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RESEARCH ARTICLE

A Comparison of Selected Quality Features of Pork Meat from Conventional and Organic Production

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Abstract

This study aimed to compare selected quality characteristics of retail pork from conventionally and organically reared animals. The material for the study was fresh culinary meat (pork loin) packed in MAP-type packaging. The scope of the study included the measurement of pH and the content of chemical constituents (protein, fat, and water), determination of water holding capacity and weight loss after heat treatment, instrumental measurement of shear force and colour parameters (CIELAB), determination of the TBARS index and organoleptic evaluation of appearance and colour as well as aroma of both types of pork loin. Pork obtained from organically reared animals was found to have favourable characteristics in terms of nutritional and organoleptic value, as well as processing utility. The results indicate that the quality of pork loin from conventional and organic production was similar. The relatively small but significant ($p \leq 0.05$) differences between both types of raw material concerned only some of the quality parameters assessed. Organic meat was characterised by a significantly ($p \leq 0.05$) lower pH value, contained significantly ($p \leq 0.05$) more protein than meat from conventionally reared pigs, and scored higher ($p \leq 0.05$) in the organoleptic assessment of the overall appearance of colour and aroma.

KEYWORDS
pork meat, organic production, quality characteristics

Introduction

In 2022, an average Pole consumed 74.0 kg of meat, of which 46.3 kg was pork [CSO 2023]. The above data prove that pork continues to be an important component of the diet of our country's population, occupying first position in the structure of meat consumption for many years. This meat is appreciated both for its high culinary value and its suitability for processing. In addition, the disappearance of small-scale pig farming over recent years in favour of developing industrial pig farming technologies has led to many efforts to improve the quality of pork meat, including nutritional and health features. Currently, Polish pork is characterised, among other things, by a lower fat content than previously and a more desirable tenderness and palatability, as well as favourable technological qualities [Przybylski 2015, Blicharski et al. 2013]. Many modern consumers are still being driven by safety and the health benefits associated with food consumption when choosing food. However, aspects such as animal welfare and the environmental impact of meat production are becoming increasingly important. It seems that the growing market offering organic food may be the answer to these expectations. Organic meat production is perceived as an important element of a sustainable economy, and consumer confidence in organic food is strengthened by legal regulations relating to this production system, as well as the control, certification and labelling system [Kułyk, Dubicki 2019, Didkowska et al. 2017, Salejda, Krasnowska 2014, Rembiałkowska, Wiśniewska 2010].

Specific production and processing methods make organic food different from conventional food. For example, higher contents of polyunsaturated fatty acids, including fatty acids of the n-3

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family, as well as some minerals and vitamin E have been found in organically produced pork [Wójciak et al. 2021, Therkildsen et al. 2012, Grela, Kowalczuk 2009].

Because of the increasing market offer of organic meat, the need to continue research on its quality still seems actual. This study aimed to conduct a comparatively produced assessment of selected quality characteristics determining the processing suitability and consumer attractiveness of pork meat (loin) obtained from two production systems: conventional and organic.

Materials and Methods

Study material

The study material consisted of pork loin (m. *longissimus thoracis et lumborum*) from animals from two rearing systems: 'conventional' and organic, offered by two Polish producers from the Lubelskie Voivodeship. Three different production batches of 'conventional' and organic pork loin were evaluated. Both raw materials (meat packaged in MAP packaging) were purchased at retail stores. Three packages of 'conventional' and organic pork loin were purchased for each experimental batch. Quality analyses of both raw materials were performed immediately after purchase. Both types of raw material were fit for consumption, as indicated by the 'use by' date. Meat from organic farming was purchased on the day it was delivered to the retail outlet from the slaughterhouse. 'Conventional' pork was purchased on the same day.

After opening the packages, the meat was cut into 1 cm thick slices. One slice of meat per pack was allocated for organoleptic evaluation and three slices for thermal treatment. The remaining raw material was used to determine the pH, basic chemical composition, water holding capacity, amount of thermal loss, measurement of shear force and colour parameters.

