Minhota breed cattle: Carcass characterization and meat quality affected by sex and slaughter age

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Abstract

This work focuses on the effect of slaughter age (6 and 9 months) and sex on carcass characteristics and meat quality of the Minhota cattle breed. In this study, data from 52 cattle (34 males and 18 females) were used for the carcass and meat characterization. Regarding carcass characteristics, male carcasses (158 kg and 223 kg for animals of 6 and 9 months, respectively) were heavier compared to female ones (130 kg and 161 kg for animals of 6 and 9 months, respectively) with better dressing percentages, increased lengths, thicknesses and depths and compactness indexes. The quality of meat from carcasses of both males and females had strong luminosity (L*), a pale pink tone (lower a*-value) and high yellowness. Mean tenderness of *Longissimus thoracis*, expressed as shear force, was below 5.5 kg/cm^2, without significant differences (P>0.05) between either the slaughter age or sex.

Keywords: Minhota bovine breed, Morphological carcass, Slaughter age, Chemical composition

Introduction

Livestock farming in the “Douro and Minho” area is an important agricultural activity with 19,000 meat farmers and 10,000 dairy farmers rearing 40,000 meat animals and 115,000 dairy cows, respectively. In this area, there are several breeds with Stud Books (Arouquesa, Barrosã, Cachena, Maronesa, Minhota and Marinhoa) that produce weaned calves at 5-10 months of age. With the exception of Minhota breed, all these other breeds have Protected Designation of Origin status. Moreover, these are rustic bovine breeds that are reared using traditional systems.

The use of local breeds as an alternative to beef production system has several important advantages. In particular, local breeds are more closely linked to the environment and can help promote biodiversity and sustainable agricultural production, even in economically depressed areas. A first step in an effective management of these breeds involves their identification, description and characterization. Especially as the current market situation determines which local breeds are produced in restrictive areas. Therefore, it is necessary to increase the census of local breeds and to guarantee that the production of this kind of meat provides acceptable profit levels for farmers.

Bovine meat production and products are commonly evaluated according to growth curve performance, carcass composition and meat quality. It is crucial to provide well-characterized, quality, labelled meats to consumers. Factors that affect bovine meat composition and quality include genotype, sex, diet and production system, slaughter weight and age (Andersen *et al.*, 2005). In addition, the commercial value of traditional food products, which can be distinguished from non-traditional ones by their special production systems, provides added value to farmers located in disadvantaged regions. Fortunately, protection rules enable the recognition of local products from indigenous breeds that are reared using traditional feeding and management systems. One such indigenous breed is the Minhota breed, whose main use is to produce meat. The livestock production system of this breed mainly involves small family farms, using indoor systems or traditional grazing. The sale of cattle for slaughter is carried out between the ages of 5-7 months (150 kg of carcass weight) and 8-10 months (195 kg of carcass weight), which is the product most sought by industry, butchers and supermarket retailers.

As mentioned, the application of objective criteria for the assessment of carcass and meat quality is essential in order to define clearly production and marketing systems that can guarantee the price, quality and consistency of the product. Beef is one of the food products that have faced major difficulties, because EU rules are limited to a subjective categorization of carcasses by conformation and fatness levels. The problem is that the diversity of production factors and rearing systems also influence quality parameters such as sensory aspects, color, tenderness, juiciness, flavor, and nutritional aspects linked to content in carbohydrates, proteins, fats, vitamins and minerals. All these parameters are considered important as quality indicators and have an impact on consumers' acceptance of and satisfaction with the product (Andersen *et al.*, 2005).

No studies on carcass and meat quality of the Minhota breed have been reported until now. This breed can be compared with genetically close populations, such as the Rubia Gallega, (RG), especially in terms of its production characteristics. Thus, the aim of this work is to identify the variables that affect the quality of carcasses and meat of the Minhota cattle breed through objective, quantitative measurements of the carcass and physicochemical characteristics of meat depending on slaughter age (6 and 9 months) and sex.

Materials and methods

Animal management and carcass measurements

This study used 52 cattle (34 males and 18 females) of the Minhota breed from 22 farms. The cattle were reared using a traditional intensive system. All cattle were in pens separated from their mothers: they suckled twice a day. From the first few weeks, animals were fed with commercial feed and grass hay "*ad libitum*" until slaughter. Cattle were slaughtered at 6 (20 males and 9 females) and 9 months (14 males and 9 females) in accredited abattoirs in the northwest of Portugal and carcasses were weighed (CW) after the refrigeration period (24 h at 4 ºC). Carcass morphology was collected according to De Boer *et al.* (1974) and Franco *et al.* (2013):

- Length of carcass (LC) was measured from the anterior edge of symphysis pubis to the middle of the anterior edge of the visible part of the first rib.

