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THE EFFECT OF WATER PLANT EXTRACTS ADDITION ON THE OXIDATIVE STABILITY OF MEAT PRODUCTS

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Background. Natural antioxidants extracted from plants have a lot of antioxidants catechins, epigallocatechins (green tea) rosmariquinone, rosmaridiphenol (rosemary), capsaicinoids (red pepper). They can be used as alternatives to the synthetic antioxidants because of their equivalence or greater effect on inhibition of lipid oxidation and haem pigment (nitrosohemachrome) protection. The aim of the study was to compare the effect of addition of green tea extract, red pepper extract and rosemary extract while curing process on colour and lipid stability during refrigerated storage of meat products.
Material and methods. The pork meat was ground (10 mm plate) and divided into four equal parts. To the first part (control sample – C) was added curring mixture in amount of 2.2% in a ratio of meat dissolved in water. To the rests of parts were added the same curring mixtures in the same proportion dissolved in 0.5% water plant extracts: green tea (GT), red pepper (P), rosemary (R) respectively. All samples were left at 4°C for 24 hours. After curing, samples were stuffed in casings and then heated in water until a final internal temperature of 70°C was reached. All samples were stored up to 30 days at 4°C. Analysis of acidity, oxidation – reduction potential, thiobarbituric acid reactive substances (TBARS), surface colour (Hunter L*, a* and b* values) were measured directly after production and after 10, 20 and 30 days of chilling storage.
Results. The addition of the plant extracts (pepper, green tea, rosemary) to the pork meat samples does not change significantly acidity of the samples during chilling storage. All plants extracts effectively reduce lipid oxidation in cooked pork meat compared to the control. Pepper extract was effective in maintaining redness because of its reduction activity (low potential redox value in sample) and low TBARS values in sample during chilling storage.
Conclusions. Addition of pepper extract and green tea extract in curing meat process helped with nitrosomyoglobin formation and curb prevention of metmyoglobin formation which stabilized the colour of product during chilling storage.

Key words: green tea, pepper, rosemary, haem pigments, water extracts, oxidation

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INTRODUCTION

Colour formation and colour stability during chilling storage and light time acting are very important quality attributes of meat products. The biochemical basis of red colour in meats is well established, and depends on the concentration and redox state of haem pigments in meat [Bekhit and Faustman 2005, Faustman et al. 2010]. The pigment responsible for the pink colour of cured meat is a ferrous complex of myoglobin ($MbFe^{2+}$) and the ligand, nitric oxide (NO) called nitrosylmyoglobin ($MbFe^{2+}NO$). Oxidative discoloration of cured meat products, transforms the nitrosylmyoglobin into nitrate and metmyoglobin ($MbFe^{3+}$) [Morita et al. 1998, Møller et al. 2003, Zhang et al. 2007]. Changes in myoglobin from a ferrous (Fe^{2+}) to a ferric (Fe^{3+}) state are critical to muscle-based food product appearance, because the consumers use browning as an indicator of spoilage. The presence of metmyoglobin may also have consequences for the oxidative stability especially for the unsaturated fatty acids because this ferric state of myoglobin acts as a pro-oxidant [Faustman et al. 2010, Zhang et al. 2007]. The nitrite which comes from discoloration of nitrosylmyoglobin may also form carcinogenic nitrosamines compounds with secondary amines [Møller et al. 2003]. On the other hand several authors have postulated strong relationship between cured haem pigments oxidation and lipid oxidation in meat and cured meat products [Fernández-López et al. 2005, Hęś and Korczak 2007]. Free radical, produced during lipid oxidation, can oxidize haem pigments to methmyoglobin form causing discoloration of meat products [Hęś and Korczak 2007, Karwowska and Dolatowski 2007, O'Grady et al. 2001].

Cooked meat with nitrosohemachrome which is a denatured form of ($MbFe^{2+}NO$) is more susceptible to lipid peroxidation than raw meat during chilling storage due to the heating process resulting in acceleration of oxidative reactions with the lipid in meat [Tang et al. 2001 b].

