

Correlation between *Longissimus thoracis* muscle ageing extent, growth and carcass traits in Simmental bulls: preliminary results

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A common practice to improve meat quality is aging under controlled conditions, which results in improved tenderness, a key factor in the consumer acceptance of beef meat. Among other traits, the tenderness and the effect of ageing are also genetically determined. Therefore, a trial was performed to assess the effect of ageing in the progeny of young bulls included in the routine breeding program for Simmental breed in Slovenia. In the trial, 127 young bulls were included, and the shear force of grilled *Longissimus thoracis* muscle was measured fresh and after three weeks of ageing. There was a significant difference between the fresh and aged muscle in shear force, but growth and other carcass traits did not affect it as it was expected. We assume that after enlarging the number of animals, the data will be usable to be included in the genetic evaluation of the breeding program for Simmental breed in Slovenia.

Keywords: *Longissimus thoracis*, beef, ageing, shear force

1 Introduction

Meat quality has a high importance in cattle producers and beef consumers, with tenderness as a key factor for the consumer acceptance of beef meat (Miller et al., 1995; Zwambag et al., 2013). Tenderness is affected by many factors including genetics, nutrition and technology as the most important, and ageing is a very common practice to improve it (Holloway and Wu, 2019). Ageing is referred to a breakdown of different structural proteins of meat (C-proteins, M-protein and the cytoskeletal proteins) by the endogenous enzymes calpains (Dikeman and Devine, 2014). Beside structural proteins, ageing and tenderness are connected also with proteins related to cell organization, metabolism and other uncharacterized proteins (Carvalho et al., 2014). It is generally known that ageing affects meat tenderness (Florek et al., 2007), but there are considerable differences between breeds and ageing times (Hanzelková et al., 2011). Beef tenderness is also heritable, with a low to moderate heritability, although it varies among different breeds and different ageing time. Reported heritability for shear force decreases from 0.194 to 0.048 as aging time increases, hence, there are animals that have more tender meat at shorter ageing times (Zwambag et al., 2013), which could be used for animals in selection. Some other authors reported even higher heritability (0.4) for shear force of beef meet (Dikeman et al., 2005).

Therefore, the aim of the study was to evaluate the effect of ageing of *Longissimus thoracis* (LT) on tenderness, and to correlate it to different carcass and growth traits in Simmental bulls included in progeny testing in Slovenia.

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2 Materials and methods

2.1 Animals and sample collection

This study included 127 young bulls of Simmental cattle from a progeny testing station. Weaned bulls (81±15 days) were bought from different herds all over Slovenia and housed at the testing station in Žipo Lenart. They were fed with a total mixed ration based on maize silage, maize, protein concentrate and straw. The total mixed ration contained between 10.6 and 11.0 MJ ME and between 12.2 and 14.3% crude protein on a dry matter basis. The bulls were slaughtered in a commercial abattoir when they achieved an appropriate commercial finishing level according to the Slovenian market. After 24 h of chilling, the right carcass side was brought to the Experimental Slaughter and Dissection House at the Department of Animal Science. During the dissection of carcasses into different carcass tissues, two 2-cm-thick steak samples of the LT muscle were removed starting at the 7th rib, and were then vacuum-packed for Warner–Bratzler shear force (WBSF) analysis. The first steak was frozen (-20°C) 3 days after slaughter and was referred as fresh meat. The second steak was aged at 2°C for 3 additional weeks, frozen until analysis, and referred as aged meat.

2.2 Warner-Bratzler measurement and cooking losses

In order to measure WBSF, frozen steaks were thawed at 5°C for 24 hours. After that, steaks were grilled to a final internal temperature of 70°C using a double-side grill (Mayway, Model PM-2015L, Austria) preheated to 200°C. The internal steak temperature was monitored by a calibrated thermocouple in the geometrical centre of the steak (Ebro TFN 530, Germany). When the end point temperature was reached, steaks were removed and hold at room temperature until equilibrated. Each cooked sample was cut into 10 square cores parallel to the muscle fibres (1.1·2.5 cm). The 10 cores were sheared once perpendicular to the long axis of the fibres using an Instron Universal Testing machine (Model 3345, Instron, Canton, MA, USA) equipped with a WBSF device. The 500 Newton load cell was used with a crosshead speed of 250 mm/min, and a sample rate of 10 points/s. The mean value of the 10 replicates was taken as the maximum shear force value and was subjected to further statistical analysis. The absolute ageing effect was calculated as a difference between WBSF of aged and fresh meat, and relative ageing effect was expressed as percentage of absolute value relative to WBSF of fresh meat. Cooking losses were calculated as a difference between steaks weight before and after cooking and chilling to room temperature.