- Length of leg (LL) was measured from the medial malleolus of the tibia in a straight line to the anterior edge of the symphysis pubis.

- Width of leg (WL) was measured as the horizontal distance between the outermost points on the medial and the lateral surface of the leg.

- Perimeter of leg (PL) was the maximum measurement of the horizontal contour of the leg at the symphysis pubis level.

- External depth of chest (EDC) was measured as the distance between the distal edges of the half carcass measured on an imaginary line and parallel to the ground level, at the level of the eighth sternebra of sternum.

- Internal depth of chest (IDC) was measured as the distance between the inside of the trailing edge of the eighth sternebra of sternum and the outer edge of the body of the vertebra by passing the imaginary line parallel to the ground level, at the level of the eighth sternebra of sternum.

- Carcass compactness index (CCI) was calculated according to the formula (CCI) = (CW/LC)

- Hind limb compactness index (HLCI) was calculated according to the formula (HLCI) = (LL/WL)

Measurements

At 48 h *post-mortem*, the *Longissimus thoracis* (LT) muscle was dissected between the 6^{th} and 10^{th} rib from the right half of the carcass. Following an average period of 50.2 days, all samples were vacuum packed and stored at -30 ºC for meat quality analysis. In the lean part, pH, colour parameters, water holding capacity (loss by thawing, pressing and cooking), proximate composition (moisture, protein, intramuscular fat and ashes) and shear force were measured, while in subcutaneous fat only the colour traits were recorded.

pH, colour and chemical composition

The pH of the samples was measured using a digital pH-meter (Hanna Instruments) equipped with a penetration probe of 6 cm. A colorimeter (Konica Minolta CR-300 Osaka, Japan) with the next setting machine (angle of 0° viewing angle geometry and aperture size of 8 mm) was used to measure the meat and subcutaneous colour (between the 7^{th} and 8^{th} rib) and in the CIELAB space. A near infrared spectrophotometer (Foss Tecator NIRS 6500, Denmark) was used to determine chemical composition, in duplicate, according to the methodology proposed by Moreno *et al.* (2007). Moisture was predicted using multiple linear regression with an r = 0.983 and standard error of prediction (SEP) of 0.37%, protein was predicted with an r = 0.886 and SEP of 0.51%, and fat was predicted with an r = 0.962 and SEP of 0.23%. Finally, ash content was predicted with an r = 0.873 and SEP of 0.28%.

Maximum shear force

To measure the maximum shear force, using a Warner–Braztler (WB) probe, steaks were cooked in a water bath at 75 ºC for 45 minutes with automatic temperature control (Selecta Tectron Bio, Barcelona, Spain). Then, samples were cooled to room temperature by placing the vacuum package bags in a circulatory water bath set at 18 ºC for a period of 30 min. Meat was cut into pieces of approximately 1 x 1 x 3-4 cm (height x width x length) by texturometer analyzer (Instron 10119, Instron Corp., Canton, MA) placing the WB probe perpendicular to the muscle fibre direction. Shear force was measured at room temperature using the WB probe (1 mm thick) at a crosshead speed of 150 mm/min

Water-holding capacity

The water-holding capacity (WHC) was measured in three ways: cooking loss (CL), pressing loss (PL) and thawing loss (TL) according to Franco *et al.* (2013). To evaluate CL, two 2.5 cm thick steaks were packed individually under vacuum (97%) (TECNOTRIP model EV-15-1-D) and cooked in a water bath at 75 °C for 45 min (Selecta Tectron Bio, Barcelona, Spain). Samples were cooled at room temperature and CL was calculated as follows:

$$CL = \frac{\text{(Initial fresh meat weight - Cooked weight)}}{\text{(Initial fresh meat weight)}} \times 100$$

To determine PL, a 5 g sample of minced meat was placed between two disks of Whatman No. 1 filter paper (Filter Lab, Spain). After weighing the meat, a mass of 2.5 kg was applied for 5 min. The percentage of released water was calculated as:

$$PL = \frac{\text{(Initial fresh meat weight - Pressed weight)}}{\text{(Initial fresh meat weight)}} \times 100$$