Research methods

The pH was measured using a temperature-compensated digital bayonet pH meter Testo 206-pH2 (Testo SE & Co. KG, Titisee-Neustadt, Germany). Before measurement, the instrument was calibrated with buffers (pH 4.0 and 7.0) according to the manufacturer's instructions. The bayonet electrode was inserted into the meat immediately after opening the package. The result of the measurement was performed in triplicate in each test series, taking the average value as the final result.

The protein, fat and water content in the meat was determined by near-infrared spectroscopy [PN-A-82109:2010] using a FoodScan™2 spectrometer (Foss Analytical A/S, Hillerød, Denmark), operating in the wavelength range from 850 nm to 1500 nm, using calibration based on the artificial neural network model. The measurement sample was prepared by grinding approximately 300 g of raw meat twice in a laboratory grinder (Zelmer S.A., Rzeszów, Poland; mesh diameter 2 mm) and mixing thoroughly. A sample of approximately 150 g was filled into a measuring cuvette, which was placed on the measuring station of the apparatus. Once the apparatus was started, the measurement took place automatically and the results were read on the computer monitor. In each series of tests, the measurement was performed in triplicate for each type of raw material, taking the average value as the final result.

The determination of water holding capacity was performed according to the method described by Tyburcy and Florowski [2014]. A sample of meat ground in a laboratory grinder (mesh diameter 3 mm) weighing 0.300 g (± 0.001 g) was placed on blotting paper (Whatman No. 1), and then between two glass plates, and was pressed using a 2 kg weight. The ImageJ computer software (Wayne Rasband, Bethesda, USA) was used to measure the surface area of the pressed meat sample and the meat juice leakage. In both raw materials, the determination was performed in triplicate in each test series, taking the average value as the result of the determination. The water holding capacity was calculated according to the equation:

$$X = (a - b) \div m,$$

where: X – water holding capacity (cm^2/g), a – surface area of the leaked meat juice (cm^2), b – surface area of the compressed meat sample (cm^2), m – weight of meat sample (g).

The amount of loss during heat treatment (thermal loss) in pork meat was determined in two ways, i.e. in samples of minced meat and slices of meat subjected to roasting. For the first method, 30 g (± 0.1 g) of meat minced in a laboratory grinder (mesh diameter 3 mm) was weighed into a 150 cm^3 beaker. The beaker with the meat sample covered with polyethylene foil was heated at 72°C for 30 min in a MLL 147/2/200 water bath (AJL Elektronic, Krakow, Poland). After removing the thermal leakage, the amount of thermal loss was determined as a percentage of the initial sample weight. In each series of tests, the determination was carried out in triplicate in each raw material, taking the average value as the final result. In the second method, 1-cm-thick slices of meat, which had previously been weighed (± 0.1 g), were subjected to thermal treatment in a Rational SCC WE 61 convection-steamer (Rational AG, Landsberg am Lech, Germany): the air temperature was 180°C and the relative humidity 100%. Heating was carried out until a temperature of 72°C was reached in the geometric centre of the slice, which was measured using a thermocouple. After heat treatment, the samples were cooled to room temperature (approx. 18°C). The amount of heat loss in the meat was determined as a percentage of its weight before heat treatment. In each series of tests, the determination was carried out in three slices of meat obtained from animals from each rearing system, taking the average value as its final result.

The shear force was measured in heat-treated meat in a combi steamer. After measuring the heat loss, the pork loin slices were stored in a cold store (4–6°C) for approximately 20 hours. Before the measurements, the meat slices were conditioned for 2 hours at room temperature and then cuboids of 1 × 1 × 4 cm (height × width × length of side) were cut from them. A Zwicki type 1120 testing machine (ZwickRoell GmbH & Co. KG, Ulm, Germany) equipped with a flat knife blade was used for the measurements. The measured texture parameter was the shear force. The head movement speed during the test was 50 mm/min, the initial force was 0.5 N, and the force cut-off threshold was 50% of the maximum force recorded during the test. The maximum value of the shear force recorded when the knife cut through the product sample was taken as the result of the measurement. In each series of tests, the shear force was measured in 10 repetitions for each type of meat, taking the average value as the result.