2.3 Statistical analyses

Data were analysed using the GLM procedure of the SAS software ver. 9.4 (SAS Institute Inc., Cary, NC, USA). In the statistical model, only the fixed effect of the sire was included. The correlations between traits were calculated using the REG procedure of SAS.

3 Results and discussion

At the beginning of the experimental period, bulls weighed 173.6 kg at an average age of 118 days. Bulls were slaughtered at an average age of 510 days when they reached in average 714 kg of live weight, 405 kg carcass weight and attained a weight gain of 1,282 g/day.

The carcasses contained 65.3% meat and 16.1% fat (Table 1). The core temperature of fresh and aged LT after grilling did not differ between the two, which assures the comparability of the results. The difference in the shear force between fresh and aged LT muscle was 27.8 N (32%). This is lower than results reported in the study of Hanzelková et al. (2011), although they cooked the meat instead of grilling it. On the other hand, the differences are similar to those reported in other studies (Florek et al., 2007). Absolute differences were altered also because of the rate of growth and consequently differences in calpain proteolytic system, as it was observed in research conducted in cattle with altered growth rates (Sazili et al., 2004).

Fresh and aged shear force of the LT muscle were relatively well correlated ($R^2=0.5689$) (Figure 1). Therefore, we can conclude that animals which had a high shear force of meat in the beginning, retained a high shear force after ageing the LT muscle for 21 days. Furthermore, animals that had a lower shear force of fresh meat, presented a lower impact of ageing in both absolute ($R^2=0.4663$) and relative ($R^2=0.1412$) values (Figures 2 and 3, respectively). This is in accordance with research conducted in Charolais and Limousine cattle, which detected that the shear force variation did not diminish during the post mortem ageing among sires, although the variation among the progeny within a sire decreased during ageing (Wulf et al., 1996). The latter and our results indicated that there are

animals that have a more tender meat, and which could be used as a selection criterion in breeding programmes.

Table 1 Growth and carcass traits of the Simmental bulls at the end of the test period

	Mean	SD	Minimum	Maximum
Weight at the beginning of the test period (kg)	173.6	27.3	112.0	255.0
Age at the beginning of the test period (days)	118.0	16.3	88.0	163.0
Weight at slaughter (kg)	713.7	56.4	572.0	910.0
Age at slaughter (days)	510.3	40.5	410.0	641.0
Weight gain in the test period (g/day)	1,281.6	130.7	937.4	1,644.1
Carcass weight (kg)	404.7	36.4	306.0	532.0
Carcass meat percentage (%)	65.3	2.50	58.9	70.5
Carcass fat percentage (%)	16.1	2.62	10.7	22.7
pH 24 h after slaughter	5.62	0.104	5.41	6.35
Core temperature of fresh LT after grilling (°C)	76.8	1.72	72.0	80.5
Core temperature of aged LT after grilling (°C)	76.8	1.98	71.4	82.3
WBSF of fresh LT (N)	87.1	22.0	28.4	127.2
WBSF of aged LT (N)	59.3	16.1	31.0	102.1