Finally, TL was calculated by determining the difference in weight between the samples before and after being frozen, following the equation:

Statistical analysis

For the assessment of meat quality (chemical composition, carcass characteristics, etc.), analysis of variance (ANOVA) using the General Linear Model (GLM) using the SPSS package (SPSS 19.0, Chicago, IL, USA) was performed for all variables considered in the study. Effects of sex and slaughter age were included in the model; however, season of birth was not included because no significant differences were found in relation to any of the variables studied:

$$Y_{ij} = \mu + CW + B_i + F_j + (B \text{ x } F)_{ij} + \varepsilon_{ij} \qquad [1]$$

where, Y_{jk} is the observation of the dependent variable; μ is the overall mean; B_i is the effect of sex (i=1,2); F_j is the effect of the slaughter age (j=1,2) and $(B \text{ x } F)_{ij}$ is the interaction term of sex and age of slaughter and ε_{ijk} is the residual random error associated with the observation. Carcass weight (CW) without interaction with main effects was included in the model as a co-variable for carcass measurements, but was not included in the assessment of meat quality parameters.

Results

Effect of slaughter age and sex on carcass characteristic

Significant differences (P<0.001) in slaughter weight between cattle slaughtered at 6 and 9 months were obtained (Table 1). The values of CW were 158.1 kg and 223.2 kg for males at 6 and 9 months, respectively and 129.9 kg and 161.2 kg for females at 6 and 9 months respectively. The differences in slaughter weight between sexes can also be observed, with males showing greater weights than females: CW of 35.6 kg *vs.* 28.1

kg for cattle slaughtered at 6 months and CW of 91.6 kg *vs*. 62 kg for cattle slaughtered at 9 months.

Regarding morphological measurements, the carcasses of older males (9 months *vs*. 6 months) were heavier and longer (LC of 106.5 *vs*. 115.1 cm, P<0.001), thicker (WL of 22.65 *vs*. 24.43 cm, P=0.037), deeper (EDC of 50.35 *vs*. 55.93 cm, P<0.001) and more compact (CCI of 1.48 *vs*.1.93, P<0.001). Similar results were obtained for older females (Table 1). Significant differences (*P*=0.049) were also found in the LTI for slaughter age. In general, variations in carcass measurements were more pronounced in males, where the maximum PL increased 9.1 cm (*P*=0.003) between cattle slaughtered at 6 and 9 months, compared to females where this increase was 5.7 cm (*P*=0.033). By contrast, when LL was studied regarding slaughter age, this parameter increased 6.30 cm between males, whereas in females it was slightly higher (6.78 cm).

Comparing sexes in cattle of 6 months, male carcasses had greater depths (EDC of 50.35 *vs*. 47.44, P=0.007), lengths (LC: 106.5 *vs*. 100.78, P=0.048), thicknesses (WL: 22.65 *vs*. 20.56, P=0.043), and compactness index (1.48 *vs*. 1.29, P=0.045) than in female ones (Table 1). However, there were no significant differences (P=0.655) in the LTI of the leg. Regarding older cattle, it can be inferred that males are better conformed than females: their carcasses showed greater lengths (LC of 115.1 *vs*. 110.5, P=0.067), depths (EDC of 55.9 *vs*. 52.4, P=0.022), thicknesses (WL of 24.4 *vs*. 22.5; P=0.008) and maximum circumferences of the leg (PL of 104.2 *vs*. 96.2, P=0.004).

Effect of slaughter age and sex on meat quality

There were no significant differences (*P*>0.05) in meat pH values depending on slaughtered age in female or male Minhota meat (Table 2). Regarding chemical composition, cattle slaughtered at 6 months showed lower IMF than those slaughtered at 9 months (1.36 *vs*. 2.13%; *P*<0.001) and higher values of moisture content (76.99 *vs*.

