The effect of chilled storage on the quality of meat from the feral wild boar (Sus scrofa)

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ABSTRACT

*M. Longissimus lumborum* from 16 wild boars was analysed 48 and 360-h post-mortem in order to evaluate the effect of storage on the quality of meat from the feral wild boar. The pH of *M. Longissimus lumborum* measured 5.72 (48 h) and increased after storage by 0.09. The colour parameters were not affected by storage at +2 °C, and were typical for game meat. The effect of chilled storage was observed in form of the following changes: a decrease in free water percentage and drip loss, and an increase of meat plasticity. A significant decrease has been recorded in the Warner-Bratzler force difference, initial biting force and biting peak force. The storage time did not affect the proximal chemical composition of the wild boar meat. The microbial growth of wild boar meat increased gradually during chilled storage. On the basis of the presented results, it can be concluded about no signs of negative effect of chilled storage on the quality of meat of the wild boar.

HIGHLIGHTS

- The 14-day storage period at +2 °C allows for the development of desirable textural traits of meat from wild boar.
- The wild boar meat stored for 14 days characterised with proper microbiological quality.
- The wild boar meat revealed some attributes of abnormal quality.

Introduction

The population of wild boar in the European countries has been increasing in the last decades (Sales and Kotra 2013; Russo et al. 2017). According to the data of Agricultural Property Agency, General Directorate of the State Forests and the Polish Hunting Association the number of wild boars (*Sus scrofa*) in the hunting season 1999/2000 was about 118,000, with a density of 0.47 animals per 1 km² (Central Statistical Office 2017). For the following seasons, the population has been much higher, even up to 284,000 in the season 2013/2014. While in the season 2016/2017, it has been estimated for 214,000 heads. According to the official data, the wild boar is still one of the most numerous game species in Poland (on the 4th place after roe deer, hare and pheasant) and the mostly hunted one, as well. The overpopulation of wild boar observed in Poland and other European countries is mainly affected by the decreasing area of woodlands, increasing area of corn production, and the great adaptability of wild boar to the changing environment (Popczyk 2016).

Today, due to greater consciousness about the influence of food on human health, the interest of modern consumer in game meat is enhancing (Soriano et al. 2006). The natural, slow growth of game animals and the nutrition based on natural feed results in lighter carcases, but also in the development of high quality meat (Babicz et al. 2018). The acquisition of wild animals does not affect the environment, and is not related to welfare concerns like animal farming. The characteristic flavour and texture of game decides about its advantage over the meat produced on the way of an intensive farming procedure known as factory farming (Daszkiewicz et al. 2015).
However, the game meat preparation is much more time consuming and requires more cooking skills than preparation of pork, and its accessibility is limited by the hunting season. Moreover there are number of factors affecting the quality of game meat, like the skills of the hunter (precision of the shot), weather conditions, the hygiene of dressing (Paulsen 2011; Mirceta et al. 2017).

The aim of this study was to evaluate meat from the feral wild boars after aging (chilled storage). In order to realise this goal, the fresh meat (48-h post-mortem) was analysed for quality attributes, and compared to measures after 14 days of chilled storage (360-h post-mortem).

**Materials and methods**

**Animals and muscle samples**

The animals analysed in this study were hunted in west-central Poland. The animals were obtained by qualified hunters. The post-mortem management of hunt-harvested wild boars was conducted according to the European (Council Directive 2004; Council Regulation 2004) and Polish law regulations (Polish Law Gazette 2005, No 61, Item 548 and the following changing acts: Polish Law Gazette 2010, No 186, Item 1250; Polish Law Gazette 2011, No 257, Item 1548; Polish Law Gazette 2013, Item 889; Polish Law Gazette 2017, Item 1485). Wild boar males (16 animals; aged about 2 years) had a mean carcase weight (after evisceration) of 63.8 kg (min 54.0 kg, max 69.5 kg). The animals were shot during a group hunt in December, in the morning hours. After shooting, the wild boars were bled out and eviscerated, transported from the hunting area to the slaughterhouse and dressed. In the slaughterhouse, all the hunted animals went through veterinary inspection. The left and right *M. longissimus lumbrorum* (LL) were cut from the carcases 48 h post-mortem. The left LL muscle (A samples) was used for analysis made directly post-mortem (48h). The right LL muscle (B samples) was packed in PA/PE (polyamide and polyethylene) vacuum bags (oxygen permeability: <10 cm³/m²/24h/atm, at temperature 23°C and 50% humidity; 90 μm thick walls) using the TEPRO vacuum packer PP4.2. The vacuum-packaged samples were stored for 14 days at +2°C (0–4°C) and then analysed on the 15th day post-mortem (360h) in terms of the effect of storage on the quality of wild boar meat. The methods used in the study are presented in Table 1.

