EFFECTS OF SHEARING ON LAMB CARCASS CONTAMINATION

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Abstract – The aims of this study were to investigate the effects of different shearing regimes and the slaughter process on microbiological contamination of lamb carcasses. The meat industry in Norway has developed national guidelines for Good Hygiene Practices for slaughtering, which include shearing of sheep immediately before slaughtering. A total of 280 swab samples were collected from the brisket areas (100 cm^2) of 140 lamb carcasses in a commercial abattoir. Half the samples were collected at skinning of brisket areas and half of them were collected at the end of slaughter-line, just before chilling. The lambs were divided into four groups (n=35) according to the duration of the period between shearing and slaughter: (i) 0 days (shorn at the abattoir immediately before slaughter); (ii) three days; (iii) seven days; and (iv) not shorn. The unshorn lambs had higher levels of carcass contamination than the shorn lambs (group i, ii, and iii combined); mean log colony forming units (CFU) per 100 cm^2 at skinning were 6.95 and 5.78 for aerobic plate count (APC) ($P<0.05$), and 2.78 and 1.65 for *Escherichia coli* ($P<0.05$) for unshorn and shorn lambs, respectively. For shorn lambs, divided according to the period between shearing and slaughter, the mean log CFU per 100 cm^2 were 5.45, 5.75, 6.12 (APC) and 1.77, 1.46, 1.71 (*E. coli*) for the 0-days, 3-days and 7-days groups, respectively ($P<0.05$ for the difference between 0- and 7- days groups in APC results). The carcasses at the end of the slaughter-line had lower levels of APC than they had at skinning. However, the *E. coli* level increased from skinning to the end of the slaughter-line. For *E. coli,* the effect of shearing that was observed at the skinning point, declined and was no longer significant at the end of the slaughter-line. This might be explained by weaknesses in slaughter hygiene, in particular suboptimal control of evisceration in the abattoir which was used as a basis for our trial.

Key Words – E. coli, lamb, shearing.

I. INTRODUCTION

Shearing usually improves the visual fleece cleanliness of sheep, since faecal material and mud is mostly attached to the outer layer of the fleece, and the inner part is cleaner. During skinning procedure the carcass surfaces are contaminated by the fleeces, knives and hands etc. of the operators. However, microbiological contamination of lamb carcasses may not be an accurate reflection of fleece cleanliness. Other studies have reported that shearing sheep decreased carcass surface bacterial counts (Biss and Hathaway, 1996; Roberts, 1980). In 2006, the Norwegian meat industry developed national guidelines for good hygienic slaughter practices. The main guidelines direct that carcasses derived from dirty animals, and thus constituting an increased food safety risk, are processed in a separate line that includes heat treatment of meat products and restricted product applications. All sheep and lambs are shorn in abattoirs. If the lambs do not become visually clean after shearing, or they are already shorn on-farm and contaminated after shearing, or slaughtered without shearing (for woolly skin production), the farmers earn a lower price. The aims of our study were to investigate the effects of different shearing regimes and the slaughter process on microbiological contamination of carcasses.

II. MATERIALS AND METHODS

The study was conducted in a commercial abattoir in Norway during two days in October 2008. Two flocks of Norwegian white crossbreed lambs were selected for inclusion in the study. The farmers randomly selected trial lambs for slaughter and sheared half of them on-farm. On both farms the lambs were kept inside a barn overnight before slaughter, and the fleeces were dry when the lambs were brought to the abattoir. A total of 140 lambs from the two flocks were divided into four groups:

i) 35 lambs shorn in the abattoir immediately before slaughter (day 0);

ii) 35 lambs shorn on-farm three days before slaughter;
iii) 35 lambs shorn on-farm seven days before slaughter;
iv) 35 lambs not shorn before slaughter.

The slaughter line speed was approximately 250 animals per hour. Skinning started with a mid-line cut through the skin along the belly and brisket, and cuts along each front leg and throat (Y-cut), while the carcass was suspended by both forelegs and right hind leg. The tip of the skin in the Y-cut was mechanically freed from the brisket and split into two halves. The fleece was then manually detached from the forelegs, shoulders, and outside brisket. The fleece was completely removed by a mechanical downward puller while the carcass was suspended by the forelegs. This abattoir did not use rodding of the oesophagus, and instead 3-5 cm of the top of the necks was cut off. Bagging of the rectum in a plastic bag was not performed. Swab samples from areas of 100 cm^2 on the briskets were collected:

i) Immediately after manual removal of the skin of the brisket. Every second carcass was swabbed on the right-hand side of the mid-line and the other carcasses on the left-hand side.
ii) At the end of the slaughter-line, after trimming, grading, and use of manual steam vacuum treatment (SFK Systems A/S, Kolding, Denmark), just before chilling, the lambs were swabbed on the briskets on the opposite side of the mid-line to where they had been previously swabbed.

