opposite end and its behaviour video-recorded for 5 min. The number of lambs from each group that contacted the human stimulus was recorded.

### 2.4. Loading test and cortisol level determination

At 49 days of age each group of lambs was loaded on a covered lorry of 4 × 2.5 m and transported for 10 min. Before the beginning of sampling and loading procedures the lorry was parked close to the blood sampling area. Blood samples (10 ml) were individually collected in vacuum tubes from the jugular vein immediately before loading, at discharging of lambs and 60 min after to evaluate cortisol concentrations. Hormone concentration was determined by a radioimmunoassay (ICN Biomedicals, Costa Mesa, CA). The sensitivity of the assay was 0.15 μg/dl. The inter- and intra-assay variation coefficients were 8.4% and 5.7%, respectively. All procedures were conducted according to the guidelines of the Council Directive 86/609/EEC (European Communities, 1986) on the protection of animals used for experimental and other scientific purposes.

### 2.5. Weight gains and post-slaughter measurements

The mean weight of the lambs at the beginning of the trial was 5.32 ± 0.13 kg (means ± SE). All the animals were weighed at the beginning and at 15 day intervals. The animals were also weighed on the morning of slaughter after 12 h of fasting (BW). The lambs were slaughtered using industrial routines used in Italy (electrical stunning, no electrical stimulation), according to the EU Dir. 93/119/CE. Dressed carcasses were weighed at 1 h post-slaughter (hot carcass weight), then chilled for 24 h at 1–3 °C, and weighed again (cold carcass weight). One and twenty-four hours after slaughter, pH was measured using a portable pH meter (Hanna, HI 9025) in *Longissimus Dorsi* (LD), *Semimembranosus* (SM) and *Semitendinosus* (ST) muscles.

### 2.6. Meat colour and instrumental texture measurements

Colour parameters were measured according to the CIE system (CIE, 1986) using a colour meter Minolta CR 200 ($D_{65}$: illuminant) on three locations of the cut surface of the *Semitendinosus* muscle. For each animal a mean value was calculated and used for statistical analysis.

Rheologic properties were tested on raw meat samples, removed from *Longissimus dorsi* muscle. An Instron 3343 was used to measure shear force (WBSF) and compression. In both tests five replicates were performed for each sample and the mean of replicates used for statistical analysis.

### 2.7. Statistical analyses

All the variables were tested for normal distribution using the Shapiro-Wilk test (Shapiro & Wilk, 1965). Blood cortisol levels and meat hardness were evaluated on $\log_{10}$ transformed data to homogenize variance. The former was elaborated using ANOVA for repeated measures (SAS, 1999) with gentling and feeding as non-repeated factors and time of blood collection (0, 10 and 60 min after isolation test) and the interactions as repeated factors. Behavioural activities and behavioural response to stationary human test were processed using ANOVA for repeated measures, having gentling (non-repeated factor), feeding (non-repeated factor), days of age and their interactions as sources of variation. Meat pH was subjected to analysis of variance for repeated measures with gentling and feeding as non-repeated factors, whereas time (1 and 24 h), muscle (LD, SM and ST) and the interactions were used as repeated factors. Individual animals were always nested within treatments. Weight gains, slaughter variables, meat colour and instrumental texture were analyzed using ANOVA with two factors (gentling and feeding) and the interaction. When significant effects were found (at $P < 0.05$, unless otherwise noted), the LSD test was used to locate significant differences between means.

Differences among groups in the number of lambs which came into contact with the stockpersons were assessed using the $\chi^2$ test in the FREQ procedure of SAS (1999).

## 3. Results and discussion

### 3.1. Animal behaviour and cortisol response to loading

The distribution of the animals in various behavioural activities and postures during the 4 h observation periods is depicted in Table 1. The proportion of animals observed standing tended to be affected by gentling and feeding ($P < 0.10$) with gentled and ewe-reared subjects displaying more often this posture compared to non-gentled and artificially reared animals ($P < 0.10$), respectively. Less ewe-reared lambs were observed idling ($P < 0.05$) compared to artificially reared animals. However, gentling tended to reduce the proportion of idling subjects ($P < 0.10$). The effects of gentling and days of age on the proportion of investigating animals tended to be significant ($P < 0.10$), whereas the effect of feeding was significant ($P < 0.01$). In particular, ewe-reared, gentled and older animals were more often involved in investigative activities than their corresponding counterparts (artificially reared, non-gentled and younger subjects; $P < 0.01$, $P < 0.10$ and $P < 0.10$, respectively). The number of animals showing locomotory and object playing was influenced by feeding ($P < 0.05$). A higher number of artificially reared lambs displayed locomotory playing, whereas a higher number of ewe-reared subjects showed object playing ($P < 0.05$). This latter variable was also affected by the interaction of feeding × gentling ($P < 0.05$) due to the fact that gentling determined an increment of the animals involved in object playing activities only in artificially reared lambs. The provision of human contacts stimulated lamb activity (i.e., exploration and playing). As a consequence, gentling resulted in a reduction of idling subjects.