**Meat pH**

The pH of LL was measured by inserting a calibrated combination glass calomel electrode (ERH-11X1, SCHOTT, Germany) connected to a portable pH-meter (Handylab 2, SCHOTT) into the meat. The pH measurement was obtained 48 and 360 h post-mortem.

**Colour coordinates**

The colour parameters were recorded 48 and 360-h after post-mortem. Each LL sample was allowed to bloom for 45 min before the measurement. The colour measures were made with the Minolta colourimeter CR-700d (illuminant D65, 10° observer with a 8-mm-diameter aperture size; Konica Minolta, The Netherlands). The instrument was calibrated using a CM-A177 white calibration cap and CM-A183 target mask with glass. The CIE system was used for the measurement of lightness (*L*), redness (*a*) and yellowness (*b*). The chroma (*C*) and hue-angle (*H*) was calculated according to the following formulae:

\[
C^* = \sqrt{(a^*)^2 + (b^*)^2}^{1/2}
\]

\[
H^0 = \tan^{-1}b^*/a^*
\]

**Capacity to hold residual water and percentage of water fractions**

The purge loss in vacuum packaging was calculated as the difference in the initial weight of the samples (48-h post-mortem), and the weight after removing meat samples from the vacuum bags (360-h post-mortem).

The drip loss, cooking loss, total water, free water and plasticity were measured for the LL muscles 48 and 360-h post-mortem. There were three repetitions of each measurement made on the fresh and stored meat.

| Type of analysis                  | 48-h post-mortem | 360-h post-mortem |
|----------------------------------|------------------|-------------------|
| Microbiological analysis         | +                | –                 |
| pH measurement                   | +                | +                 |
| Colour measurement               | +                | +                 |
| Purge loss in vacuum bags        | +                | +                 |
| Drip loss                        | +                | +                 |
| Cooking loss                     | +                | +                 |
| Free water                       | +                | +                 |
| Plasticity                       | +                | +                 |
| Texture analysis                 | +                | +                 |
| Dry matter                       | +                | +                 |
| Crude protein                    | +                | +                 |
| Fat                              | +                | +                 |
| W/CP                             | +                | +                 |

W/CP: water to crude protein ratio.

Table 1. Quality evaluations of wild boar *Longissimus lumbrorum*.
The drip loss (%) was measured according to the method of Honikel (1998). The 2.5-cm-thick, transverse slices of the analysed muscles (40–50 g) were weighed, hung on hooks and placed in a container to reduce evaporation (±2°C). After 24 h, the samples were reweighed. The result was calculated as the difference in weight before and after 24 h storage in hanging position, and expressed in percentage.

The cooking loss (%) was measured according to the method of Honikel (1998). The 2.5-cm-thick, transverse slices of the analysed muscles (40–50 g) were placed in thin polyethylene bags, with the bag’s wall firmly adhered to the meat sample. The bags with meat were placed in a water bath at 75°C for 30 min, and then cooled to room temperature and reweighed after removing the excess of moisture with a paper towel. The result was calculated as the difference in weight before and after thermal processing, and expressed in percentage.

The analysis of the total water content was conducted using the AOAC International (2000) method for analysis of moisture (Method 950.46).