WBSF - Warner–Bratzler shear force; SD – standard deviation

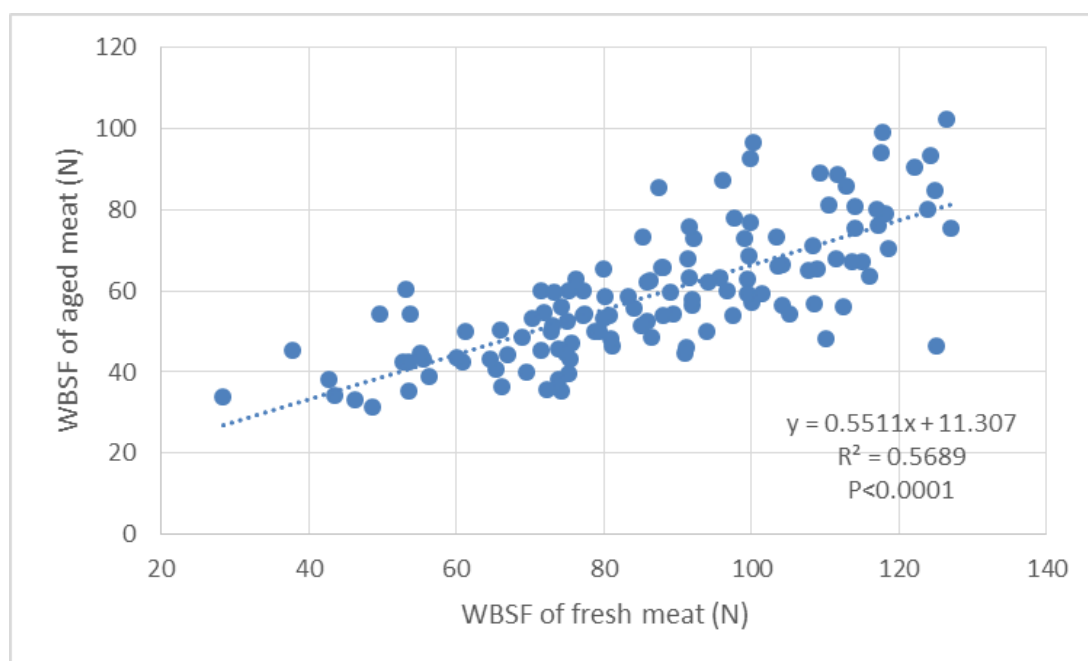


Figure 1 Warner–Bratzler shear force (WBSF) of fresh and aged *Longissimus thoracis* muscle

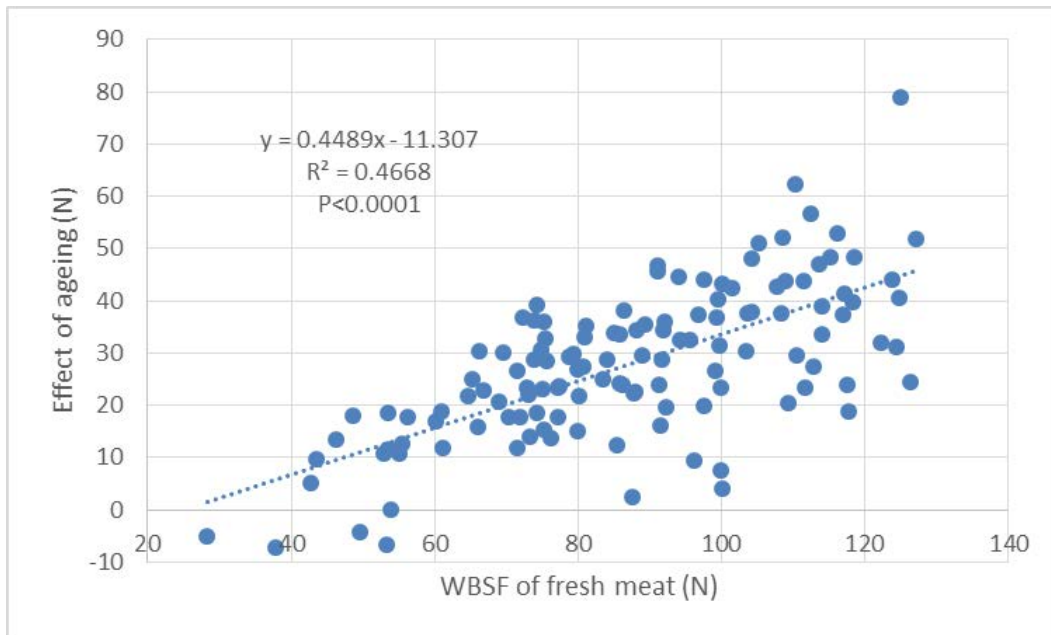


Figure 2 Correlation between Warner–Bratzler shear force (WBSF) of fresh meat and absolute ageing effect of *Longissimus thoracis* muscle

