ACTA SCIENTIARUM POLONORUM

Acta Sci. Pol. Zootechnica 20(2) 2021, 39–46

www.asp.zut.edu.pl pISSN 1644-0714 eISSN 2300-6145 DOI:10.21005/asp.2021.20.2.05

ORIGINAL PAPER

Received: 12.09.2021
Accepted: 25.09.2021

THE EFFECT OF PEPPER (*CAPSICUM ANNUUM* L.) AND ROSEMARY (*ROSMARINUS OFFICINALIS* L.) ON PORK QUALITY

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ABSTRACT

The aim of this study was to analyse the effect of pepper (*Capsicum annuum* L.) oleoresin (PO) and rosemary (*Rosmarinus officinalis* L.) extract (RE) on the quality of ground pork (*m. longissimus dorsi*). Vacuum-packaged pork samples were cold-stored for 4 weeks. The quality of meat without additives and with the addition of PO (0.4 and 0.2 $g \cdot kg^{-1}$ meat) and 4% RE (0.6 and 0.3 $g \cdot kg^{-1}$ meat) was evaluated. The pH of vacuum-packaged ground pork decreased during 4 weeks of storage in all experimental groups. The rate of lipid oxidation and changes in the colour and sensory properties of stored meat were determined by the type and quantity of natural antioxidants. Rosemary extract added at 0.6 $g \cdot kg^{-1}$ meat was the most potent inhibitor of lipid oxidation. Pepper oleoresin added at 0.4 $g \cdot kg^{-1}$ meat had the most beneficial influence on colour intensity evaluated instrumentally and colour desirability evaluated visually. Pork containing RE added at 0.3 $g \cdot kg^{-1}$ meat was characterised by the most desirable aroma and taste after storage.

Key words: ground pork, natural antioxidants, TBARS, colour parameters, sensory properties

INTRODUCTION

Antioxidant substances prolong the shelf-life of meat and meat products by inhibiting fat rancidification. The addition of synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) limits lipid oxidation, but a growing body of evidence suggests that these compounds exert adverse effects on human health [Sebranek et al. 2005, Wójciak et al. 2011]. Many countries have introduced legal restrictions on the use of synthetic antioxidants in food production. The health concerns associated with synthetic compounds have increased the interest in natural compounds. Research has demonstrated that natural antioxidants are often more effective than synthetic compounds in preventing adverse changes in meat products [Estévez et al. 2006, Lara et al. 2011, Bianchin et al. 2017]. The demand for plant-based materials, including extracts and oils containing natural antioxidants, is on the rise due to their natural origin and health-promoting properties. When added in appropriate quantities, these substances can improve the sensory quality of meat products [Macura et al. 2011, Nissen et al. 2004, Govaris et al. 2010] and prevent undesirable changes in their colour [Balentine et al. 2006, Hernández-Hernández et al. 2009, Rohlík et al. 2013].

Herb and spice plants are a valuable source of antioxidants in the meat processing industry [Wójciak et al. 2011, Karre et al. 2013, Rohlík et al. 2013]. Rosemary contains antioxidant compounds such as rosmanol, rosmariquinone, rosmaridiphenol and carnosol [Fernández-López et al. 2005)]. Red pepper is used mainly to preserve the red colour of meat during storage. However, red pepper is also abundant in phenolic compounds, mainly quercetin and luteolin, phenolic acids, capsaicinoids, tocopherols and carotenoids and it is a powerful antioxidant [Chen et al. 2012]. Attempts are being made to determine the optimal form and amounts of natural antioxidants and to evaluate their effectiveness in preserving various types of fresh and processed meat.

The aim of this study was to analyse the effect of different quantities of pepper oleoresin (PO) and rosemary extract (RE) on the quality of ground pork stored at refrigerator temperature for 4 weeks. The research hypothesis states that the addition of PO and RE can inhibit lipid

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oxidation and enhance the colour parameters and sensory attributes of pork.