The free water (%) was measured using a filter-paper press method, according to the method of Grau and Hamm (1953) in modification of Pohja and Niinivaara (1957). A 2.0-cm-thick, transverse slices of the LL (30–40 g) has been ground. Subsamples (0.300 g) of ground meat were placed on a filter paper between two glass tiles. A 2-kg weight was applied on each sample for 5 min. Then, samples were removed from the filter paper and reweighed straight after to calculate the change in their weight. The calculations were made using the following formula:

\[
\text{Free water (\%) = \left(\frac{\text{sample of ground meat (g)}}{\text{sample of meat after 5 min of 2 kg pressure (g)}}\right) \times 100/\text{sample of ground meat}}
\]

Meat plasticity (cm²) measurement was conducted according to the method of Pohja and Niinivaara (1957), simultaneously to the free water measurement. The area of pressed meat was marked on the filter paper, scanned and measured by means of ImageJ ver. 1.52 software. The plasticity was expressed as the area of the compressed meat sample (cm²) used for the measurement of free water.

Texture analysis

The Shear Force measurement was done with the Warner–Bratzler V-shaped blade attached to the TA.XT Plus Texture Analyser (Stable Micro Systems, UK; test speed 2 mm/s; distance 20 mm; trigger force 20 g). The meat texture was evaluated on cooked and raw samples. The raw samples included the fresh (48 h) and stored meat (360 h). The cooked samples were obtained after the measurement of cooking loss, and kept for 24 h at 2°C in plastic bags. In order to analyse the shear force value of raw material, the samples after drip loss measurement were used. Two samples were evaluated per day per animal to record the Warner–Bratzler measures of cooked or raw meat. Prior to analysis, the 1.6 cm diameter cores were removed from each LL sample with a round knife (2–3 cores per sample, parallel to the muscle fibres). The measurement projects used by the Texture Analyser to cut/bite through were set to record two forces—the initial force used to cut through the sample surface and the peak force (maximal force used by the instrument to cut/bite the sample). The idea to include the initial force to the texture measures was adapted from the study of Gornowicz et al. (2016). Warner–Bratzler Shear force measurements included: the initial force (WB initial; N), the peak force (WB pick force; N), the difference between the peak force and the initial force (WB force difference; N) and the area under the curve referred as the Warner–Bratzler Shear Energy (WB energy; N/mm). The measurement of biting was done by means of Volodkevich Bite Jaws (test speed 2 mm/s; strain 100%; trigger force 5 g). The measurement was done 48 and 360-h post-mortem, and included measures of two samples per day per animal. The meat samples were obtained from the muscle parts used for the measurement of cooking loss. Prior to analysis, the muscle parts were placed at a room temperature. The Twin Blade Sample Preparation Tool was used to cut 10 × 10 mm size stripes laterally to the muscle fibres (two stripes per sample). The following measurements were taken: the initial biting force (V initial; N) and the peak force (V peak force; N) and the difference between the peak force and the initial force (V force difference; N).

Proximal chemical composition

The analysis of the chemical composition was conducted using the AOAC International (2000) methods for analysis of moisture (Method 950.46), crude fat (Method 960.39) and protein content (Method 976.05). The analysis of wild boar LL were made 48 and 360-h post-mortem and included: the dry matter content calculated on the basis of moisture content measurement (the samples were dried at 105°C to a constant weight), the determination of the total protein content.
with the Kjeldahl procedure (K-424 Buchi digestion unit; Büchi Labortechnik AG, Switzerland), the determination of extractable fat content by Soxhlet extraction with diethyl ether (MLL 147, AJL Electronics, Poland).

**Microbiological analysis**

Fresh meat samples (48-h post-mortem) weighting about 100 g were packed in sterile bags and kept at 0–2°C until microbiological analysis, which took place at a maximum time of 12 h after collection. The analysis was repeated on samples collected from meat stored in vacuum packaging. Method for enumeration of micro-organisms that are able to grow and form colonies on the surface of a solid medium after aerobic incubation for 72 h at 30°C was used for determination of the total number of mesophilic aerobic micro-organisms (TM) (ISO 4833-2:2013-12). ISO 16649-2:2004 method was used for the enumeration of betaglucuronidase-positive *Escherichia coli* (EC) incubated at 44°C on a solid medium containing a 5-bromo-4-chloro-3-indolyl beta-D-glucuronide. Detection and enumeration of *Enterobacteriaceae* (EB) were carried out according to ISO 21528-2:2005 standard. *Salmonella spp.* (SL) and *Listeria monocytogenes* (LM) were determined using ISO 6579-1:2017-04 and ISO 11290-1:1999+A1:2005 methods, respectively. The results of TM, EC and EB analysis were expressed as log10 of colonies forming unit per gram of meat sample (CFU/g), while SL and LM were expressed as detectable/not detectable in 25 g of meat sample.