The oxidative and colour stability of meat products depends mostly on the balance of anti- and pro-oxidants. Synthetic antioxidants, such as butylated hydroxytoluene (BHT) and butylated hydroxyanisol (BHA), can quickly inhibit lipid oxidation but they have carcinogenic potential [Mc Carthy et al. 2001, Mitsumoto et al. 2005, Sebranek et al. 2005, Tang et al. 2001 a, b, Zarena and Sankar 2009].

The purpose of the study was to compare the effect of adding green tea extract, red pepper extract and rosemary extract while curing process on colour and lipid stability during refrigerated storage in meat products. Green tea has been chosen for its antioxidant properties correlated with the presence of tea catechins especially epigallocatechin gallate, epigallocatechin, epicatechin gallate, epicatechin [Jeszka et al. 2010, Tang et al. 2001 a], rosemary for content of certain compounds including rosmanol, rosmariquinone, rosmaridiphenol, carnosol [Fernández-López et al. 2005, Hać-Szymańczuk et al. 2009], red pepper for content of mainly quercetin, luteolin, phenolic acids, capsaicinoids, tocopherols, carotenoids [Aguirrezábal et al. 2000]. Natural antioxidants extracted from plants such as rosemary, tea, sage, sesame seed, peppers, *ginkgo biloba* [Kobus-Cisowska et al. 2010] can be used as alternatives to the synthetic antioxidants because of their equivalence or greater effect on inhibition of lipid oxidation and haem pigment (nitrosohemachrome) protection.

MATERIAL AND METHODS

Meat sample preparation

The pork meat was minced (10 mm plate) and divided into four equal parts. To the first part (control sample – C) was added curring mixture (99.4-99.5% sodium chloride, 0.5-0.6% sodium nitrite) in amount of 2.2% in a ratio of meat dissolved in water (10% water in a ratio of meat). To the second part (green tea sample – GT) was added the same curing mixture in the same proportion dissolved in 0.5% water diluted green tea extract (10% in a ratio of meat). To the third part of meat (rosemary sample – R) was added curing mixture in amount of 2.2% in a ratio of meat dissolved in 0.5% water diluted rosemary extract (10% in a ratio of meat). To the last part of meat (red pepper sample – P) was added curring mixture in amount of 2.2% in a ratio of meat dissolved in 0.5% water diluted sweet red pepper extract (10% in a ratio of meat). All samples were left at 4°C for 24 hours. After curing, samples were ground again (3 mm plate). Samples were stuffed in casings (65 mm) and then heated in water (75°C) until a final internal temperature of 70°C was reached. Then the samples were chilled with cold water until reaching the temperature of 20-25°C and stored at refrigerated temperature (4°C).

The studies were conducted in 0, 10, 20 and 30 days of chilled storage.

Plant extracts preparation

The preparation of the three of extracts was made as follows: 0.5 g of green tea leaves ("Gun Powder" from Bio-Active) or rosemary (from Kamis) or sweet red pepper (from Kamis), were added in turns to 100 ml of extract solution (water). Extraction, were performed on a PolySience shaker, model 8106 at room temperature (20-23°C) for 60 minutes. After this time the extracts were filtrated. Different wrapping of green tea leaves ("Gun Powder" from Bio-Active), rosemary (from Kamis) and sweet red pepper (from Kamis) were, used to prepared extracts in two experiments.

Colour measurement

Instrumental colour measurements were taken immediately after the samples were prepared and then after 10, 20 and 30 days of chilling storage. Colour was checked also for plant extracts after preparation. Immediately after production (0 days) of meat products, directly after slicing the sample, and then after 1, 2 and 3 hours of keeping meat products exposed to light, colour changes were checked. L*, a*, b* values and reflectance values between 390 and 700 nm were measured by a X-Rite 8200 colorimeter using the D65 illuminant, 8 mm port size and a 10º standard observer. Pigment nitrosation (NI) and pigment discoloration (RSI) were evaluated based on the percent reflectance values. Pigment nitrosation (NI) was defined as R_{560}/R_{500}. R_{560} and is an estimate of nitrosomyoglobin and R_{500} estimates Fe^{2+} native pigments (myoglobin and oxymyoglobin). Pigment discoloration (RSI) value is an estimate of Fe^{2+}/Fe^{3+} ratio and is defined as R_{570}/R_{650}. Pigment nitrosation and pigment discoloration parameters have been used to measure the colour of cured meat products by Űren and Babayiğit [1996].