Table 1
Least square means ± SEM of behavioural activities recorded in ewe-reared lambs when subjected to gentling (ERG) or not (ER), and in artificially reared lambs when subjected to gentling (ARG) or not (AR)

| | Groups | | | | SEM | Effects, *P* | | |
|---|---|---|---|---|---|---|---|---|
| | ERG | ER | ARG | AR | | Feeding | Gentling | Days of age |
| Standing, *p* | 0.54b | 0.53b | 0.53b | 0.38a | 0.03 | 0.0656 | 0.0753 | 0.3779 |
| Idling, *p* | 0.46a | 0.47a | 0.47a | 0.62b | 0.03 | 0.0464 | 0.0826 | 0.3297 |
| Walking, *p* | 0.03 | 0.03 | 0.04 | 0.04 | 0.01 | 0.4963 | 0.8150 | 0.4803 |
| Investigation, *p* | 0.46b | 0.46b | 0.42b | 0.29a | 0.02 | 0.0083 | 0.0812 | 0.0750 |
| Eating, *p* | 0.05 | 0.04 | 0.07 | 0.04 | 0.01 | 0.3232 | 0.1345 | 0.0002 |
| Locomotory playing, *n* | 0.39 | 0.33 | 2.91 | 2.37 | 1.13 | 0.0358 | 0.8097 | 0.6185 |
| Object playing, *n* | 4.49b | 5.25b | 4.57b | 3.13a | 0.30 | 0.0270 | 0.3412 | 0.9497 |

Values are expressed as either proportion (*p*) or number (*n*) of animals.
Means in the same raw followed by different letters are significantly different at $P < 0.05$.

Table 2
Number (and %) of ewe-reared lambs subjected to gentling (ERG) or not (ER), and artificially reared lambs subjected to gentling (ARG) or not (AR) that came into contact with the person during the stationary human tests

| Test days | Groups | | | | Effects, *P* | | |
|---|---|---|---|---|---|---|---|
| | ERG | ER | ARG | AR | Feeding | Gentling | Feeding × gentling |
| 10d | 2(25.0)a * | 2(25.0)a | 3(37.5)a | 7(87.5)b * | 0.0325 | 0.1540 | 0.3890 |
| 30d | 6(75.0) | 4(50.0) | 7(87.5) | 6(75.0) | 0.2382 | 0.2382 | 0.5812 |

Means in the same raw followed by different letters are significantly different at $P < 0.05$.
* indicate significant difference within columns at $P < 0.05$.

The number of lambs that came into contact with the person during the stationary human test (Table 2) was affected by feeding ($P < 0.05$) only at 10 days of age, whereas at 30 days no significant effects were observed. However, at increasing age (10 vs. 30 days) only gentled groups (ERG and ARG) showed a significant increase in the number of subjects contacting the person ($P < 0.05$). These results indicated that a prolonged gentling treatment was able to increase lamb confidence towards humans, as also observed by Markowitz et al. (1998).

In all cases there was an increased cortisol level in response to loading at 10 min ($P < 0.001$) that fell to pre-transport values at 1 h (Fig. 1). There were significantly different cortisol levels between groups before loading (ER group showed higher cortisol levels than ERG and ARG, $P < 0.05$), but the response to transport and unloading were not significantly different for any group.

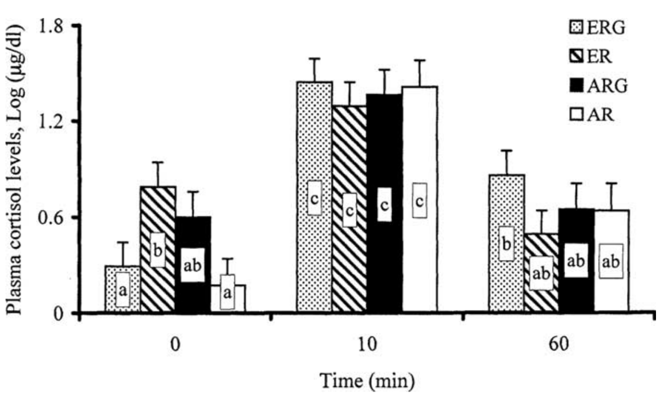


Fig. 1. Least square means + SEM of plasma cortisol levels (log µg/dl) in ewe-reared lambs when subjected to gentling (ERG) or not (ER), and in artificially reared lambs subjected to gentling (ARG) or not (AR). Different letters indicate significant differences between groups at $P < 0.05$.