CIELAB colour parameters were measured on the surface of the meat slices after approximately 20 minutes after removal from packaging and conditioning at room temperature. A Konica Minolta CR-400 colourimeter was used (measuring aperture diameter 8 mm, light source D65, observer 10°). The instrument was calibrated on a white standard tile (Y: 95.2 x: 0.3159, y: 0.3326) before measurement. In each series of tests, the measurement was performed at three different points for each type of raw material, taking the average value as the final result.

Determination of the lipid oxidation index TBARS was performed using the extraction method according to Shahidi et al. [1990]. A Sigma 4K15 laboratory centrifuge (Polygen Sp. z o.o., Wrocław, Poland) was used to centrifuge the meat samples after they had been treated with trichloroacetic acid and 2-thiobarbituric acid. The absorbance of the filtrate was measured using a CampSpec M501 spectrophotometer (Spectronic Campspec Ltd, Great Britain), at a wavelength of 532 nm against a reagent sample (5 cm^3 of 0.02 M 2-thiobarbituric acid solution and 5 cm^3 of 10% trichloroacetic acid). The value of the TBARS index, as the malondialdehyde content in 1 kg of raw material [MDA/kg], was calculated by multiplying the absorbance result by the conversion factor of 2.34. In each series of tests, the determination was performed in triplicate for each type of raw material, taking the average value as the final result.

The organoleptic evaluation of the pork meat included only two quality characteristics: overall appearance and colour, and smell. The reason for these limitations was the epidemic emergency in force during the implementation of research concerning SARS-CoV-2 virus infections. The meat was assessed in slices approximately 1 cm thick, conditioned at room temperature for about 30 minutes after being removed from the packaging, placed on white plates and coded. A trained team of six people carried out the testing using a five-point scale, where a score of 1 indicated a highly undesirable (unacceptable, 'atypical') characteristic and a score of 5 indicated a highly desirable characteristic. The assumptions for the organoleptic evaluation were developed based on the literature [Baryłko-Pikielna, Matuszewska 2009].

To determine the influence of the production system ('conventional' versus organic one) on the quality features of the pork loin, the results obtained were subjected to statistical analysis using the computer software STATISTICA 13PL (StatSoft Inc., Tulsa, OK, USA). One-way analysis of variance (One-Way ANOVA) was used to identify differences between the mean values, while Tukey's HSD detailed test for a significance level of α = 0,05 was used to separate homogenous groups.

Results and Discussion

Pork loin obtained from organically reared pigs was characterised by a significantly ($p \leq 0.05$) lower pH than the same culinary element obtained from the 'conventionally bred' pigs, despite the relatively small difference between the mean values (see Table 1).

Feature	Loin – meat from conventionally reared animals	Loin – meat from organically reared animals
pH	5,61 ± 0,25 b	5,41 ± 0,10 a
Protein content [%]	22,99 ± 0,22 a	23,64 ± 0,42 b
Fat content [%]	3,32 ± 0,92 a	3,59 ± 0,94 a
Moisture content [%]	73,26 ± 0,82 a	72,19 ± 1,01 a
Water holding capacity [cm^2/g]	17,5 ± 3,3 a	18,0 ± 4,4 a
Thermal loss [%] – minced meat	7,1 ± 2,1 a	7,3 ± 1,7 a
Thermal loss [%] – sliced meat	25,4 ± 2,6 a	27,5 ± 2,9 a
Shear force [N]	41,80 ± 6,96 a	44,61 ± 7,24 a
L*	51,17 ± 2,44 a	49,95 ± 1,80 a
a*	9,17 ± 1,25 a	8,97 ± 0,94 a
b*	2,44 ± 0,41a	2,64 ± 0,48 a
TBARS [mg MDA/kg]	0,22 ± 0,03 a	0,24 ± 0,07 a
Overall appearance and colour [pkt]	4,5 ± 0,37 a	4,8 ± 0,24 b
Smell [pkt]	4,7 ± 0,39 a	4,8 ± 0,35 a

a, b – mean values in a row with different letters are significantly different ($p \leq 0,05$)

