# Weight Loss in the Processing of Dry-cured Mutton: Effect of Age, Gender and Processing Technology

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**Summary**

In order to determine the effect of age, gender and castration, as well as ripening duration and anatomical position on the weight loss (WL) during processing of castradina production (an indigenous Dalmatian dry-cured mutton), 60 ewes (E) of three age groups (up to 2.5 yr, from 3 to 5 yr, more than 5.5 yr) and 40 males (wethers - W and rams - R), 20 in each group, were slaughtered. After cutting the carcasses, whole legs, shoulders and rest parts called "kora" were subjected to processing (salting, drying, ripening) during which the WL was determined. Since the total WL of the $E_{3-5}$ was the lowest (27.72%) and total WL of the $E_{2.5}$ and $E_{5.5}$ were the similar (30.71% and 30.48%, respectively), despite significant differences of these three age groups of E-castradina, one cannot conclude that age of the sheep affects the WL of the E-castradina. The procedure of the castration had significant effect on the total WL, since the total WL of the R-castradina was the highest (38.76%) compared to the total WL of W (29.92%) and $E_{2,5}$ and $E_{5,5}$, which were the similar (except $E_{3-5}$ which was lower than W). The highest total WL was found for the shoulder (35.05%), and the lowest was found for the whole leg (27.26%), while the one of the "kora" was in between (31.95%), whereby the differences among all three groups were significant ($p<0.001$ and $p<0.05$, respectively). Considering the thickest muscle of the whole leg and much shorter ripening period of the "kora" (despite the larger surface area and smaller thickness) these values of the total WL are logical.

**Key words**

weight loss, dry-cured mutton, castradina, age, gender

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## Aim

The modest natural conditions of the dominant Croatian sheep areas (karst area) are favorable to extensive system of sheep breeding, thus the possibility of intensification of sheep production is limited and a need for rationalization of existing production is a must. One of the ways to further rationalize sheep production, especially in livestock intended for meat production, is the production of dried mutton-castradina, an indigenous dry-cured meat product from sheep that is now very rarely found on the market. Castradina is a semi-durable or durable dry-cured product, traditionally produced from the sheep or goat through the processes of salting, dry-brining, smoking, drying and ripening (Krvavica et al., 2009). Castradina production is mainly based on the culled ewes and rams, fattened wethers and barren sheep slaughtered at the age of 1-5 years, which otherwise increase the burden on farmers because they are difficult to sell, they achieve a low price in the market, and their breeding requires additional costs. The best price for these animals is achieved through the production of castradina. Carcass quality and meat quality of slaughtered animals depends on many factors (species, genotype, gender, age, breeding and nutrition technology, ante- and post-mortem procedures, etc.) that affect muscle structure and pre- and post-slaughter muscle biochemistry, which in turn has a crucial effect on the technological, sensory and organoleptic properties of meat as a raw material (Okeudo and Moss, 2005) what, besides production technology, determines the finite properties of castradina as a final dry-cured product. Numerous studies show that the quality of lamb meat depends on the slaughtering mass and fattening level, gender, age, genotype, etc. (Santos et al., 2007; Mioč et al., 2009). However, there is relatively little research regarding the carcass traits and meat traits of older sheep age categories, as well as factors affecting its quality (Vergara et al., 1999) and the possible use of sheep meat in processing (Hand et al., 1992; Kowale et al., 1995; Berian et al., 1997). In particular, there is little research on the impact of the sheep meat quality and processing technology in the production of castradina and similar indigenous meat products. Previous studies are mainly of gastronomic and historical nature, and a smaller number of researches relates to the production technology (Prgomet, 1970; Čaušević et al., 1984; Gajić, 2000; Krvavica et al., 2009; Ganić et al., 2009; Krvavica, 2010).

Therefore, the goal of this research is to determine the extent to which age, gender and castration, as well as anatomical position and ripening duration influence the weight loss in castradina production that will, through the contribution to the standardization of the technological process of castradina production as an indigenous product, contribute to the improvement of existing production and market promotion of castradina and ultimately affect the rationalization of sheep production of the karst area through faster and better placement of animals culled from breeding.