MATERIAL AND METHODS

Material

The experimental materials comprised samples of *musculus longissimus dorsi* (LD muscle) with pH of 5.5–5.8, collected 24 h *post mortem* (after chilling –2°C, 24 h). During dressing of right half-carcasses, 15 LD muscles were cut between the 4th and the 5th thoracic vertebrae, and along the flank edge anterior to the hip bone, leaving cartilage at the loin. The muscles were vacuum-packaged and transported to the laboratory in isothermal containers. In the laboratory, the muscles were divided into 5 equal samples (500 g each), and ground. The first, control sample contained no additives. The remaining samples were supplemented with natural, certified food additives, available in retail stores. Rosemary extract (4%) was prepared by solvent extraction of dried aboveground parts of rosemary (*Rosmarinus officinalis* L.). Pepper oleoresin was prepared by solvent extraction of dried fruit of red pepper (*Capsicum annuum* L.); the compounds responsible for its pungent taste were removed. The second sample was supplemented with PO at 0.4 g · kg^{-1} meat (P0.4). The third sample was supplemented with PO at 0.2 g · kg^{-1} meat (P0.2). The fourth sample was supplemented with 4% RE at 0.6 g · kg^{-1} meat (R0.6). The fifth sample was supplemented with 4% RE at 0.3 g · kg^{-1} meat (R0.3). Each sample was divided into two subsamples. One subsample (250 g) was analysed before storage (approx. 36 h *post mortem*), and the other subsample (250 g) was analysed after 4 weeks of storage. The samples were vacuum-packaged in bags with enhanced gas barrier performance, using the PP15 (MGO) Tepro Vacu Tronic 2000 vacuum packaging machine (Tepro S.A.), and were stored in a refrigerating chamber at 2°C and relative air humidity of 50%.

Methods

Meat pH was measured in homogenates (meat to distilled water ratio of 1:1), with a combined Double Pore electrode (Hamilton) and a 340i pH-meter equipped with the TFK 150/E temperature sensor (WTW).

The extent of lipid oxidation was estimated based on thiobarbituric-acid-reactive substance (TBARS) values [Pikul et al. 1989], using 10 g of ground raw meat, sampled from the whole ground steak previously trimmed of adjacent fat and connective tissue. Absorbance was measured with the Specord® 40 spectrophotometer (Analytik Jena AG, Jena, Germany) at a wavelength of 532 nm, and TBARS values were expressed in mg of malondialdehyde (MDA) per kg of meat.

Meat colour was determined based on the values of CIELAB coordinates, L* (lightness), a* (redness), b*(yellowness), C* (chroma), h° (hue angle) and ΔE (total colour difference). Colour space parameters L*a*b* were measured by the reflectance method using a HunterLab MiniScan XE Plus spectrocolorimeter (Hunter Associates Laboratory Inc., Reston, VA, USA) with standard illuminant D65, a 10 standard observer angle and a 2.54-cm-diameter aperture. The values of L*a*b* were the means of three independent measurements, which were performed at random sites across the muscle, before and after storage, on unpackaged samples that were exposed to light for 15 min. Based on the values of L*a*b*, the values of chroma $C^* = (a^{*2} + b^{*2})^{0.5}$ and hue angle $h° = \tan^{-1} (b^*/a^*)$ were determined. The total colour difference after storage was calculated from the following formula:

$$\Delta E = [(L^*_{30} - L^*_0)^2 + (a^*_{30} - a^*_0)^2 + (b^*_{30} - b^*_0)^2]^{0.5}$$

The sensory properties of raw meat and thermally processed meat were evaluated by 6 trained panellists selected for their sensory sensitivity. The panellists assessed samples in individual compartments. Fluorescent white lights (500 lx) that simulated daylight, installed at a height of approximately 1 m, were used to evenly illuminate the table. Relative air humidity of minimum 60% and temperature of 21°C were maintained in the panel room. The sensory attributes of pork, including its colour, taste and aroma, were evaluated after cooking at 96°C until the temperature in the geometric centre of the sample reached 75°C. The samples, weighing around 25 g, were spherical in shape. They were presented to the panellists at a temperature of around 40°C. A 9-point hedonic scale was used in the assessment: 9 – Like Extremely, 8 – Like Very Much, 7 – Like Moderately, 6 – Like Slightly, 5 – Neither Like nor Dislike, 4 – Dislike Slightly, 3 – Dislike Moderately, 2 – Dislike Very Much, 1 – Dislike Extremely.

The results were processed statistically using the STATISTICA data analysis software, ver. 13.3. The effect of the tested additives (PO and RE) on meat quality was determined by one-way ANOVA. The differences in pork quality before and after storage were evaluated by the Student's *t*-test. The significance of differences between means in groups was determined by Duncan's multiple range test with a significance level of $P < 0.05$ and $P < 0.01$. The following linear model is used:

$$x_{ij} = \mu + a_i + e_{ij}$$

where:

x_{ij} – trait level,
μ – general average,
a_i – effect of analysed factor,
e_{ij} – random error.