### 3.2. Weight gain and carcass quality

Weight gain from 0 to 14 days of age was affected by feeding ($P < 0.05$) with a higher growth in animals fed by their mothers (Table 3). However, prematurely separated lambs showed a compensatory growth in the following period (15–30 days; $P < 0.05$) as a possible consequence of adapting to artificial rearing conditions. Therefore, in the overall period (0–49 days) no feeding effect was observed. In the first 14 days of age, weight gain tended to be also affected by gentling ($P < 0.10$), as gentle contacts induced the animals to gain more weight.

Warm and cold dressing percentages were influenced by feeding ($P < 0.01$) and the interaction of feeding × gentling ($P < 0.05$ and $P < 0.10$. respectively). In agreement with the results obtained by Vergara and Gallego (1999) lambs left with their dams showed higher warm and cold carcass yields compared to artificially reared animals. In addition, group ERG, which benefited from both maternal care and gentling, had the highest dressing percentage ($P < 0.05$).

### 3.3. Meat quality

The pH values measured at 1 h showed that only for the SM was there a significantly higher value for the ARG lambs. However, at 24 h there were no significant treatment differences for any groups (Table 4). More interestingly, a significant interaction time × gentling was observed

Table 3
Least square means ± SEM of weight gains (kg/d) and post-slaughter measurements of ewe-reared lambs subjected to gentling (ERG) or not (ER), and of artificially reared lambs subjected to gentling (ARG) or not (AR)

| | Groups | | | | SEM | Effects, *P* | | |
|---|---|---|---|---|---|---|---|---|
| | ERG | ER | ARG | AR | | Gentling | Feeding × gentling | |
| Weight gain | | | | | | | | |
| 0–14d | 0.32b | 0.29b | 0.26ab | 0.20a | 0.03 | 0.0122 | 0.1099 | 0.5076 |
| 15–30d | 0.28 | 0.26 | 0.30 | 0.30 | 0.02 | 0.0564 | 0.3764 | 0.5599 |
| 31–49d | 0.27b | 0.25ab | 0.23a | 0.27b | 0.01 | 0.344 | 0.3573 | 0.0349 |
| 0–49d | 0.29 | 0.26 | 0.26 | 0.27 | 0.01 | 0.3859 | 0.4695 | 0.433 |
| Warm carcass yield (%) | 67.77c | 65.92b | 63.60a | 65.42ab | 0.65 | 0.0016 | 0.9796 | 0.0102 |
| Cold carcass yield (%) | 64.04b | 62.03ab | 60.17a | 61.12a | 0.82 | 0.0077 | 0.5260 | 0.0845 |

Mean in the same raw followed by different letters are significantly different at $P < 0.05$.

Table 4
Least square means ± SEM of meat pH at 1 and 24 h post-mortem measured *Longissimus Dorsi* (LD), *Semimembranosus* (SM) and *Semitendinosus* (ST) muscles in ewe-reared lambs subjected to gentling (ERG) or not (ER), and in artificially reared lambs subjected to gentling (ARG) or not (AR)

| | Hours post-mortem | Muscle | Groups | | | | SEM | Effects, *P* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ERG | ER | ARG | AR | | Feeding | Gentling | Time | Muscle |
| pH | 1 | LD | 6.8 | 6.73 | 6.72 | 6.62 | | | | | |
| | | SM | 6.37a | 6.31a | 6.59b | 6.36a | | | | | |
| | | ST | 6.55 | 6.40 | 6.45 | 6.6 | | | | | |
| | | Mean | 6.57 | 6.48 | 6.59 | 6.52 | | | | | |
| pH | | | | | | | 0.08 | 0.2028 | 0.7971 | 0.0001 | 0.0001 |
| | 24 | LD | 5.62 | 5.70 | 5.67 | 5.75 | | | | | |
| | | SM | 5.50 | 5.53 | 5.52 | 5.6 | | | | | |
| | | ST | 5.47 | 5.59 | 5.56 | 5.57 | | | | | |
| | | Mean | 5.53 | 5.61 | 5.58 | 5.64 | | | | | |

Means in the same raw followed by different letters are significantly different at $P < 0.05$.