Table. 1. Results of the measurement of physicochemical and organoleptic quality characteristics of pork loin obtained from animals from conventional and organic production systems (mean ± standard deviation)

A similar trend relating to the active acidity of pork *(m. longissimus lumborum)* obtained from pigs of the native Slovenian breed from different production systems was found by Tomažin et al. [2019]. According to the researchers, the significantly ($p \leq 0.05$) higher acidity of meat from 'organic' pigs, compared to meat from 'conventional' animals, may have been due to the higher glycogen content in the muscles of these animals. This, in turn, was most likely a consequence of the more intensive physical activity and the greater temperature fluctuations prevailing in the enclosure to which organic animals had access. In contrast, different results regarding the pH of pork were obtained by Kim et al. [2009], who found no significant ($p > 0.05$) differences between the pH values of pork loin, i.e. the longissimus dorsi muscle *(m. longissimus dorsi)* from organic and 'conventional' rearing, taking measurements 24 h after slaughter.

The nutritional value of meat is mainly determined by its protein, fat and water content. In the present study, the basic chemical composition of pork loin from organic and 'conventional' animals was found to be similar, although the loin obtained from pigs from organic rearing contained relatively little, but significantly ($p \leq 0.05$) more protein than the loin from 'conventional' animals. In contrast, the organic meat had an insignificantly ($p > 0.05$) higher fat content and lower water content (Table 1). The content of the basic chemical constituents in the meat assessed in this study was similar to the data cited in the literature for pork loin. According to other authors [Szamocka et al. 2017, Castro Cardoso Pereira, Reis Baltazar Vicente 2013, Kim et al. 2008], the water content in pork loin was on average 72-75%, protein 19–22%, and fat 1.2–5.0%.

Previous studies indicate that the effect of the pig-rearing system on the content of basic chemical components in meat is inconclusive. Grela and Kowalczuk [2009], in a comparative assessment of the meat quality of loin and pork ham obtained from organic and 'conventional' porkers, found only a slightly higher, i.e. non-significant ($p > 0.05$), content of total protein and crude fat in 'conventional' raw materials. Similarly, Kim et al. [2009] showed no effect of the rearing method (organic vs. 'conventional') on the water, protein and fat content of pork loin meat of native Korean black pigs. In contrast, different results were obtained in a study of pigs reared in Sweden under organic and 'conventional' systems, which showed significantly ($p < 0.001$) higher protein levels in the meat *(m. longissimus dorsi)* of organic pigs [Olsson et al. 2003]. As in the present study, a slightly but significantly ($p < 0.05$) higher protein content was found in the meat *(m. longissimus lumborum)* of native Slovenian organic pigs than for 'conventional' animals. In contrast, no significant differences were found in water and fat content [Tomažin et al. 2019]. In the context of assessing the nutritional value of organic pork, researchers emphasise that - irrespective of differences in fat content – this meat has a more nutritionally favourable fatty acid profile than 'conventional' raw material [Mroczek et al. 2015, Hansen et al. 2006, Nilzen et al. 2001].

The mean values of the water holding capacity coefficient for the raw material from conventional and organic production did not differ significantly ($p > 0.05$) between each other (Table 1). Also, it was found that organic pork was characterised by only slightly, i.e. non-significantly ($p > 0.05$) greater weight loss than 'conventional' pork – for both the determination of this quality trait in minced meat and sliced meat (Table 1). The results obtained therefore indicate similar properties of both raw materials relating to water retention during processing.