The samples were analysed for aerobic plate counts (APC) by Petri film (3M Microbiology, St Paul, Minnesota) with dilution series from 0.1 to 0.000001, and *Escherichia coli* was analysed on pour plate agar according to NMKL method No. 125 (Nordic Committee on Food Analysis, 2005). This method starts with a non-selective agar medium Tryptone Soya Agar (TSA, Oxoid), in order to resuscitate sub-lethally stressed bacteria. Violet red bile agar (Oxoid) was poured on top of the TSA-agar and incubated at 44.0 ±0.5 ^oC for 24 ±3 h. Confirmation as *E. coli* (five colonies per plate) was performed by testing gas production in lactose liquid and indole-positive reactions at 44 ^oC. Descriptive statistics were performed and differences between groups were tested by ANOVA and paired t-tests.

After stunning and bleeding, but before skinning, all the lambs were assessed and scored for visual cleanliness of the fleece (0-3 scale) by a skilled observer. The score '0' represented a visually clean fleece, with minor faecal material or mud in the fleece; a score of '1' represented small spots of dirt under the belly, legs, and tail; a score of '2' represented a generally dirty fleece; and a score of '3' represented a very dirty fleece, stained with faecal material or mud under the belly, legs, and tail.

III. RESULTS AND DISCUSSION

At skinning, the mean APC value of carcasses derived from unshorn lambs (n=35) was 6.95 log CFU per 100 cm^2 and from shorn lambs (all three groups of shorn lambs combined; n=105) the mean was 5.78 log CFU per 100 cm^2, representing an average CFU reduction of 81 % ($P<0.001$). For *E. coli*, the mean CFU per 100 cm^2 was 2.78 for unshorn lambs and 1.65 for shorn lambs ($P<0.05$).

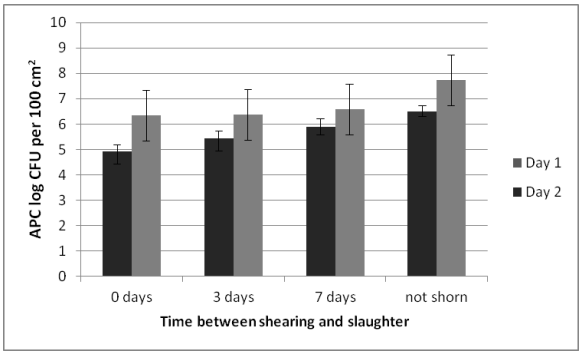

Figure 1. APC results from the brisket area on carcasses immediately after skinning on the two trial days (black and grey bars) and also divided into groups according to times from shearing to slaughter. Error bars indicate 95 % CI.

Lambs shorn in the abattoir the same day as slaughter (0-days group) yielded carcasses with the lowest microbial loads. The longer the time from shearing to slaughter, the higher were the APC values on the carcass surfaces (Fig. 1), for both trial days. The 0-days group yielded carcasses with significantly lower APC values at skinning

than lambs shorn 7 days before slaughter (P<0.05). Lambs slaughtered without shearing had higher APC values on carcass surfaces than all groups of shorn lambs (P<0.05). At skinning, shearing proved to be effective for reducing microbial loads on carcasses. However, previous studies on the efficacy of shearing sheep as a pre-slaughter tool for hygienic improvement of carcasses have provided contradictory results (Biss and Hathaway, 1996).

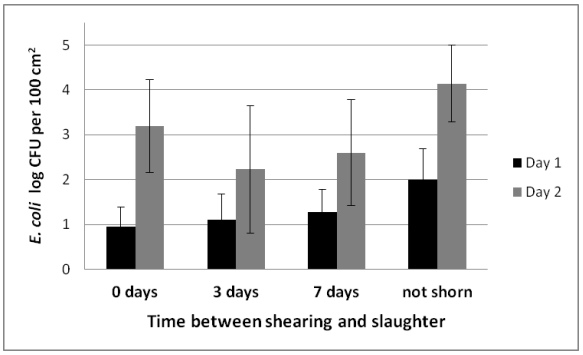

Figure 2. *E. coli* results from the brisket area on carcasses immediately after skinning on the two trial days (black and grey bars) and also divided into groups according to times from shearing to slaughter. Error bars indicate 95 % CI.

Lambs that were shorn immediately before slaughter yielded carcasses with the lowest microbial loads with respect to APC. The *E. coli* results were less definitive, but a similar trend was demonstrated (especially on the first day of the trial).

The *E. coli* results in our study showed a trend of increasing contamination of carcasses with increasing time between shearing and slaughter, but surprisingly high levels of *E. coli* contamination were demonstrated on carcasses derived from lambs shorn immediately before slaughter on the second day of sampling. Although two lambs in the group shorn in the abattoir had exceptionally high *E. coli* numbers, almost all carcasses from the second day of sampling had higher counts of both APC and *E. coli* than on the first day of slaughter 14 days earlier. Many studies have reported difficulties in making valid microbiological comparisons associated with differences in slaughter hygiene, due to individual operators, uneven distribution of microorganisms on carcasses, variations between groups of animals, day-to-day variations, and seasonal variations (Bell and Hathaway, 1996).