pH determination

Homogenates were prepared by blending 10 g of sausage with 50 ml of distilled water for 60 s and readings were taken with a pH-meter CPC-501 equipped with a pH electrode ERH-111.

Oxidation-reduction potential (ORP)

Oxidation-reduction potential was measured in sausage homogenates as described by Nam and Ahn [2003]. ORP were determined using pH meter set to the milivolt scale and equipped with redox electrode (ERPt-13).

Determination of TBARS

The lipid oxidation was determined by assaying values of TBARS according to the method of Pikul et al. [1989]. Intensity of colour produced in the reaction of malondialdehyde with 2-thiobarbituric acid was measured by means of Nicole Evolution 300 spectrophotometer (Thermo Electron Corporation) at a wave length of 532 nm. The values of TBARS, were expressed in mg malondialdehyde per 1 kg of meat product.

ABTS radical cation decolorization assay

The antioxidant activity was assayed on the basis of a method represented by Re et al. [1999]. The reduction level of ABTS was determined by a spectrophotometric method. The ABTS solution revealed maximum absorbance at 734 nm, the addiction of the antiradical compound resulted with the drop of the absorbance. The results were expressed as antioxidant activity (%) of plant extracts against $ABTS^{\cdot+}$ radicals [Drużyńska et al. 2007].

Statistical analysis

The experiment was carried out on two parts of raw meat and plant extracts in three replications. All data were subjected to analysis of variance (ANOVA). Significance of differences between the mean values at a significance level of $p \leq 0.05$ with the Tukey's – test.

RESULTS AND DISCUSSION

The raw pork meat and plant extracts characteristic are shown in Table 1. Raw pork meat had acidity on the level of 6.15 ±0.01 which means that it was normal meat without defect. Oxidation – reduction potential of fresh meat was 288.95 ±0.55 mV and the TBARS value, was 0.95 mg MDA/kg. All plant extracts had pH value higher than 7.0 units. The highest pH value was noted in green tea extract (~7.70 units) and the lowest pH values, was observed in red pepper extract (~7.27). Oxidation – reduction potential had the lowest value in red pepper extract (~271.48 mV). Extract of red pepper had also the biggest antioxidant activity against $ABTS^{\cdot+}$ radicals (~57.84%).

Table 1. The raw materials and plant extracts description

Quality	Extract						Meat	
	green tea		pepper		rosemary			
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
pH	7.70	0.01	7.27	0.05	7.29	0.12	6.15	0.01
ORP, mV	281.73	4.39	271.48	4.48	310.63	0.93	288.95	0.55
TBARS, mg/kg	–		–		–		0.95	0.03
Colour								
L*	86.81	0.23	27.87	6.84	61.05	3.99	46.28	4.10
a*	–4.52	0.08	19.38	0.5	3.66	0.14	8.35	1.78
b*	36.4	0.11	40.39	5.15	40.14	1.44	9.34	1.19
Water content, %	–		–		–		72.84	0.51
Fat content, %	–		–		–		8.06	0.08
$ABTS^{\cdot+}$, %	56.50	2.57	57.84	2.11	17.63	1.32	–	

$\bar{x}$ – average value.
SD – standard deviation.

The acidity measurement of meat products (Fig. 1) indicated that the plant extracts did not affect the pH values. For 0 day of storage all the samples had similar pH values approximately 6.2. The biggest differences were observed after 10 days of chilling storage. The meat sample with green tea extract and the sample with rosemary extract addition had significantly ($p \leq 0.05$) lower pH values compared to the control sample.