Table 5
Least square means ± SEM of colour parameters (*L*, *a**, *b**, *C*, *H*) measured in *Semitendinosus* muscle of ewe-reared lambs subjected to gentling (ERG) or not (ER), and of artificially reared lambs subjected to gentling (ARG) or not (AR)

| | Groups | | | | SEM | Effects, *P* | | |
|---|---|---|---|---|---|---|---|---|
| | ERG | ER | ARG | AR | | Feeding | Gentling | Feeding × gentling |
| *L* | 46.29 | 46.01 | 46.25 | 45.93 | 0.88 | 0.9428 | 0.7351 | 0.9793 |
| *a** | 15.24 | 15.44 | 15.45 | 14.86 | 0.72 | 0.7924 | 0.7857 | 0.5843 |
| *b** | 4.06b | 4.33b | 4.25b | 3.18a | 0.29 | 0.1223 | 0.1895 | 0.0317 |
| *C* | 15.81 | 16.08 | 15.91 | 15.23 | 0.72 | 0.6103 | 0.7769 | 0.5211 |
| *H* | 15.27b | 15.58b | 15.63b | 11.89a | 1.09 | 0.1429 | 0.1312 | 0.0777 |

Means in the same raw followed by different letters are significantly different at $P < 0.05$.

($P < 0.05$). This result may be attributed to the fact that, although the meat produced by gentled animals showed a higher pH compared with that of the non-gentled lambs 1 h after slaughtering (6.58 vs. 6.50; $P < 0.10$), an opposite trend was observed at 24 h post-mortem, as the gentled groups tended to show lower pH values (5.55 vs. 5.62; $P < 0.10$). Gentling may have inhibited medullar adrenal response to emotional stress thus inducing a more rapid reduction in muscle pH. Accordingly, Lensink et al. (2001) suggested that a positive behaviour of stockpeople towards animals during rearing can determine a more marked reduction of ultimate meat pH due to a lower fear of handling before slaughter.

No effect of feeding, gentling and the interaction could be detected on *L*, *a** and *C*. Conversely, *b** and the related hue value (Table 5) were affected by the interaction of feeding × gentling ($P < 0.05$ and $P < 0.10$. respectively). This depended on the failure to find any difference between ewe reared groups (ER and ERG), whereas Group ARG showed higher values of *b** and hue compared to Group AR ($P < 0.05$). Accordingly, Apple et al. (1995) found that *b** values were lower for muscle from lambs subjected to restraint and isolation stress.

There was no significant differences as regards shear force and compression (Fig. 2). However, there was a tendency for ARG to have both a lower shear value and a lower compression value compared to the corresponding ungentled group (AR; $P < 0.15$). A recent study showed that

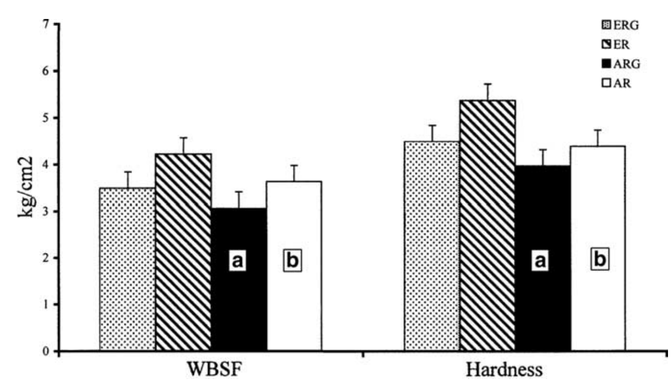


Fig. 2. Least square means + SEM of WBSF and hardness measured in *Longissimus Dorsi* muscle of ewe-reared lambs subjected to gentling (ERG) or not (ER), and of artificially reared lambs subjected to gentling (ARG) or not (AR). a,b indicate significant differences between groups at $P < 0.15$.

stressful pre-slaughter handling increased the shear force of meat from suckling lambs (Vergara, Linares, Berruga, & Gallego, 2005).

## 4. Conclusion

The provision of human contacts stimulated gentled subjects to explore. As a consequence, gentling resulted in a reduction of idling subjects and in a higher proportion of investigating animals. Object playing was also increased by gentling in artificially reared lambs. At increasing age the number of subjects contacting the person increased in the gentled groups. Thus, a prolonged gentling treatment increased lamb confidence towards humans. Lambs benefiting from both maternal care and gentling had the highest dressing percentage. In addition, gentling tended to induce a more rapid reduction in muscle pH and a higher tenderness in terms of shear force and hardness.

We conclude that gentling did not dramatically change the meat quality of lambs. However, in lambs subjected to this treatment most of the variables were oriented towards increased levels of animal welfare and meat quality, thus confirming that in lambs, as in other animal species (cattle, pigs and poultry), human–animal relationship can play an important role in affecting productive performances and product quality, in particular when young subjects are prematurely separated from mothers.

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