**Statistical analysis**

The statistical analysis was made using the procedures of SAS (2012). The effect of the storage time on the pH, colour parameters (L*, a*, b*, chroma, hue-angle), drip loss, total water, free water, cooking loss, plasticity, WB initial force, WB peak force, WB force difference and WB energy, V initial force, V peak force, V force difference, dry matter, crude protein, extractable fat content, and W/CP (water to crude protein ratio) was calculated with the model:

\[
Y_{ijk} = \mu + \alpha_i + \beta_{j(i)} + e_{ijk}
\]

where:

- \(Y_{ijk}\) - the phenotypic value of the trait
- \(\mu\) - the overall mean of the analysed trait,
- \(\alpha_i\) - the random effect of \(i\)th animal (\(i=1, 2, 3, \ldots 16\))
- \(\beta_{j(i)}\) - the effect of \(j\)th storage time as the repeated measures factor nested in \(i\)th animal,
- \(e_{ijk}\) - random error.

The Tukey–Kramer adjustment was implemented for multiple comparisons of the measures of quality traits.

For the results of TM, EC and EB analysis, the mean value, standard deviation and significance of differences between the mean values was calculated (the Student’s t test) based on log10 CFU/g values. The results of the statistical test were considered significant for \(p < .05\).

**Results and discussion**

**Value of pH and colour coordinates**

The meat analysed in this study was subjected to a chilled storage in order to develop characteristics of aged meat. Meat aging is a complex, not fully understood process, essential for proper meat palatability (Herrera-Mendez et al. 2006; Aaslyng and Meinert 2017). The results of pH and colour measurements made in the LL of wild boars 48 and 360 h post-mortem are presented in Table 2. The meat storage only slightly affected the pH (\(p = .015\)), and after 14 days storage the pH was higher by 0.09 points compared to its value 48-h post-mortem. No negative effect of storage on the pH value and colour parameters indicates good shelf life and colour stability of the wild boar meat. There was a slight increase in the pH value recorded between the 48 and 360 h post-mortem, but the final pH value did exceed the normal range of pH given in the literature for hunted wild boar meat. Compared to this study, a lower value of pH measured 24-h post-mortem was presented in other research papers (Marchiori and Felício 2003; Marsico et al. 2007; Cifuni et al. 2014) for the *longissimus muscle* of wild boars (5.62–5.64, 5.46 and 5.48, respectively). In their study, Florek et al. (2017) report even higher pH for wild boar meat kept frozen in vacuum pouches for 60 days. After thawing, the pH measured 5.93 and increased to 6.00 after 7 days of chilled storage. It was found by Marchiori and Felício (2003), that the wild

| Trait               | 48 h  | 360 h | SEM  | Effect (p-value) |
|---------------------|-------|-------|------|-----------------|
| pH                  | 5.720 | 5.810 | 0.020| .006            |
| Lightness (L*)      | 42.640| 44.340| 1.010| .267            |
| Redness (a*)        | 15.300| 13.870| 0.810| .246            |
| Yellowness (b*)     | 13.710| 13.440| 1.040| .858            |
| Chroma              | 20.570| 19.360| 1.270| .525            |
| Hue angle           | 41.630| 43.530| 1.120| .239            |

Values are presented as least square mean and standard error of the mean (SEM).
boar meat was lighter ($L^* = 49.82$), less red ($a^* = 9.50$) and less yellow ($b^* = 12.99$) compared to the meat in our study. Similarly to the measures presented in this article, Cifuni et al. (2014) give the lightness of wild boar meat measuring $L^* = 45.37$, however the analysed meat characterised with DFD-like abnormal quality, probably due to the dog-driven hunting.