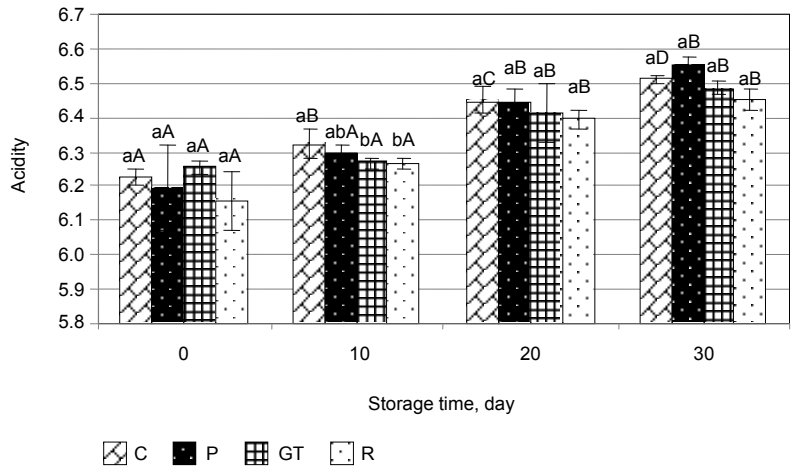

Fig. 1. Changes of acidity in meat products during chilling storage. Means followed by different capital letters $^{A-D}$ within the same sample or by small letters $^{a-b}$ within different samples are significantly different ($p \leq 0.05$)

The acidity, measured after 20 and 30 days of storage was similar for all samples (6.4-6.5). Over the 30 days of storage period the pH values of all samples did vary greatly. The pH values of all samples changed over time. Significantly ($p \leq 0.05$) highest values of pH were observed from 10 to 20 days of chilling storage for samples with plant extracts.

The addition of plant extract, especially rosemary extract and red pepper extract decreased the pH value in 0 days of chilling storage, which might have helped during curing process in correct reduction of nitrite to nitric oxide (NO) [Űren and Babayiğit 1996].

Plant extracts in cooked meat product had an effect on oxidation – reduction potential (ORP) of this product (Fig. 2). At 0 day, 10 and 20 days of storage, all the samples with plant extracts had significantly ($p \leq 0.05$) lowered ORP value compared to the control sample. Oxidation – reduction potential was about 30 mV lower in samples with addition of plant extracts (green tea, red pepper, rosemary) compared to control sample. At 30 days of storage, sample with green tea extract had significantly the highest ORP values compared to control sample. Potential redox of most meat samples increased during the whole storage period (Fig. 2).

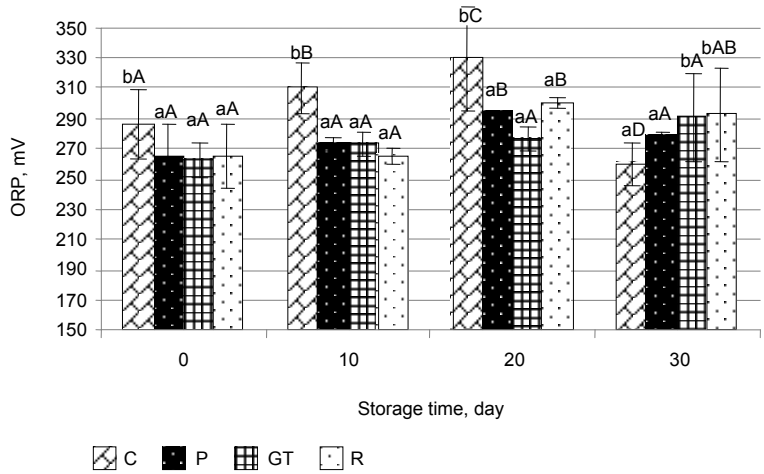

Fig. 2. Changes of oxidation-reduction potential (ORP) in meat products during chilling storage. Means followed by different capital letters $^{A-D}$ within the same sample or by small letters $^{a-b}$ within different samples are significantly different ($p \leq 0.05$)

An exception to the rule was control sample, the ORP value of which increased at 20 days of storage and then decreased at 30 days of refrigerated storage.