## Material and methods

The study was conducted on 100 sheep (breed Pramenka specific to Travnik region) classified into 5 categories (3 female and 2 male) as follows: 20 ewes up to 2.5 years ($E_{2.5}$), 20 ewes aged 3-5 years ($E_{3-5}$), 20 ewes aged more than 5.5 years ($E_{5.5}$), 20 rams (R) and 20 wethers (W) that were castrated at least 6 months prior to slaughter. After slaughtering and a 24-hour chilling achieving the temperature inside the leg of + 4°C, for the purpose of castradina production carcasses were cut into 6 parts as follows: after cutting each carcass in half, the whole leg (with hindshank) were separated of each half by making the section from the loin and paunch between the last lumbar vertebra and the first cross vertebra, and then the blade shoulder with the foreshank were separated from the neck, chest and ribs by a circular-elliptical incision through the natural muscle connection. The rest, the third part of the half that in Dalmatia is called "kora" (crust) includes the neck, part of the ribs under the blade shoulder, chest, ribs, back, loin and paunch. These cut carcass parts were subjected to processing that includes: dry salting, drying + smoking and ripening. After 7 ("kora"), 10 (shoulder) and 13 days (whole leg) the meat was removed from the salt, washed, drained and put into the smoking-drying chamber. The combination of drying and cold smoking was used for a period of 8 days ("kora") to 10 days (shoulder and whole leg), and then the meat was moved in the drying-ripening chambers with controlled microclimate. During the processing the temperature and the RH was controlled (salting: up to +4°C; drying + smoking: +8 to +20°C, RH 60-80%; ripening: +7 to +15°C, RH 60-84%). The processing of "kora" lasted 35 days while the processing of shoulders and whole legs lasted 60 days. Shorter processing (ripening) period of the “kora” is necessary due to its faster dehydration (larger surface area and smaller thickness). During the processing procedure, before and after each processing stage, the weight of all the individual parts ("kora", shoulder, whole leg) was determined by weighing. In the ripening stage the weighing was done twice: for "kora" - after 25 days (ripening I) and 35 days (ripening II) of the processing, and for shoulders and whole legs - after 35 days (ripening I) and 60 days (ripening II) of the processing. From these measurements the weight loss (WL) of the products for all individual parts in particular was calculated, and expressed as a weight loss (%) of each processing stage (WL) and weight loss from the start of processing to the end of each processing stage (WL II). Assessment of the effect of animal categories (age, gender and castration), as well as anatomical position and ripening duration on the weight loss (WL and WL II for the effect of ripening duration) of dried mutton was performed using the software package SAS V8 (SAS, 1999). Data were analyzed using GLM procedure according to the model:

$$Y_{ijkl} = \mu + C_i + AP_j + R_k + M_{ijk} + e_{ijkl}$$

where: $Y_{ijk}$ = measured trait; μ = overall mean; $C_i$ = effect of category (i = 1,2,3,4,5); $AP_j$ = effect of anatomical position (j = 1,2,3); $R_k$ = effect of ripening duration (k = 1,2); $M_{ijk}$ = initial weight of the “kora”, shoulder and whole leg (covariate in the model); $e_{ijkl}$ = unexplained effect.

## Results and discussion

### Effect of age, gender and castration on the weight loss of castradina

WL II of specific anatomical position of castradina ("kora", shoulder, whole leg) in five different categories of sheep ($E_{2.5}$, $E_{3-5}$, $E_{5.5}$, R, W) expressed as the means of WL II of certain categories of sheep, is shown in Figure 1 that shows that the highest WL II was determined for the shoulder, and the lowest for the whole leg, except in two cases: WL II of R-"kora" at ripening I (37.52%) was higher than WL II of R-shoulder (36.76%); and total WL II (ripening II) of $E_{5.5}$-"kora" (27.16%) was lower than WL II of $E_{5.5}$-whole leg (27.16%). The highest total WL was determined for R-shoulder (42.66%) and lowest for the $E_{3-5}$-whole leg (24.21%).

The effect of sheep categories (age, gender and castration) on WL at different processing stages is shown in Table 1 from which it is evident that the differences in WL of individual categories were statistically significant in all processing stages for at least one pair compared. Comparing all processing stages in castradina production, the biggest WL was determined in R-castradina, although a significant difference compared to the W-castradina was found only in the drying stage (p<0.001), and considering that the largest WL is of drying stage, a significant difference was found for total WL as well (p<0.001). For the salting stage it was determined that the WL was significantly higher in both R and W in relation to all three age groups of E (p<0.001). However, WL of drying for R group was significantly higher than in all three categories of E (p<0.001), while the WL for W group was significantly higher only in relation to the $E_{2.5}$ group (p<0.001).

WL of ripening I for R group was significantly higher only in relation to the $E_{2.5}$ group (p<0.01), while the WL of ripening II was significantly higher than in all three categories of E (p<0.001), and WL of ripening II for W group only in relation to the $E_{2.5}$ (p<0.01).