**Capacity of wild boar meat to hold its residual water and percentage of water fractions**

The capacity of meat to hold its residual water and the share of different water compartments (bound, immobilised and free water), strongly affects the culinary and technological usefulness of meat (Huff-Lonergan and Lonergan 2005; Bodnar and Bodnar 2015). Table 3 contains the measurements defining the capacity of meat from the wild boar to hold its residual water and the measurements of selected water fractions. In this study, the quality trait that was mostly affected by the meat storage was the free water percentage, which decreased after storage by 5.1 percentage points ($p = .008$). The 15-day-storage resulted in a decrease of drip loss and free water share in total water ($p = .010$), together with an increase of meat plasticity ($p = .034$). According to the current state of knowledge, the capacity of meat to hold residual water should increase with the process of aging, due to microstructural changes in myofibrils causing the ‘sponge effect’ (Farouk et al. 2012). The amount of drip loss in our study (2.36% in meat stored for 48 h, and 1.76% in meat stored for 360 h) was lower compared to the value obtained in the study of Marchiori and Felício (2003) in the meat of wild boar males (4.55%) and females (3.42%). The same authors reported a free water percentage of 20.75% for males and 20.15% for wild boar females, differently to the free water measures presented in our study (35.46% and 30.36%). This contrast in the percentage of free water is probably related to the method of measurement, and differences in the used force and time of pressure. To examine the free water percentage, the mentioned authors used a force of 3450 kPa to press 500 g meat samples for 1 min. In comparison to the results presented in our article, Borilova et al. (2016) reported a higher cooking loss (cooked at 70 °C for 60 min) for the shoulder and the leg of wild boars (36.74 and 37.08%). However, the authors analysed meat that was frozen and thawed before the examination, and therefore the greater cooking loss might be related to the damages in the structure of muscle cells (Ngapo et al. 1999). In the study of Cifuni et al. (2016), they give a 32.85% cooking loss (samples cooked at 80 °C, until the internal temperature reached 70 °C) in the meat of wild boars hunted with a harvest culling. The differences in free water and cooking loss levels found between results of different research are most probably related to different conditions of measurement. In the measurement of free water percentage, the value of this trait increases with the force and time of sample pressure. While cooking loss is majorly affected by temperature of cooking and the target temperature inside the sample.

**Meat texture**

In this study, the storage caused a decrease of the WB peak force of raw meat by 3.40 units (the difference between WB peak force 48 h and 360 h post-mortem), but it was not statistically significant (Table 4). A significant change has been recorded in the WB force difference, which decreased after storage of raw meat by 7.58 units (the difference between WB force difference 48 and 360 h post-mortem; $p = .047$). The measures taken by means of the Bite Jaws indicate that the V

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**Table 3.** The capacity of wild boar *Longissimus lumborum* to hold its residual water, water fractions and plasticity.

| Trait                  | Storage time | SEM | Effect (p-value) |
|------------------------|--------------|-----|------------------|
| Purge loss in vacuum (%) | 48 h 360 h   |     |                  |
| Drip loss (%)           | 2.360 1.760  | .130 | .004             |
| Total water (%)         | 33.970 35.460| .480 | .136             |
| Free water (%)          | 35.460 30.360| 1.070| .008             |
| Plasticity (cm³)        | 2.870 3.980  | .320 | .021             |
| Cooking loss (%)        | 34.400 33.970| .840 | .958             |

Values are presented as least square mean and standard error of the mean (SEM).

**Table 4.** The texture measurements of wild boar *longissimus lumborum*.

| Trait                  | Storage time | SEM | Effect (p-value) |
|------------------------|--------------|-----|------------------|
| WB initial force (N)   | 15.800 20.100| 1.900| .127             |
| WB peak force (N)      | 28.800 24.900| 1.800| .216             |
| WB force difference (N)| 12.220 6.460 | 2.100| .017             |
| WB energy (N·mm)       | 12.209 8760  | 691 | .003             |
| V initial force (N)    | 34.200 33.800| 2.200| .912             |
| V peak force (N)       | 36.000 25.800| 2.900| .025             |
| V force difference (N) | 0.170 0.060  | 0.090| .362             |