Potential redox was stable at 20 days of chilling storage in two samples: with red pepper extract and with green tea extract (~280 mV). Significantly ($p \leq 0.05$) the highest oxidation – reduction potential value was observed between 10 to 20 days of chilling storage for sample with rosemary extract addition. These results, agree with those reported by Bilska et al. [2007] in vacuum stored slaska type of sausage. The use of plant extracts reduced oxidation – reduction potential which might have helped to release NO

from nitrite and limited the production of ferric state myoglobin (MetMb) giving appopriate colour to the cured meat product [Űren and Babayiğit 1996].

Oxidation (TBARS values) in meat products is shown in Figure 3. TBARS values have increased in all samples during 30 days of chilling storage. There were not significant ($p \leq 0.05$) differences between TBARS values in sample with pepper extract during the whole time of storage.

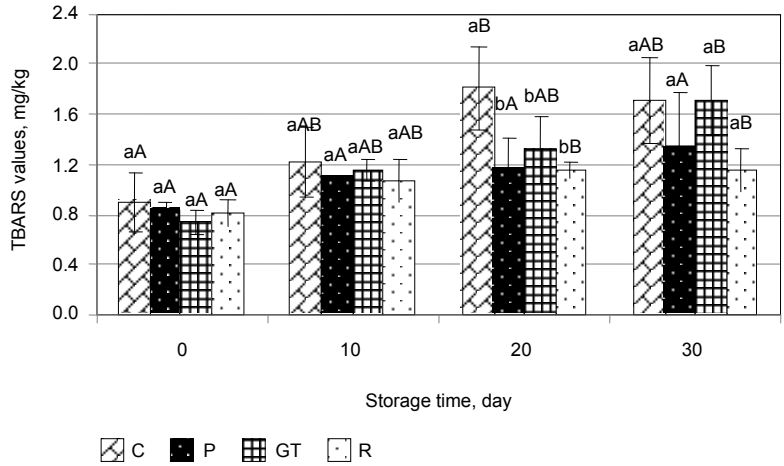

Fig. 3. Changes of TBARS values in meat products during chilling storage. Means followed by different capital letters $^{A-B}$ within the same sample or by small letters $^{a-b}$ within different samples are significantly different ($p \leq 0.05$)

Significantly ($p \leq 0.05$) highest TBARS values were noted after 20 days of storage in control sample (~1.80 mg MDA/kg) and after 30 days of storage in sample with green tea extract addition (~1.63 mg MDA/kg). TBARS formation was strongly inhibited by some of the antioxidant treatments, so all of them lowered the lipid oxidation significantly ($p \leq 0.05$) during the whole time of chilling storage. In the 30 days of storage the sample with green tea extract was significantly ($p \leq 0.05$) less effective particularly within samples with red pepper extract or with rosemary extract addition. These results, suggest that the addition of pepper extract and rosemary extract had retarded the lipid oxidation during the storage. This result, agrees with that reported by Fernández-López et al. [2005], Karwowska and Dolatowski [2007], Mc Carthy et al. [2001], Sebranek et al. [2005], Tang et al. [2001 a, b].

In all samples, lightness decreased with storage time ($p \leq 0.05$) and the lowest values of L* were obtained after 30 days of chilling storage in sample with green tea extract addition (Table 2). There were significant ($p \leq 0.05$) differences between samples with plant extracts compared to the control sample at 0 and 10 days of storage period. There were not significant ($p \leq 0.05$) differences between lightness of all samples at 20 and 30 days of storage. Two samples: with green tea extract and red pepper extract had significantly ($p \leq 0.05$) lower L* values compared to control sample, however the one with rosemary extract had the highest lightness compared to control sample directly