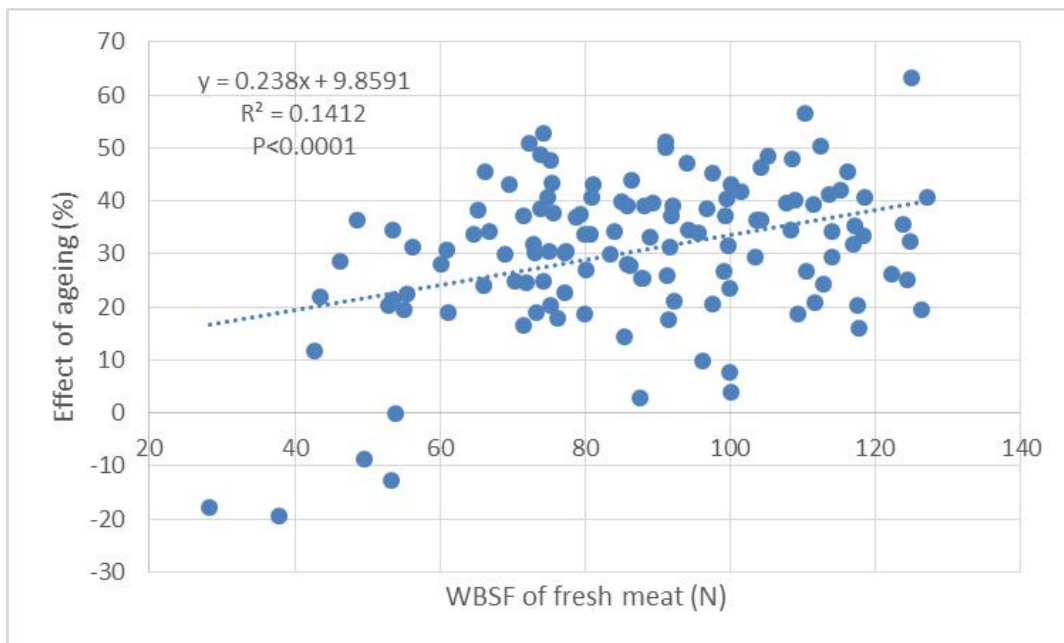


Figure 3 Correlation between Warner–Bratzler shear force (WBSF) of fresh meat and relative ageing effect of *Longissimus thoracis* muscle

Researchers have demonstrated that alterations in the growth of the animals affect the calpain-calpastatin proteolytic system and the meat tenderness in cattle (Koochmaraie et al., 2002; Sazili et al., 2004). Therefore, in the present study, it was expected that the growth rate was reflected in the ageing effect of the meat. The growth of the animal in test period affected the WBSF of the fresh LT muscle (Figure 4; $R^2=0.0386$), but not the effect of ageing (Figure 5). It is expected that with more observations, a different outcome, connected to the ancestors, is obtained.

Similar results were found also for the correlation between age and live weight at slaughter on one side, and for the WBSF of fresh meat and the ageing effect on the other side (data not presented). Generally, tenderness and sensory panel scores for tenderness decrease with animal age

(Shackelford et al., 1995; Purslow, 2005). Changes in the characteristics of collagen during the growth are the main reason for tougher meat in older animals (Harper, 1999). The small differences in the age of the animals and in the live weight and the complex interaction among different effects are probably responsible for the lack of correlation between the age of the animals, the live weight and the WBSF of fresh and aged beef.