Values are presented as least square mean and standard error of the mean (SEM).
initial force and V peak force decreased after storage (\(p = .043\) and \(p = .040\)). The decrease of V force difference was also observed (by 0.11 units), however it was not significant (\(p = .381\)). The texture measures in our study indicate an increase of tenderness due to post-mortem changes in the muscle tissue. In the study of Górecka et al. (2012), they analysed the WB shear force of fresh and stored wild boar meat (\textit{longissimus lumborum}), using different times and temperatures of storage. The WB shear force of fresh LL was 86.21 N/cm\(^2\), and it decreases after storage (\(p < .05\)): to 70.39 N/cm\(^2\) in LL stored at \(-1^\circ C\) for 14 days, to 64.22 N/cm\(^2\) in LL stored at \(-1^\circ C\) for 28 days, and to 78.51 N/cm\(^2\) in LL stored at \(-18^\circ C\) for 28 days. Cifuni et al. (2014), in their study, presented much greater hardness of the wild boar meat compared to our study. The authors examined the tenderness of the \textit{longissimus thoracis} muscle of wild boars obtained either with dog-driven hunting or harvest culling, and noted that the WB shear force measured 43.57 N and 52.49 N, depending on the hunting method. However, considering the fact that there was a great variety of age among the hunted wild boars, that both males and females were examined, and that the meat was frozen for 3 months at \(-20^\circ C\), and thawed prior to laboratory analysis, the mentioned results are also difficult to compare with the data in our study.

### The proximal chemical composition

The chemical composition of meat might be affected by the chilled storage, due to loss of moisture as purge (Pearce et al. 2011). However, the chemical composition of meat from the wild boar examined in our study was not affected by the storage (Table 5). In their study, Pedrazzoli et al. (2017) reported a similar proximal chemical composition of wild boar meat (animals older than 2 years, average weight of 84 kg) compared to chemical composition in our study. An analysis made by Borilova et al. (2016) noted a slightly higher dry matter content for the wild boar meat the early post-mortem period (24.82 and 24.27% in the shoulder and leg), compared to the dry matter content in this study. In the study of Florek et al. (2017), they reported a lower content of protein and fat in the meat of wild boar measuring 19.24 and 0.83%, and a higher W/P ratio measuring 3.86 compared to the results of our study. During chilled storage of raw meat typically some amount of purge loss can be observed. This purge contains valuable chemical compounds, like sacroplasmatic proteins and water-soluble vitamins (Savage et al. 1990). Similarly to our results, Borilova et al. (2016) found no effect of 14-day storage on the dry matter content. This allows us to conclude about no loss of soluble muscle proteins together with the moisture that is lost during the chilled storage of meat. On the other hand, Szmarniko et al. (2007) found a negative effect of wild boar meat storage on its chemical composition. In their study, the dry matter content in fresh meat was 27.41%, and decreased to 25.64% after 14 days of storage at \(-1^\circ C\), and to 26.08% after 28 days of storage at \(-1^\circ C\) (changes were significant at \(p < .05\)). The observed decrease in the dry matter content was most probably related with loss of total fat (2.62% in fresh meat versus 2.56% and 2.06% after storage; \(p < .05\)) and soluble proteins (6.41% in fresh meat versus 6.18% and 6.17% after storage; \(p < .05\)).

### Microbiological quality

The microbiological quality of game meat is very diversified and depend on numerous factors, e.g. qualitative and quantitative characteristics of the primary microflora on the surface and digestive tract of the carcase; the hunting method and the anatomical location of the shot; time and precision of evisceration; time-temperature history and hygienic practise during transport, and carcase dressing operations (Mirceta et al. 2017). Quality and shelf-life of meat during storage is also directly related to storage conditions and intrinsic biochemical features of the meat (Boers et al. 1994). Results of total number of mesophilic aerobic micro-organisms (TM), \(\beta\)-glucuronidase-positive \textit{Escherichia coli} (EC), \textit{Enterobacteriaceae} (EB), \textit{Salmonella spp.} (SL) and \textit{Listeria monocytogenes} (LM) of wild boar LL stored for 48 and 360 h in 2°C are presented in Table 6. Compared to the results in our study considering wild boar meat analysed 48 h post-mortem, Russo et al. (2017) reported higher total mesophilic bacteria, \textit{Enterobacteriaceae} and \textit{E. coli} loads of wild boar \textit{Longissimus dorsi} (0–4°C, 24 h post-mortem) measuring 5.36, 4.32 and 4.12 log10 CFU/g. In their study, Atanassova et al. (2008) reported values of