RESULTS AND DISCUSSION

pH of meat. Before storage, sample P0.2 had lower (P < 0.05) pH than the remaining samples (Table 1). In all samples, pH values were higher (P < 0.01) before than after storage. Macura et al. [2011] analysed the effects of essential oils (EO) of coriander (*Coriandrum Sativum* L.) and lemon balm (*Melissa Officinalis* L.) on changes in the pH of stored ground veal. Similarly to the present study, the cited authors noted a decrease in the pH of all samples (including the control sample without additives) already in the first week of storage. In the second week, pH dropped below 5.3, except for the control group.

Lipid oxidation. Before storage, all samples were characterised by similar TBARS values (P>0.05), ranging from 0.13 to 0.15 mg MDA per kg meat (Table 1). After storage, sample R0.6 had lower (P < 0.05) TBARS values than the remaining samples. In all samples, TBARS values were higher (P < 0.01) after 4 weeks of storage than before storage.

The effect of RE on delaying lipid oxidation in meat, observed in this study, has also been reported by other authors [Nissen et al. 2004, Jongberg et al. 2013]. According to Estévez et al. [2006] and Lara et al. [2011] RE has potent antioxidant properties and can replace synthetic antioxidants. Rosemary can be used as a natural antioxidant in fresh and processed pork [Hernández-Hernández et al. 2009], ground beef [Balentine et al. 2006] and various meat and poultry products, and it was found to be more effective than a combination of BHA and BHT in raw frozen sausages [Sebranek et al. 2005].

The antioxidant effects of red pepper added to meat and meat products remain insufficiently investigated. Wójciak et al. [2011] found that red pepper was equally effective in suppressing lipid oxidation in pork as RE and green tea extract. In the present study, PO had no significant inhibitory effect on lipid oxidation, probably due to a too low quantity of the additive.

Colour parameters. Before storage, samples C and R0.3 were characterised by higher (P < 0.01) values of L* than sample P0.4, and they were also lighter (P < 0.05) than P0.2 and R0.6 (Table 2). After storage, the values of L* were higher in sample R0.3 than in C, P0.4, P0.2 (P < 0.01) and R0.6 (P < 0.05). In all groups, meat was lighter in colour (P < 0.01) after storage than before storage, and the greatest increase in L* was noted in samples R0.6 and R0.3.

Before storage, the contribution of redness (a*) was higher in samples P0.4 and P0.2 than in the remaining samples (P < 0.01), and in sample R0.3 than in sample C (P < 0.05). After storage, the values of a* were higher in sample P0.4 than in C, R0.6 and R0.3 (P < 0.01), and in samples P0.4 and P0.2 than in C (P < 0.05). Samples P0.4, P0.2 (P < 0.01) and R0.3 (P ≤ 0.05) were characterised by higher values of a* before than after storage.

Before storage, the contribution of yellowness (b*) was higher in samples P0.4 and P0.2 than in the remaining samples (P < 0.01), and in sample P0.2 than in sample P0.4 (P < 0.01). After storage, the values of b* were higher in sample P0.4 than in C (P < 0.01), R0.6 and R0.3 (P < 0.05). Samples P0.2 (P < 0.01) and P0.4 (P ≤ 0.05) were characterised by higher values of b* before than after storage.

The differences in the contribution of redness and yellowness between pork samples resulted in different average values of chroma (C*) and hue angle (h°). Before storage, the average values of C* were higher in samples P0.4 and P0.2 than in the remaining samples (P < 0.01), and lower in P0.2 than in P0.4 (P < 0.05). Colour saturation was also greater (P < 0.05) in samples R0.6 and R0.3 than in C. After storage, the average values of C* were higher in sample P0.4 than in the remaining sam-

Table 1. pH and TBARS value (mg malondialdehyde kg^{-1} meat) of pork before and after storage ($\bar{x}$ ±SEM)

Traits	Week	Additive				
		C	P0.4	P0.2	R0.6	R0.3
pH	0	5.66^{aX} ±0.01	5.68^{aX} ±0.03	5.59^{bX} ±0.01	5.68^{aX} ±0.01	5.70^{aX} ±0.01
	4	5.42^{Y} ±0.01	5.46^{Y} ±0.01	5.47^{Y} ±0.01	5.45Y ±0.01	5.46^{Y} ±0.01
TBARS	0	0.14^{Y} ±0.01	0.14^{Y} ±0.02	0.15^{Y} ±0.01	0.13Y ±0.01	0.14^{Y} ±0.01
	4	0.46^{aX} ±0.01	0.41^{aX} ±0.01	0.40^{aX} ±0.01	0.29^{bX} ±0.01	0.39^{aX} ±0.01