76.87%; *P*=0.737). In females, there were only significant differences in the IMF parameter (2.74 *vs.* 1.72%; *P*<0.001for cattle slaughtered at 9 and 6 months, respectively). With regard to colour, the age of slaughter did not affect L* and b*-values for either sex. However, the a*-value was significantly influenced by animal age: the youngest cattle showed lower values (13.14 *vs.* 15.46, *P=0.028* in males, and 11.62 *vs.* 14.66, *P*=0.007 in females). As for subcutaneous fat, L* and a*-values were not affected by animal age, whereas the highest b*-values corresponded to the older cattle (8.45 *vs.* 8.41, *P*=0.928 for 9 and 6 months, respectively). Finally, water holding capacity measured by CL was significantly higher only in female older cattle with values of 30.08 *vs.* 27.74% (*P*=0.098) in males and 29.15 *vs.* 24.40% (*P*=0.004) in females. No significant differences were found in TL and PL by animal age or sex. Likewise, maximum shear force was unaffected by animal age or sex.

Discussion

Effect of slaughter age and sex on carcass characteristic

Carcass weights of cattle slaughtered at an early age (6 months) was higher than those obtained by Franco *et al.* (2010) in male Galician rustic breeds (Cachena, Vianesa, Limia and Caldela). Regarding male cattle slaughtered at 9 months, our CWs were slightly higher than those indicated by Bispo *et al.* (2010), with values of 204 kg, although in their study cattle were slaughtered at 8 months.

Carcass yields were lower than those obtained by Piedrafita *et al.* (2003), who worked with seven Spanish breeds (range is between 56.3 to 58.1%). However, they were higher than those found in male non-weaned cattle of RG with values of 52.8% (Bispo *et al.*, 2010) and in male rustic Galician cattle breed slaughtered at 9 months of age (Cachena, Caldelá, Vianesa, and Limiá; Franco *et al.*, 2010), whose values were nearly 48%. Obviously, comparisons should be made with caution because the use of genetically selected animals, different rearing systems with intensive finishing period or differences in carcass measurements could also influence yields. However, Arthur *et al.* (1995) working with calf breeds such as Angus, Hereford and Charolais, slaughtered at an older age than the animals presented in this study, reported DPs of 55.7%, 56.6% and 55.6%, respectively, only slightly higher than the average value of the present work at 54.6%.

Males of the Minhota breed slaughtered at 9 months presented larger carcasses and legs than those found by Franco *et al.* (2010) in males of the Vianesa and Limia breed slaughtered at a similar age with average values of 108.5 cm and 72.7 cm for LC and LL, respectively. Regarding variables related to the volume of the leg, such as WL, EDC and PL, the Minhota breed also presented higher values than the aforementioned Galician breeds. Within the carcass variables, six linear measurements (LC, PL, LL, IDC, EDC and CCI) were able to differentiate between types of animals. CCI denotes carcass compactness, so a higher CCI denotes better conformation. In a study by Alberti *et al.* (2005), which analyzed the CCI of seven carcasses from Spanish breeds, better results in RG cattle were obtained than in other breeds: the values were very similar to those for the Minhota breed slaughtered at 9 months in this study. Significantly higher values for CCI were also found with respect to rustic Galician breeds (1.25 for Limia breed *vs.* 1.93 for Minhota breed). Our results confirm the data obtained by Barriada (1995), who stated that CCI in the Asturiana de los Valles breed of cattle improved with increasing slaughter weight. The CCI was higher in males than in females due to weight increase from the age effect. With respect to HLCI, a good indicator of the amount of meat in the hind quarter, no significant differences (P=0.265) between sexes were observed, although values were slightly lower in males than in females.

Effect of slaughter age and sex on meat quality

The pH values varied between 5.39 to 5.41 for the youngest cattle and 5.41 to 5.43 for the oldest ones. Our results were in the same range of those reported by Bispo *et al.* (2010) and Oliete *et al.* (2006) in the RG breed. The chemical composition of the *L. thoracis* obtained in this study was not affected by slaughter age or sex as indicated by Sañudo *et al.* (1999). A similar range of values for the chemical composition (moisture, protein and ash) has been found by other authors for RG cattle (Moreno *et al.*, 2006; Bispo *et al.*, 2010) and for other endangered Galician cattle breeds (Franco *et al.*, 2010). The average values obtained for IMF, regardless of the sex, were 1.36% and 2.13% for cattle slaughtered at 6 and 9 months, respectively. These values were higher than those obtained by Moreno *et al.* (2006), who reported for RG weaned cattle values of 0.60% in males and 1.19% in females.