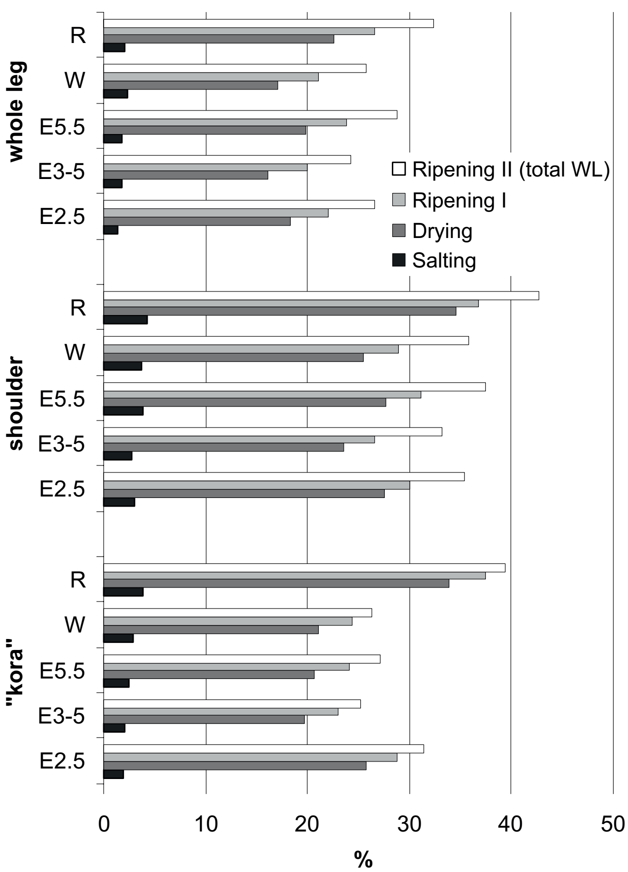


**Figure 1.** Weight loss II (WL II) of the castradina at particular processing stages (WL II – weight loss from the start of processing to the end of each processing stage)

**Table 1.** The effect of sheep categories on the weight loss (WL) of the castradina by the processing stages

| WL, % | Sheep/Category | | | | | SE | SL |
|---|---|---|---|---|---|---|---|
| | $E_{2.5}$ | $E_{3-5}$ | $E_{5.5}$ | W | R | | |
| Salting | $2.04^{a}$ | $2.23^{ab}$ | $2.58^{b}$ | $3.10^{c}$ | $3.51^{c}$ | 0.13 | * |
| Drying | $22.21^{a}$ | $18.05^{b}$ | $20.66^{ac}$ | $19.08^{cb}$ | $28.27^{d}$ | 0.50 | ** |
| Ripening I | $4.08^{a}$ | $4.35^{ab}$ | $4.57^{b}$ | $4.59^{b}$ | $4.69^{b}$ | 0.12 | * |
| Ripening II | $5.43^{a}$ | $5.92^{ab}$ | $6.23^{b}$ | $6.65^{bc}$ | $7.31^{c}$ | 0.20 | * |
| Total WL | $30.71^{a}$ | $27.72^{b}$ | $30.48^{a}$ | $29.92^{a}$ | $38.76^{c}$ | 0.52 | * |

SE - standard error of difference; SL - significance level; WL – weight loss of the particular processing stages; E2.5 – ewes up to 2.5 years; E3-5 – ewes aged 3-5 years; E5.5 – ewes aged more than 5.5 years; W – wethers ; R – rams; [a, b, c, d] values in the same row marked with different letter or letters are significantly different; * (p<0.05); ** (p<0.01).

**Table 2.** The effect of anatomical position ("kora", shoulder, whole leg) on weight loss (WL)

| WL, % | Anatomical position (LSM±SE) | | | SL |
|---|---|---|---|---|
| | "Kora" | Shoulder | Whole leg | |
| Salting | $2.28 \pm 0.17^{a}$ | $4.04 \pm 0.16^{b}$ | $1.76 \pm 0.10^{c}$ | ** |
| Drying | $22.74 \pm 0.69^{a}$ | $25.05 \pm 0.64^{a}$ | $17.17 \pm 0.40^{b}$ | *** |
| Ripening I | $5.13 \pm 0.15^{a}$ | $3.44 \pm 0.14^{b}$ | $4.80 \pm 0.09^{a}$ | *** |
| Ripening II | $4.03 \pm 0.22^{a}$ | $8.81 \pm 0.20^{b}$ | $6.06 \pm 0.13^{c}$ | *** |
| Total WL | $31.95 \pm 0.72^{a}$ | $35.05 \pm 0.66^{b}$ | $27.26 \pm 0.43^{c}$ | * |

(LSM±SE) – least square means ± standard error of difference; WL – weight loss of the particular processing stages; SL – significance level;[a, b, c] values in the same row marked with different letters are significantly different; *(P<0.05); **(P<0.01); ***(P<0.001).