Table 2. Colour parameters (CIE LAB) of meat products during chilling storage

Colour parameters	Variants							
	C		P		GT		R	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Parameter L*								
0	62.46 ^{aA}	1.27	59.51 ^{bA}	1.11	61.91 ^{bA}	1.05	63.66 ^{bA}	1.22
10	55.10 ^{aB}	2.95	60.83 ^{bA}	0.67	60.49 ^{bA}	0.86	54.89 ^{acB}	4.59
20	56.20 ^{aB}	0.85	55.72 ^{aB}	0.88	55.74 ^{aB}	3.29	56.27 ^{aCB}	1.37
30 days	50.29 ^{aC}	3.57	54.36 ^{aB}	1.99	50.12 ^{aC}	2.88	50.77 ^{aB}	1.65
Parameter a*								
0	9.71 ^{aA}	0.46	10.74 ^{bAB}	0.87	10.12 ^{abA}	0.36	10.05 ^{abAB}	0.65
10	5.96 ^{aB}	3.11	10.17 ^{bA}	0.43	9.94 ^{bA}	0.86	8.72 ^{abA}	1.33
20	10.43 ^{abA}	0.42	11.06 ^{aAB}	0.53	9.82 ^{bA}	1.05	10.39 ^{abB}	0.55
30 days	12.06 ^{aA}	1.06	11.41 ^{aB}	0.39	11.36 ^{aB}	0.42	11.20 ^{aB}	0.62
Parameter b*								
0	9.65 ^{aAB}	0.58	10.30 ^{aA}	0.43	9.34 ^{aA}	0.31	9.44 ^{aA}	0.89
10	10.08 ^{aA}	0.65	8.76 ^{aB}	0.97	9.67 ^{aA}	0.49	10.15 ^{aC}	0.99
20	8.83 ^{abB}	0.75	9.26 ^{aAB}	0.80	9.14 ^{aA}	0.82	7.71 ^{bB}	0.62
30 days	7.50 ^{aC}	0.73	8.26 ^{abB}	0.30	9.00 ^{bA}	0.43	8.15 ^{abAB}	0.99
NI								
0	1.20	0.02	1.16	0.01	1.19	0.02	1.18	0.01
10	1.19	0.01	1.16	0.00	1.19	0.02	1.17	0,01
20	1.19	0.01	1.16	0.01	1.17	0.01	1.16	0.01
30 days	1.18	0.01	1.12	0.02	1.16	0.01	1.15	0.01
RSI								
0	0.39	0.02	0.38	0.02	0.35	0.02	0.37	0.02
10	0.40	0.01	0.38	0.00	0.37	0.01	0.39	0.03
20	0.41	0.01	0.39	0.02	0.39	0.01	0.42	0.01
30 days	0.42	0.01	0.40	0.03	0.40	0.01	0.42	0.01

Means followed by different capital letters $^{A-C}$ within the same sample or by small letters $^{a-c}$ within different samples are significantly different ($p \leq 0.05$).

$\bar{x}$ – average value.

SD – standard deviation.

at the meat sample production (0 day). There were observed significantly higher redness values for probes with plant extracts compared to the control. Adamczak et al. [2010] concluded that similar a* values for all probes of frankfurters with addition of vegetable extract can provide indirectly similar level of nitrosomyoglobin in those samples. There was noted a great difference in redness of the sample with red pepper extract contrary to the rest of samples. The sample with pepper extract had significantly ($p \leq 0.05$) highest a* values compared to the rest of samples.