Values within a row followed by different superscript letters are significantly different: a, b – P < 0.05.
Values within a column followed by different superscript letters are significantly different: X, Y – P < 0.01.
C – control; P0.4 – pepper oleoresin added at 0.4 g · kg^{-1} meat, P0.2 – pepper oleoresin added at 0.2 g · kg^{-1} meat, R0.6 – rosemary extract added at 0.6 g · kg^{-1} meat, R0.3 – rosemary extract added at 0.3 g · kg^{-1} meat.

Table 2. Colour parameters (L*a*b*) of pork before and after storage ($\bar{x}$ ±SEM)

Traits	Week	Additive*				
		C	P0.4	P0.2	R0.6	R0.3
L* lightness	0	57.37^{AaY} ±0.46	55.58^{BY} ±0.31	55.89^{bY} ±0.25	55.65^{bY} ±0.79	57.51^{AaY} ±0.29
	4	60.56^{BX} ±0.46	59.29^{BX} ±0.49	59.70^{BX} ±0.74	61.32^{bX} ±0.24	63.00^{AaX} ±0.27
a* redness	0	10.46^{Bb} ±0.38	16.49^{AX} ±0.12	15.36^{AX} ±0.21	11.95^{B} ±0.22	$12.22^{a\ Bx}$ ±0.25
	4	10.51^{Bb} ±0.59	14.27^{AaY} ±0.21	12.48^{aY} ±0.31	11.90^{B} ±0.22	11.26^{BY} ±0.25
b* yellowness	0	18.03^{B} ±0.24	22.94^{ABx} ±0.13	26.87^{AX} ±0.31	19.31^{B} ±0.11	19.28^{B} ±0.21
	4	18.76^{B} ±0.33	21.79^{AaY} ±0.14	20.28^{Y} ±0.24	19.65^{b} ±0.14	19.56^{b} ±0.14

Values within a row followed by different superscript letters are significantly different: a, b – P < 0.05; A, B – P < 0.01.
Values within a column followed by different superscript letters are significantly different: x, Y – P < 0.05; X, Y – P < 0.01.
*Explanation as in Table 1.

Table 3. Colour parameters (C*, h°, ΔE) of pork before and after storage ($\bar{x}$ ±SEM)

Traits	Week	Additive*				
		C	P0.4	P0.2	R0.6	R0.3
C* chroma saturation	0	20.85^{Bb} ±0.39	28.25^{Aax} ±0.18	26.87^{AbX} ±0.31	22.71^{aB} ±0.19	22.83^{aB} ±0.31
	4	21.52^{Bb} ±0.56	26.05^{AY} ±0.22	23.81^{aBY} ±0.33	22.98^{B} ±0.21	22.57^{B} ±0.24
h° hue angle	0	59.92^{Aa} ±0.66	54.28^{aBY} ±0.16	55.14^{aBY} ±0.16	58.24^{A} ±0.39	57.65^{b}Y ±0.31
	4	60.86^{Aa} ±1.07	56.78^{aBX} ±0.23	58.41^{bX} ±0.46	58.82^{b} ±0.37	60.10^{AaX} ±0.42
ΔE total color difference	0	–	–	–	–	–
	4	3.83^{b} ±0.57	4.56 ±0.29	5.24 ± 0.57	5.76^{a} ± 0.93	5.72^{a} ± 0.49

Values within a row followed by different superscript letters are significantly different: a, b – P < 0.05; A, B – P < 0.01.
Values within a column followed by different superscript letters are significantly different: x, Y – P < 0.05; X, Y – P < 0.01.
*Explanation as in Table 1.

ples (P < 0.01), and in P0.2 than in C* (P < 0.05). Samples P0.4 (P < 0.05) and P0.2 (P ≤ 0.01) were characterised by higher values of C* before than after storage. Before storage, the values of h° were higher in samples C and R0.6 than in P0.4 and P0.2 (P < 0.01). Differences (P < 0.05) in the values of h° were also noted between R0.3 vs. C, P0.4 and P0.2. After storage, the values of h° were higher in C and R0.3 than in sample P0.4 (P < 0.01). Differences (P < 0.05) in the values of h° were also found between P0.2 and R0.6 (P < 0.05) vs. the remaining samples. During 4 weeks of storage, the values of h° increased in samples P0.4, P0.2 and R0.3 (P < 0.01).