Concerning colour parameters, luminosity values coincided with those indicated by Oliete (2006) in the RG breed. These L*- values did not differ significantly between sexes, although slightly higher values were observed in males. The red index of *L. thoracis* was significantly influenced by animal age. This index increased with age because older animals grow more fat in the muscle, decreasing the pigment permeability necessary to ensure an adequate supply of oxygen to the cell. Regarding a*-values, Minhota cattle showed similar values to those found by Oliete *et al.* (2006) and Bispo *et al.* (2010), which indicate that the RG does not have a pinker meat than the Minhota breed. These differences in a*-values between cattle are in agreement with those obtained by Oliete *et al.* (2006) in the RG breed. Nevertheless, the values obtained for Minhota breed were slightly lower, possibly due to the lower amount of fatness of unweaned animals and lower myoglobin content of meat. Values for b*-values were lower than those reported for the RG breed (Oliete *et al.*, 2006). In animals slaughtered at 9 months, b*-values were significantly higher ($P<0.01$) in males than in females. L*-

values from subcutaneous fat were higher in younger animals, although they did not reach statistical significance (*P*=0.178). The diminishing L*-values in subcutaneous fat occurred with increasing age due to the accumulation of chromogenic pigments from their diet. Values for subcutaneous fat luminosity were slightly lower than the values found by Bispo *et al.* (2010). The red index was not affected by slaughter age. The red component, like the yellow component, depends on diet pigments, although these pigment have less influence on a*-values than in b*-values (Moreno *et al.*, 2006).

Slaughter age only affected CL, which is in contrast to the results obtained in the RG breed. Oliete *et al.*, (2006) attributed these differences to the pH influence. Additionally, Bispo *et al.* (2010) and Oliete *et al.* (2006) did not find any differences in WHC between animals from RG depending on weaning status. The results obtained for CL in male animals of 9 months (29.61%; Table 2) were close to those obtained by the aforementioned authors with values ranging from 30.30% to 31.46% for non-weaned cattle.

Regarding texture, in the literature review, studies do not agree on the slaughter age effect. The increase in shear force over a wider range of age is associated with increased resistance of connective tissue primarily due to an increase in its insolubility (Bosselman *et al.*, 1995). The absence of differences in the animals of our study may be because the age range was not wide enough to notice an increase in meat hardness. The minimum difference between the average values of the meat's shear force between young and old cattle could be due to the age effect. This is balanced by IMF, which is higher in old animals, since meat tenderness increases with higher IMF content. Shear force was not affected by sex, which agrees with the results obtained by Paterson *et al.* (1988). However, Eilers *et al.* (1996) found lower values in females, which may be due to the lower amount of collagen in females or a higher IMF content that implies a higher marbling degree.

According to shear force, female animals from 6 months were the tenderest (4.40 kg/cm^2), and the toughest were the 9-month females (5.43 kg/cm^2). These values are in the same range as other Galician cattle breeds (4.13 and 4.50 kg/cm^2, for Caldelá and Vianesa breeds, respectively) but were higher than those obtained for Cachena (3.80 kg/cm^2) and Limiá (3.87 kg/cm^2) breeds (Franco *et al.,* 2010). According to the tenderness classification proposed by Belew *et al.* (2003), Minhota meat could be considered as “intermediate” (3.9<WB shear force<4.6 kg) for two cases and “tough” (WB shear force>4.6 kg) for the other two (Table 2)

Conclusions

The male carcasses were heavier compared to those of the female, with higher dressing percentages, increased lengths, thicknesses and depths and higher compactness indexes. Both male and female calf meat was of a strong light colour, a pale pink tone and had a high yellow index, which is common for animals without weaning. The toughness of the meat was below 5.5 kg/cm^2, in all cases. Although the market demands very young bull cattle, the slight differences that have been obtained in the characteristics of the meat between the different ages show that the slaughter of these cattle could be carried out at later ages to the current ones without any decrease in quality.

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Table 1. Effect of sex and slaughter age on carcass parameters of male and female cattle of the Minhota breed