### Table 5. The proximal chemical composition of wild boar \textit{Longissimus lumborum}.

| Trait           | 48 h    | 360 h   | SEM   | Effect (\(p\)-value) |
|-----------------|---------|---------|-------|-----------------------|
| Dry matter (%)  | 23.74   | 24.86   | 04.8  | .122                  |
| Crude protein (%)| 21.76   | 22.18   | 05.6  | .602                  |
| Fat (%)         | 1.73    | 1.89    | 0.15  | .438                  |
| W/CP            | 3.46    | 3.33    | 0.11  | .403                  |

Values are presented as least square mean and standard error of the mean (SEM). W/CP: total water to protein ratio.
mesophilic aerobic plate counts between 1.0 and 5.6 log10 CFU/cm² and the numbers of Enterobacteriaceae 1.7–3.5 log10 CFU/cm² which emphasise high heterogeneity of microbiological quality even in wild boars killed by sterile punch. Similarly to our results, it was found by Borilova et al. (2016) that the microbiota of wild boar hind leg increased gradually during chilled storage. The same authors observed increase of total viable count by 2 log10 after 14 days of chilled storage. The same authors observed increase of total aerobic colony count and Enterobacteriaceae of wild boars tenderloins (m. psoas major) during 35 days of storage in vacuum packaging at 0°C by 2.60 and 1.47 units, respectively. In this study, TM of samples after 360 h of chilled storage increased by 1.42, EC by 0.74 and EB by only 0.23 log10 CFU/cm² in comparison to meat samples analysed 48 h post-mortem. In all samples, pathogens such as Salmonella spp. and Listeria monocytogenes were not detected. Sales and Kotrba (2013) confirmed low frequencies of Salmonella spp. in wild boars hunted in EU, were absence of Listeria monocytogenes indicates good hygiene practice and handling of meat in the slaughterhouse.

Conclusions

On the basis of the presented results, it can be observed that the analysed wild boar meat characterised with slightly elevated pH and dark colour in connection with increased capacity to hold its residual water. Despite the analysed meat revealed some attributes of DFD-like abnormal meat (comparing with the literature data, the meat analysed in our study characterised with higher pH and lower lightness), no negative changes in quality after the storage period were noted. On the contrary, the wild boar meat after chilled storage characterised with increased tenderness. Moreover, the microbiological traits of this type of meat indicate a proper quality of this animal product. The aforementioned results indicate that wild boar meat may be used as culinary meat or for processing, and the 14-day storage period is crucial for the development of desirable textural traits. Further research is needed in order to examine the reasons and possibilities of prevention the DFD-like conditions.

Disclosure statement

In accordance with Taylor and Francis policy and Agnieszka Ludwiczak's ethical obligation as a researcher, Agnieszka Ludwiczak is reporting that Agnieszka Ludwiczak have no financial and/or business interests. Agnieszka Ludwiczak do not receive funding from a company that may be affected by the research reported in the enclosed article. Agnieszka Ludwiczak have disclosed those interests fully to Taylor and Francis.

The authors declare that they have no conflict of interest.

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Table 6. The microbiological quality of wild boar Longissimus lumborum.

| Storage time | Type of microbial analysis | 48 h | 360 h | SD  | Effect (p-value) |
|--------------|----------------------------|------|-------|-----|-----------------|
|              | Total number of mesophilic aerobic micro-organisms (TM) (log10 CFU/g) | 4.52 | 5.94 | 0.82 | .261 |
|              | Enterobacteriaceae (EB) (log10 CFU/g) | 3.07 | 3.30 | 0.79 | .785 |
|              | Salmonella spp. | 1.69 | 2.43 | 0.49 | .351 |
|              | Listeria monocytogenes | ND | ND | — | — |

Values are presented as least square mean and standard deviation (SD).
ND: not detected in 25 g of sample; CFU: colony forming units.

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