In a study on the processing suitability of meat from Slovenian Krskopolje pigs, Tomažin et al [2019] obtained results different from those of the present study, indicating that the raw material *(m. longissimus lumborum)* obtained from organically reared animals has a lower water retention capacity compared to meat from 'conventional' pigs. According to Huff-Lonergan [2006], other processing quality characteristics of raw meat, such as the amount of weight loss during cold storage, transport and thermal processing, are closely related to the water-binding capacity of the meat.

The results of studies by other authors on the amount of thermal loss of organic and conventional meat are clear. Comparing the processing suitability of organic and 'conventional' pork (loin), Kim et al [2009] found no significant differences ($p > 0.05$) in heat loss. In contrast, in light of the results obtained by Olsson et al. [2003], organic pork *(m. longissimus dorsi)* had less weight loss after heat treatment than meat from 'conventional' production.
Based on the results of the shear force measurements obtained, there were no significant ($p > 0.05$) differences between pork loin meat obtained from 'conventional' animals and the same culinary element obtained from organic animals (Table 1).

Also, Tomažin et al. [2019] comparing the results of shear force measurements for 'conventional' and organic pork (*longissimus dorsi* muscle) showed no significant ($p > 0.05$) differences between both raw materials. As in the present study, the organic pork was only characterised by a non-significantly higher mean value for this texture parameter. However, results obtained by Olsson et al. [2003] indicate a significantly ($p \leq 0.05$) higher hardness of pork (*longissimus dorsi* muscle) of pigs from organic production, compared to similar raw material from 'conventional' production, as evidenced by the results of shear force measurements carried out in heat-treated meat. According to the authors, the differences in shear force values between the two types of raw material could be due to differences in intramuscular fat content, as pork from organic production was characterised by a lower intramuscular fat content. In addition, it was hypothesised that the slower growth rate of organically reared porkers, caused, among other things, by free access to free-ranging, could have weakened the rate of proteolysis in the meat after slaughter, leading to a deterioration in meat tenderness, which was reflected in an increase in shear force. The toughness of the meat may also have been affected by differences in collagen content between the two raw materials. Different results regarding cutting force were obtained in a study by Kim et al. [2009], who recorded a significantly ($p \leq 0.05$) lower value of this texture parameter for the meat of organic Korean Black pigs *(m. longissimus dorsi)* compared to meat from these animals reared in a 'conventional' system.

Based on the instrumental measurements of the colour parameters of pork loins obtained from organic and 'conventional' pigs, no significant ($p > 0.05$) difference was found for the lightness of colour (colour parameter L^*), the redness (a^*) and yellowness (b^*) between the raw materials tested (see Table 1). Only slight colour differences were observed towards darker colour, less redness and more yellowness of the organic meat.

The results of colour measurement of organic and 'conventional' pork meat obtained in this study are at variance with the results of some previous work [Hansen et al. 2006, Millet et al. 2004]. This is most likely because meat colour is influenced by a great many other pre-slaughter factors, such as the type of feed fed and the individual characteristics of the animals, and post-slaughter factors, such as the course of post-slaughter transformation and carcass cooling conditions [Wójciak et al. 2012]. In light of the results obtained by Olsson et al. [2003] and Tomažin et al. [2019] also found no significant differences in colour parameters L^*, a^* and b^* between pork meat obtained from pigs kept under organic and 'conventional' conditions. Another study [Hansen et al. 2006] found greater differences in myoglobin content in muscle due to the seasonality of animal husbandry (lower myoglobin content in meat from pigs reared in the summer season) than due to the husbandry system (organic and 'conventional'). An experiment conducted by Millet et al. [2004] on a commercial pig line showed that the colour of meat *(m. longissimus dorsi)* from organic animals was significantly ($p \leq 0.05$) darker in the cross-section and was characterised by more reddening and yellowing. According to the authors, the increase in redness of the colour of meat from organic production could be a consequence of the increased spontaneous activity of the animals, which would be due to the higher concentration of myoglobin in the muscles of 'organic' pigs.