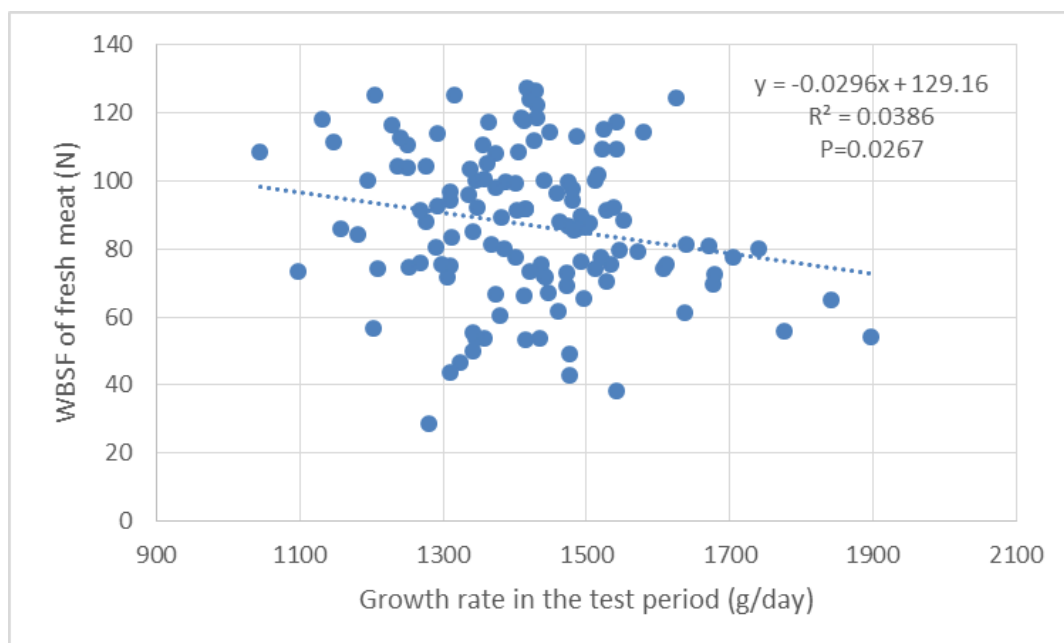


Figure 4 Correlation between growth rate in test period and Warner–Bratzler shear force (WBSF) of fresh *Longissimus thoracis* muscle

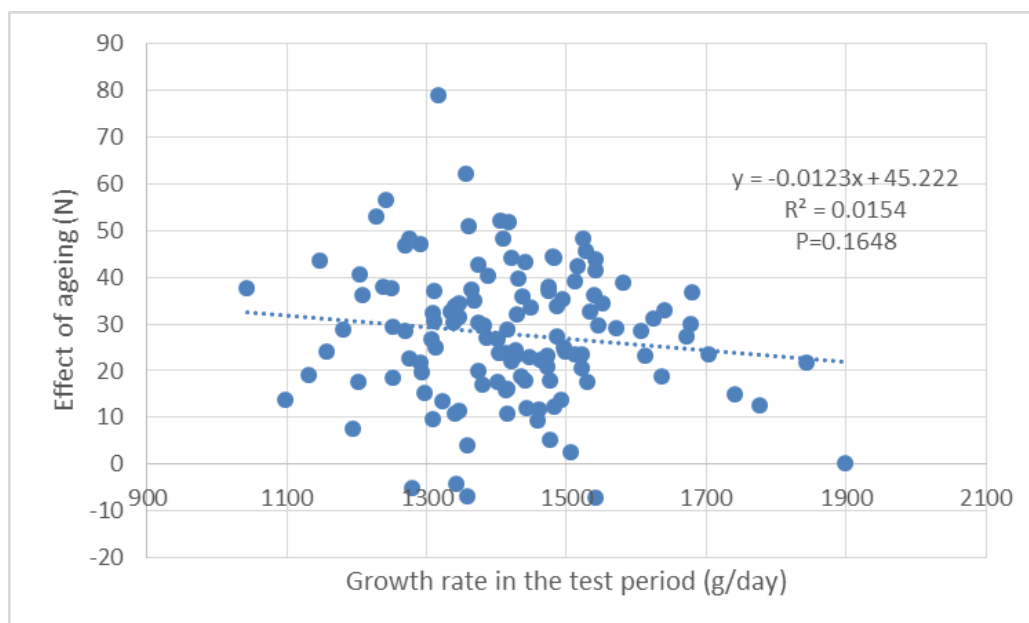


Figure 5 Correlation between the growth rate in the test period and the ageing effect of *Longissimus thoracis* muscle

Measuring the WBSF is a complex procedure that depends on many technical features, mainly the core temperature, the duration of the heating and the type of heater. There are many studies that detected significant differences in the WBSF with only slight changes in the cooking methodology (Lawrence et al., 2001). The core temperature is a key factor in the shear force of meat, and therefore