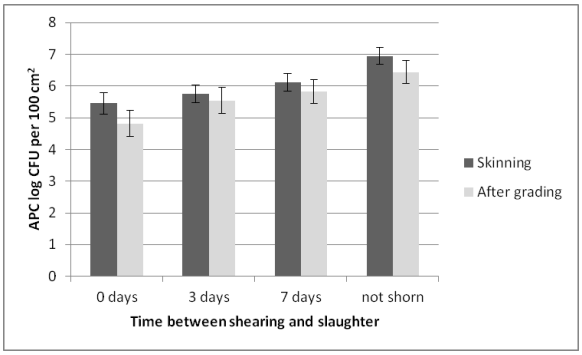

Figure 3. APC results from the brisket area on 140 carcasses immediately after skinning (black bars) and after grading (grey bars), divided into groups according to times from shearing to slaughter. Error bars indicate 95 % CI.

The samples collected at the end of the slaughter-line had lower APC values than at skinning (Fig. 3), indicating that knife-trimming and steam vacuum treatment of spot contamination on the carcasses reduced APC.

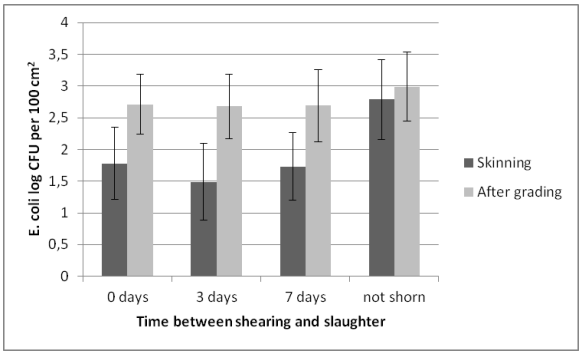

Figure 4. *E. coli* results from the brisket area on 140 carcasses immediately after skinning (black bars) and after grading (grey bars), divided into groups according to times from shearing to slaughter. Error bars indicate 95 % CI.

However, *E. coli* results for all four groups of lambs increased from skinning to the end of slaughter-line (Fig. 4), even though steam vacuum treatment was used. At the end of the slaughter-line, the significant differences between the unshorn and shorn groups which were found after skinning were reduced due to carcass contamination. Rodding of the oesophagus and bagging of the rectum were not performed in this abattoir, and the absence of these procedures, in

addition to suboptimal evisceration which was observed, might have contributed to both direct contamination and also cross contamination between carcasses during direct contact and handling. For this abattoir, the national guidelines for hygienic slaughter, which require shearing of lambs and sheep immediately before slaughter, were not efficient in cost-benefit terms due to these shortcomings.

The overall purpose of the national guidelines is to improve meat safety and avoid food-borne diseases caused by lamb meat consumption. In our study, we did not analyse for pathogens and obviously can not draw conclusions about the safety of Norwegian lamb meat. We analysed indicator bacteria. In the Norwegian sheep population, in which pathogens, such as STEC, exist in some live animals, higher levels of *E. coli* on carcass surfaces could be indicative of higher risks of STEC contamination.

At skinning, the APC results according to fleece cleanliness scores for carcasses of lambs with cleanliness score 0, 1, 2 and 3 (Fig 5), were 5.71, 5.95, 6.46, and 6.71, respectively. The results for score 0 were significantly lower than for score 2 and 3, and results for score 1 were significantly lower than for score 3. Corresponding results for *E. coli* at skinning were mean log CFU of 1.65, 1.88, 2.16, and 2.49 for score 0, 1, 2 and 3, respectively. For *E. coli* the differences were not significant.

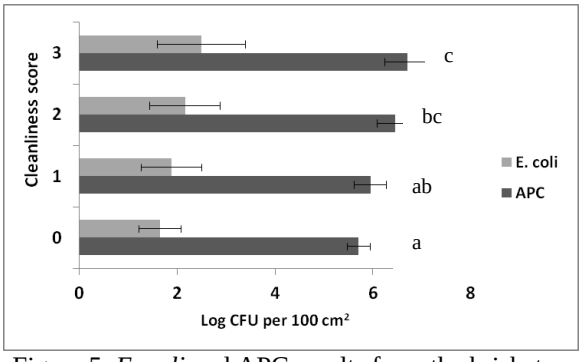

Figure 5. *E. coli* and APC results from the brisket area on carcasses immediately after skinning, divided into categories of fleece cleanliness (0 being clean and 3 being very dirty). Error bars indicate 95 % CI.

IV. CONCLUSION

After skinning of the brisket area, shorn sheep had less carcass contamination than unshorn with regard to *E. coli* and APC. At the end of the slaughter-line, just before chilling, the APC results for shorn sheep were lower then for unshorn sheep. The APC results concur with the intentions of the national guidelines in Norway, in which visually clean sheep shorn in the abattoir are regarded as low risk animals, and visually dirty sheep are treated as producing high risk carcasses. For *E. coli*, the effect of shearing found after skinning, was reduced during the slaughter and dressing process, and at the end of the slaughter-line, the *E. coli* level had increased and there were no differences between the groups of shearing regimes (shorn 0-days, 3-days, 7-days before slaughter, and not shorn). The increased *E. coli* level at the end of the slaughter-line might be explained by weaknesses in slaughter hygiene in the abattoir where this study was performed.

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