The mean values of the TBARS fat oxidation index found in the present study were reactively low, and the difference between them did not indicate that the pig-rearing method significantly ($p > 0.05$) differentiated the degree of lipid oxidation in the meat studied (Table 1).

The effect of the pig rearing system on the susceptibility of lipids to oxidation has also been studied by other authors, as increased lipid oxidation can cause a reduction in the technological and processing quality of meat [Wood et al. 2008]. Millet et al. [2005] also showed no significant ($p > 0.05$) differences in the degree of fat oxidation in meat obtained from pigs kept in the 'conventional' and organic systems. In a study by Hansen et al. [2006], both the effect of the pig-rearing system and feed composition modifications on fat oxidation in meat were assessed. Based on the results, no significant ($p < 0.001$) differences in TBARS values were found between 'conventional' and organic meat. However, it was observed that the addition of silage, especially clover silage, to the feed given to 'organic' animals, resulted in a significant increase in the value of this parameter. According to Nilzen et al. [2001], the lower oxidative stability of fats in pork obtained from organic farming may be due to a higher proportion of unsaturated fatty acids in the total pool of these compounds, compared to 'conventional' meat. In turn, the differences in fatty acid composition may be due to free access to the animals' run in the organic farming system and increased pasture feeding. This thesis is supported by the results obtained by Tomažin et al. [2019], who proved that the organic pig housing system and diet resulted in increased TBARS values compared to meat from pigs of the same breed kept conventionally.

Despite the relatively small differences between the mean values of the scores obtained in the organoleptic evaluation of raw pork loin slices from animals from the two different rearing systems for the distinguishing mark of external appearance and colour, it was found that organic meat was characterised by significantly ($p \leq 0.05$) better quality (see Table 1). For aroma, both raw materials were of similar quality, slightly ($p > 0.05$) in favour of organic meat (Table 1).

Meat colour is an important quality differentiator for the consumer, often determining the purchase decision. Some consumers prefer pork with a darker colour [Mroczek 2015], which meat from alternative farming systems may have [Olsson et al. 2003]. The consumer's assessment of the external appearance and colour of the meat is also influenced by the intramuscular and intermuscular fat content, which varies depending on the type of meat (logging site) [Makała 2018]. According to Olsson et al. [2003], who subjected pork from organic and 'conventional' pigs to a comparative quality assessment, the average consumer may not be able to distinguish organoleptically between the two types of meat, so small differences in organoleptic quality will not be a decisive purchasing factor. The above thesis was confirmed by Gaviglio and Pirani [2015] in their study of consumer preferences for organic meat products. According to their study, consumers are willing to pay a higher price for organic meat and products, but the main purchasing factors were concern for their health and the state of the environment, as well as the protection of the biodiversity of native animal breeds.

In other studies, [Kim et al. 2009] it has been found that there were no significant ($p > 0.05$) differences in the juiciness, aroma and hardness of raw pork from organic and 'conventional' production, while a significant ($p < 0.05$) lower mean score was given to organic meat in the chewiness assessment. Hansen et al. [2006], in a sensory evaluation of organic and 'conventional' but heat-treated pork (loin), found that the external appearance of meat slices was not significantly differentiated by the rearing method. However, organic meat was characterised by a significantly ($p < 0.01$) less pronounced 'meaty' flavour than 'conventional' meat.

Conclusions

The results obtained in this study indicate good technological and organoleptic quality of pork (loin) obtained from animals from different production systems, i.e. organic and 'conventional'. Significant ($p \leq 0.05$) differences between both raw materials, although relatively small, concerned only some quality characteristics. Meat from organic farming was characterised by significantly lower active acidity contained significantly more protein than 'conventional' meat, and scored significantly higher in the organoleptic assessment of overall appearance and colour. It can therefore be assumed that the raw material obtained from organically reared animals will meet the expectations of modern consumers, who pay particular attention to the high quality of meat.

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