The greatest changes in colour (ΔE) during storage were observed in samples R0.6 and R0.3, where the values of ΔE were higher (P < 0.05) than in C. No significant (P > 0.05) differences in ΔE were found between the remaining groups.

Natural antioxidants inhibit lipid autoxidation and protect the fresh colour of meat and meat products [Semeriak and Jarmoluk 2011, Karre et al. 2013]. In a study by Wójciak et al. [2011], ground pork with the addition of pepper extract was characterised by higher values of L* than meat samples without additives and with the addition of RE after 30 days of storage. The cited authors also found that pork with additives was less red and more yellow than pork without additives. The total colour difference was greater in meat without additives and with the addition of RE than in samples with pepper extract. In the current experiment, the highest values of L* were noted in samples R0.3 and C after 4 weeks of storage, and samples P0.4 and P0.2 were characterised by the highest values of a* and b*. An increase in the inclusion level of RE from 0.3 to 0.6 g · kg^{-1} meat led to a decrease in the above values. Similar observations were made by Fernández-López et al. [2005], Hernández-Hernández et al. [2009] and Semeriak and Jarmoluk [2011], who found that RE contributed to the darkening of meat. Estévez et al. [2006] demonstrated that the values of a* and b* in porcine liver pâté with the addition of rosemary EO, stored for 30 days, were higher, compared with the samples containing BHT. In the work of Lara et al. [2011], cooked pork patties with the addition of RE were darker, with a higher contribution of redness and lower values of h°, compared with patties without additives and with BHT, both before storage and after 6 days of storage under modified atmosphere.

Sensory properties. Before storage, the aroma of sample C was less desirable, compared with R0.3 (P < 0.01), P0.4, P0.2 and R0.6 (P < 0.05) (Table 4). After storage, samples R0.3 and P0.2 were characterised by more desirable aroma than R0.6 (P < 0.05). Samples R0.6 and R0.3 scored higher for aroma before than after storage (P < 0.05).

Before storage, samples P0.4 and R0.3 scored higher (P < 0.01) for colour than C and R0.6. After storage, the colour of sample P0.4 was more desirable than that of the remaining samples (P < 0.01), and the colour of P0.2 was desirable than that of R0.6 (P < 0.05). Samples R0.6, R0.3 and P0.2 received higher (P < 0.01) scores for colour before than after storage.

Before storage, samples P0.4 and R0.3 (P < 0.01) had a more desirable taste than C. Samples R0.6 and P0.2 scored lower for taste than R0.3, and sample C had a less desirable taste than P0.2 and R0.6 (P < 0.05). After storage, sample R0.3 had a better (P < 0.01) taste than C, P0.4 and P0.2, and sample R0.6 had a better (P < 0.05) taste that P0.4 and C. All samples scored higher (P < 0.01) for taste before than after storage.

According to Macura et al. [2011], similarly to herbs and spices, natural antioxidants should be properly selected for different types of fresh and processed meats because they influence their sensory properties, which was also noted in the present study. When added in too large amounts, natural antioxidants can adversely affect sensory quality. Govaris et al. [2010] reported on a beneficial influence of oregano EO on the sensory attributes of stored lamb. However, at the beginning of storage, the sensory quality of experimental samples with higher inclusion levels of the additive was lower, compared with control samples.

The sensory properties of meat and meat products is affected not only by the amount of the antioxidant, but primarily by its type [Nissen et al. 2004], which was also observed in the current experiment. Semeriak and Jarmoluk [2011] demonstrated that colour desirability was higher in cured meat products with RE than in those with sage and clove extracts. Bianchin et al. [2017] found that RE can replace synthetic antioxidants in pork sausages, offering a natural antioxidant alternative also for other meat products, with high consumer acceptance. In a study by Estévez et al. [2006], the hardness of porcine liver pâté with the addition of rosemary EO was lower, compared with the products without additives and with BHT. Lara et al. [2011] reported that pork patties with RE had more desirable texture and aroma than those with BHT. According to Sebranek et al. [2005], RE clearly provides an alternative to synthetic antioxidants for extending the shelf-life of processed meats such as pork sausages, and appears to be particularly effective in raw-frozen pork sausages.