	Male		Female		P-values		
	6 months	9 months	6 months	9 months			
	n=20	n=14	n=9	n=9	Age	Sex	Age x Sex
Age (days)	182	284	179	262	--	--	n.s.
Carcass characteristics							
Live weight (kg), LW	283.2 (0.13)	400.6 (0.13)	247.6 (0.12)	309.0 (0.06)	<0.001	<0.001	0.245
Carcass weight (kg), CW	158.1 (0.17)	223.2 (0.13)	129.9 (0.15)	161.2 (0.08)	<0.001	<0.001	0.321
Dressing percentage (%), DP	55.68 (0.07)	55.81(0.05)	52.47 (0.07)	52.16 (0.04)	0.012	0.729	0.358
Carcass measurements (cm)							
Length of carcass, LC	106.50 (0.04)	115.10 (0.05)	100.80 (0.10)	110.62 (0.04)	0.313	0.504	0.067
Length of leg, LL	69.20 (0.04)	75.50 (0.05)	64.44 (0.08)	71.22 (0.02)	0.060	0.801	0.024
Width of leg, WL	22.65 (0.12)	24.43 (0.06)	20.56 (0.08)	22.56 (0.05)	0.172	0.333	0.028
Perimeter of leg, PL	95.15 (0.09)	104.2 (0.06)	90.67 (0.07)	96.33 (0.03)	0.098	0.050	0.176
External depth of chest, EDC	50.35 (0.05)	55.93 (0.07)	47.44 (0.05)	52.44 (0.03)	0.017	0.575	0.358
Internal depth of chest, IDC	32.35 (0.06)	37.21 (0.11)	30.22 (0.06)	34.00 (0.07)	0.030	0.357	0.936
Carcass compactness index, CCI	1.48 (0.15)	1.93 (0.09)	1.29 (0.13)	1.46 (0.07)	0.295	0.729	0.271
Hind limb compactness index, HLCI	3.09 (0.09)	3.10 (0.05)	3.14 (0.07)	3.17 (0.05)	0.049	0.265	0.460

In brackets, after mean value, relative standard deviation is calculated as SD divided by mean value

Table 2. Effect of sex and slaughter age on chemical composition, colour parameters, water holding capacity and texture of *Longissimus t horacis* from male and female cattle of the Minhota breed

	Male		Female		P -values		
	6 months	9 months	6 months	9 months			
	n=20	n=14	n=9	n=9	Age	Sex	Age x Sex
Chemical composition							
pH	5.39 (0.009)	5.41 (0.007)	5.41 (0.01)	5.43 (0.009)	0.370	0.466	0.948
Moisture (%)	77.47 (0.008)	76.84 (0.007)	76.43 (0.008)	76.90 (0.010)	0.737	0.043	0.024
Ashes (%)	1.17 (0.008)	1.17 (0.010)	1.17 (0.008)	1.15 (0.010)	0.140	0.534	0.210
Protein (%)	22.11 (0.03)	22.44 (0.017)	23.03 (0.03)	22.32 (0.02)	0.398	0.077	0.025
IMF (%)	1.01 (0.36)	1.52 (0.25)	1.72 (0.30)	2.74 (0.30)	<0.001	<0.001	0.183
Colour parameters							
L thoracis							
Luminosity (L*)	40.03 (0.03)	38.25 (0.04)	39.53 (0.09)	36.83 (0.05)	0.016	0.280	0.596
Redness (a*)	13.14 (0.06)	15.46 (0.09)	11.62 (0.08)	14.66 (0.13)	<0.001	0.043	0.511
Yellowness (b*)	8.31 (0.08)	9.27 (0.12)	8.52 (0.20)	7.64 (0.11)	0.928	0.129	0.053
Subcutaneus fat							
Luminosity (L*)	65.78 (0.02)	64.74 (0.05)	64.67 (0.02)	63.38 (0.04)	0.205	0.178	0.888
Redness (a*)	3.77 (0.41)	4.69 (0.30)	2.27 (0.26)	3.48 (0.39)	0.060	0.019	0.791
Yellowness (b*)	8.43 (0.20)	10.50 (0.10)	10.08 (0.110)	8.30 (0.008)	0.785	0.610	0.001
Water holding capacity							
Thawing loss (%), TL	1.98 (0.39)	2.98 (0.40)	2.66 (0.39)	2.50 (0.36)	0.376	0.836	0.224
Pressing loss (%), PL	19.63 (0.24)	20.77 (0.11)	18.17 (0.20)	20.10 (0.03)	0.257	0.429	0.770
Cooking loss (%), CL	27.74 (0.12)	30.08 (0.07)	24.40 (0.13)	29.15 (0.04)	0.010	0.036	0.223
Texture parameter							
Shear force (kg)	4.76 (0.26)	4.48 (0.30)	4.40 (0.34)	5.43 (0.21)	0.424	0.526	0.164

In brackets, after mean value, relative standard deviation is calculated as SD divided by mean value