it is crucial to have a repeatable procedure of the cooking method (Wall et al., 2019). Although strict measures were followed to obtain a constant core temperature of the meat, the variability of the final core temperature after the heat treatment was relatively high. Although some authors detected a high correlation between the shear force and the core temperature (Yancey et al., 2011), we did not observe any correlation between the two traits (Figure 6). On the other hand, Yancey et al. (2011) observed that the cooking losses increased concomitantly with the end point core temperature. This is in compliance with the results obtained in our trial (Figure 7), in which the core temperature strongly influenced the cooking losses for fresh, but not aged meat (R^2 for fresh LT meat = 0.1553; R^2 for aged LT meat= 0.0943). Furthermore, the cooking losses were well connected with the WBSF of LT muscle (Figure 8; $R^2=0.1953$). To sum up, it seems that core temperature influenced the cooking losses of the LT muscle, and that the cooking losses influenced the WBSF of LT meat, but interestingly the core temperature did not correlate with WBSF. We expected a strong correlation between the core temperature and the WBSF, but these differences could be annotated to genetic differences among the animals, as proposed by some authors (Splan et al., 2002).

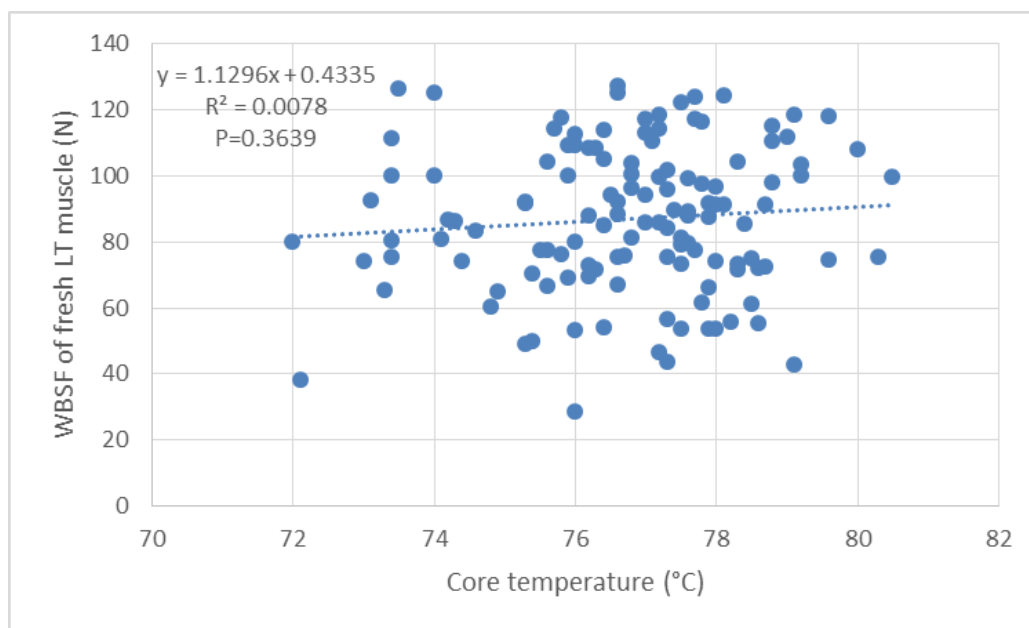


Figure 6 Correlation between core temperature and Warner–Bratzler shear force (WBSF) of the fresh *Longissimus thoracis* (LT) muscle