CONCLUSIONS

The pH of vacuum-packaged ground pork decreased during 4 weeks of storage in all experimental groups. The rate of lipid oxidation and changes in the colour and sensory properties of stored meat were determined by the type and quantity of natural antioxidants. Rosemary extract added at 0.6 g · kg^{-1} meat was the most potent inhibitor of lipid oxidation. Pepper oleoresin added at 0.4 g · kg^{-1} meat had the most beneficial influence on colour intensity evaluated instrumentally and colour desirability evaluated visually. Pork containing RE added at 0.3 g · kg^{-1} meat was characterised by the most desirable aroma and taste after storage.

ACKNOWLEDGEMENT

Project financially supported by the Minister of Education and Science under the program entitled "Regional Initiative of Excellence" for the years 2019–2022, Project No. 010/RID/2018/19, amount of funding 12,000,000 PLN.

Table 4. Sensory properties (points) of pork before and after storage ($\bar{x}$ ±SEM)

Traits	Week	Additive*				
		C	P0.4	P0.2	R0.6	R0.3
Aroma	0	5.62^{Bb} ±0.08	6.71^{a} ±0.11	6.87^{a} ±0.27	6.87^{ax} ±0.17	7.29^{Ax} ±0.11
	4	6.04 ±0.11	6.25 ±0.23	6.62^{a} ±0.24	5.79^{bY} ±0.13	6.75^{aY} ±0.09
Colour	0	6.54^{Bb} ±0.11	7.75^{A} ±0.12	7.25^{aX} ±0.19	6.79^{BX} ±0.17	7.45^{AX} ±0.07
	4	6.37^{B} ±0.08	7.29^{A} ±0.07	6.45^{aBY} ±0.13	5.87^{BbY} ±0.12	6.33^{BY} ±0.05
Taste	0	6.50^{BbX} ±0.19	7.41^{AX} ±0.11	7.25^{aX} ±0.21	7.16^{aX} ±0.11	7.79^{AbX} ±0.11
	4	5.21^{BbY} ±0.14	5.29^{BbY} ±0.13	5.79^{BY} ±0.21	6.33^{aY} ±0.35	6.91^{AY} ±0.24

Values within a row followed by different superscript letters are significantly different: a, b – P < 0.05; A, B – P < 0.01.
Values within a column followed by different superscript letters are significantly different: x, Y – P < 0.05; X, Y – P < 0.01.
*Explanation as under Table 1.

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WPŁYW DODATKU PAPRYKI (*CAPSICUM ANNUUM* L.) I ROZMARYNU (*ROSMARINUS OFFICINALIS* L.) NA JAKOŚĆ MIĘSA WIEPRZOWEGO

STRESZCZENIE

Celem pracy była analiza wpływu dodatku oleorezyny papryki (*Capsicum annuum* L.) i ekstraktu rozmarynu (*Rosmarinus officinalis* L.) na jakość mielonego mięsa wieprzowego (*m. longissimus dorsi*), zapakowanego próżniowo i przechowywanego przez 4 tygodnie w warunkach chłodniczych. Analizowano jakość mięsa bez dodatków oraz z dodatkami: oleorezyny papryki (0,4 i 0,2 g · kg^{-1} mięsa) i ekstraktu rozmarynu 4% (0,6 i 0,3 g · kg^{-1} mięsa). Przechowywanie mielonego mięsa wieprzowego przez 4 tygodnie w próżni skutkowało obniżeniem wartości pH we wszystkich grupach doświadczalnych. Zmiany oksydacyjne lipidów oraz barwy i właściwości sensorycznych badanego mięsa w czasie przechowywania uzależnione były od rodzaju i ilości naturalnych antyoksydantów. Najwyższą zdolnością hamowania zmian oksydacyjnych charakteryzował się ekstrakt rozmarynu w ilości 0,6 g · kg^{-1} mięsa. Spośród zastosowanych dodatków najefektywniejszy pod względem kształtowania barwy ocenianej instrumentalnej oraz jej pożądalności ocenianej wzrokowo był dodatek 0,4 g · kg^{-1} mięsa oleorezyny papryki. Najbardziej pożądanym zapachem oraz smakiem po przechowywaniu charakteryzowało się mięso z dodatkiem 0,3 g · kg^{-1} mięsa ekstraktu rozmarynu.

Słowa kluczowe: mielona wieprzowina, naturalne antyoksydanty, TBARS, parametry barwy, właściwości sensoryczne

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