The lowest WL of salting, ripening I and ripening II were for the $E_{2.5}$, but significant differences were determined only in relation to the category of the $E_{5.5}$ (p<0.05).

WL of drying for the $E_{3-5}$ was significantly lower than for the $E_{2.5}$ (p<0.001), and the $E_{5.5}$ (p<0.01). The total WL in W group was similar to WL in E groups, except in relation to the $E_{3-5}$ (p<0.05), which differed from the other two categories of E (p<0.01) and R where the total WL was significantly higher than in all other categories (p<0.001).

### Effect of the ripening duration and anatomical position on weight loss of castradina

As expected, ripening duration had a significant impact on WL II of "kora", shoulder and whole leg as well. The WL II of "kora" after 35 days (29.85%) was significantly higher (p<0.01) then the WL II of "kora" after 25 days of ripening (27.57%), and WL II of shoulders (36.90%) as well as whole legs (27.45%) after 60 days of processing was significantly higher (p<0.001) than the WL II after 35 days of ripening (27.10% and 22.75%, respectively).

Differences in WL of "kora", shoulder and whole leg as well, were significant at all processing stages for at least one pair (Table 2). At the salting stage the WL was the highest for the shoulder (4.04%), and the lowest for the whole leg (1.76%; p<0.001).

Differences in WL of "kora" (22.74%) and shoulder (25.05%) for the drying stage were not significant, while the WL of whole leg (17.17%) was significantly lower than the previous one ($p<0.001$). At the ripening I stage the lowest WL was determined for shoulder (3.44%) that was significantly lower than WL of "kora" and the whole leg ($p<0.001$).

Differences in WL of the ripening II stage were significant between all the anatomical positions ($p<0.001$), and the highest WL was determined for the shoulder (8.81%), while the lowest was determined for "kora" (4.03%). Differences in the total WL of "kora", shoulder and the whole leg were also significant. The total WL of shoulder (35.05%) was significantly higher ($p<0.05$) than the total WL of "kora" (31.95%) and total WL of the whole leg (27.26%) ($p<0.001$), and total WL of "kora" was significantly higher ($p<0.001$) than the total WL of the whole leg. According to the Čaušević et al. (1984) in the production of mutton products called "stelja" and "pastrma" that lasted for 35 days, WL was from 40.82 to 43.81%, with a higher WL recorded in lighter carcasses, while the amount of salt in the final product did not affect WL. Also, Dumić (2008) stated that WL during "stelja" production was from 30.76 to 38.03%, which depends not only on the mass of raw "stelja", but also on the amount of salt in the final product, i.e. the largest WL was determined for the lightest "stelja" with the highest salt content. Regarding to the fact that "stelja" and "pastrma" are produced from completely or partially deboned sheep carcasses, it is understandable that WL was somewhat greater compared to castradina researched. In fact, such processing technology of the carcasses (deboning), results in greater exposure of meat to ambient conditions, which favors a more rapid dehydration regardless of the higher initial mass. The same reason for higher weight loss of Istrian prosciutto in relation to other types of prosciuttos declared Karolyi (2002) and Krvavica (2003), explaining that the specific treatment of the Istrian prosciutto without the skin and subcutaneous adipose tissue exhibits greater surface of leg to ambient conditions, which increase dehydration.

## Conclusions

Despite the fact that significant differences in the total weight loss (WL) were found among the three age groups of ewe-castradina (E), since the total WL of the $E_{3\text{-}5}$ was the lowest and total WL of the $E_{2,5}$ and $E_{5,5}$ were the similar, one cannot conclude that age of sheep affects the WL of the E-castradina. The procedure of the castration had significant effect on the total WL, since the total WL of the ram-castradina (R) was the highest compared to the total WL of wether-castradina (W) and E-castradina that were the similar (except $E_{3\text{-}5}$ that was lower than W). Considering the thickest muscle, as expected the whole leg had the lowest total WL, the shoulder had the highest, while the “kora” was in between, which is logical since the much shorter period of ripening had great influence despite the larger surface area and smaller thickness of the “kora”.

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