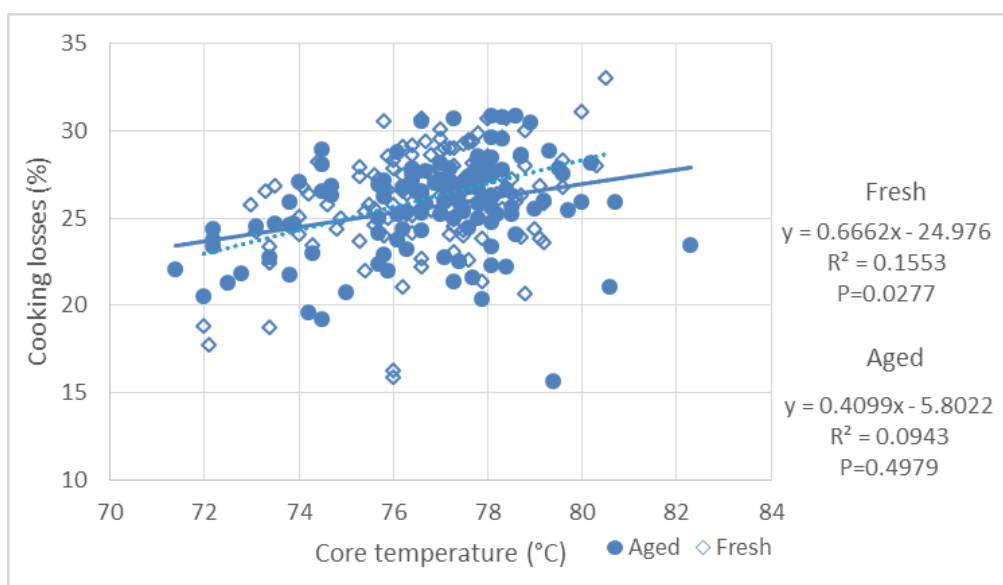


Figure 7 Correlation between the core temperature of the *Longissimus thoracis* muscle (fresh and aged) and the cooking losses

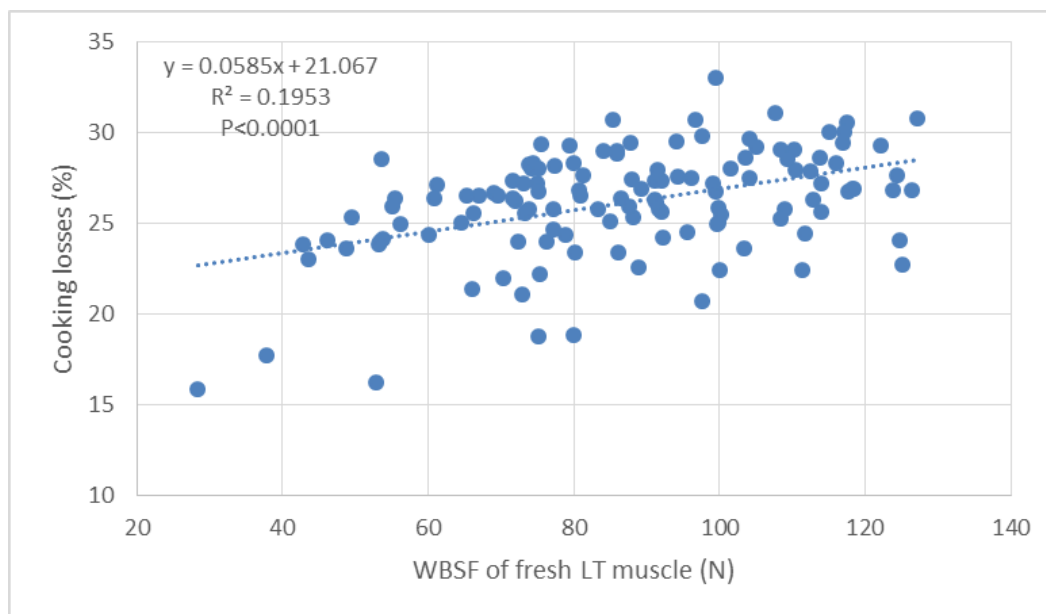


Figure 8 Correlation between the Warner–Bratzler shear force (WBSF) of the fresh *Longissimus thoracis* (LT) muscle and the cooking losses

The initial idea of collecting the data was to initiate a genetic evaluation of the bulls in the progeny test. Therefore, we tested the data with GLM procedure of SAS software preliminary, in which a sire was tested as fixed effect for some traits. The P values for the sire were statistically significant for the WBSF of fresh ($P=0.0429$) and aged meat ($P=0.0257$), but not for the effect of ageing ($P=0.1844$). Hence, we can suggest that with the continuation of the trial, the data will be usable to include in the genetic evaluation, as it was suggested by some authors (Wulf et al., 1996; Splan et al., 2002).

4 Conclusions

We detected a significant influence of ageing of the LT muscle on the WBSF. The preliminary analyses also showed differences between the animals in WBSF of fresh and aged WBSF LT muscle, but there were no correlations with growth or other slaughter characteristics. The drawback of the study is a very high influence of the grilling method and the cooking losses on the WBSF of the LT muscle, although it is expected that with a higher number of animals, the genetic evaluation would be possible. Even though the present research is only preliminary, the statistical evaluation showed differences between animals. Therefore, it is expected that with a higher number of measurements, the data on meat tenderness could be included in the genetic evaluation of animals with an animal model.

Acknowledgments

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