An explanation for the observed meat colour stability in sample with red pepper, can be that pepper extract could protect haem pigments from oxidation. But there is also another explanation. Fernández-López et al. [2005] suggested that the highest red colour in sample with pepper extract could be the result of plenty of red component pigments such as carotene in red pepper extract. Samples with pepper, green tea and rosemary extracts had significantly higher ($p \leq 0.05$) mean a* values than the control sample after production (0 day) and after 10 days of chilling storage. No significant ($p \leq 0.05$) differences in redness of the samples were observed after 20 and 30 days of storage condition (a* = 11.20 – 12.06). In all samples with water plant extracts, pigment nitrosation values (NI) were lower compared to the control sample (Table 2). The lowest NI value was observed for the sample with pepper extract (1.16-1.12) during the whole time of chilling storage. Small NI value, indicate high conversion of myoglobin and oxymyoglobin into nitrosomyoglobin [Űren and Babayiğit 1996]. The lower RSI value was observed for the samples with water plant extracts compared to the control sample during the whole time of refrigeration storage. Small levels of brown metmyoglobin pigment in probes with pepper extract and green tea extract can be seen through the small RSI values. It is also noticable that these samples had the biggest CIE a* value compared to control sample. Several authors have studied the effect of addition of different antioxidants like for example: rosemary extract, tea catechins, garlic extract, lemon fiber, orange fiber etc. on the colour of meat and meat products [Fernández-López et al. 2005, He and Shahidi 1997, Karwowska and Dolatowski 2007, Mc Carthy et al. 2001, Sebranek et al. 2005, Tang et al. 2001 a, b]. They have reported that oxidation of lipids initiates haem pigments oxidation and decreases red colour in meat and meat products [Freybler et al. 1993, O'Grady et al. 2001]. There was, also increased, methmyoglobin form in their products which was also confirmed in our studies.

In all samples yellowness values, were not significantly ($p \leq 0.05$) different between samples at 0 and 10 days of chilling storage. Significantly ($p \leq 0.05$) lowest b* values were observed for the sample with rosemary extract compared to other samples. Also significantly ($p \leq 0.05$) highest, yellowness values were noted in meat products with green tea extract addition, after 30 days of storage (Table 2). In all samples yellowness decreased as the storage time was progressing.

Changes in the value of ΔE during chilling storage are shown at Figure 4. Slight total colour change (ΔE) was observed in samples with pepper extract and with green tea extract. The significant colour changes, were noted in two samples: control and rosemary extract. The most significant colour changes were noted after 10 days of chilling storage in control sample and in sample with rosemary extracts. A bit slower changes in colour were observed in other days of refrigeration storage.

In sample with rosemary extract and in sample with green tea extract, lightness decreased during exposure to light period ($p \leq 0.05$). In samples control and with pepper extract L* value was stable during the 3 hour- long light operations (Table 3). There were significant ($p \leq 0.05$) differences between sample, with pepper extract compared

Table 3. Colour parameters (CIE LAB) of meat products during its exposure on light in 0 day of chilling storage

Colour parameters	Variants							
	C		P		GT		R	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Parameter L*								
0	62.46 ^{bA}	1.27	59.91 ^{aA}	1.11	61.91 ^{bA}	1.05	63.66 ^{bA}	1.22
1	62.30 ^{aA}	1.41	59.31 ^{bA}	1.29	60.96 ^{bA}	0.82	63.67 ^{acA}	0.62
2	62.23 ^{aA}	0.42	59.02 ^{bA}	1.79	61.77 ^{aA}	0.64	62.13 ^{aB}	1.03
3 hours	62.79 ^{aA}	1.22	59.54 ^{bA}	1.80	61.50 ^{aA}	0.55	62.50 ^{aAB}	0.58
Parameter a*								
0	9.71 ^{bA}	0.46	10.74 ^{aA}	0.87	10.12 ^{A}	0.36	10.05 ^{A}	0.65
1	8.52 ^{aB}	1.25	8.54 ^{aB}	0.90	8.72 ^{aB}	0.16	8.24 ^{aB}	0.43
2	5.99 ^{aC}	0.38	7.07 ^{bC}	0.20	6.87 ^{bC}	0.24	6.99 ^{bC}	0.13
3 hours	5.64 ^{aC}	0.42	6.58 ^{bC}	0.15	6.79 ^{bC}	0.36	6.89 ^{bC}	0.27
Parameter b*								
0	9.65 ^{A}	0.58	10.30 ^{bA}	0.43	9.34 ^{aA}	0.31	9.44 ^{A}	0.89
1	10.66 ^{aA}	0.83	11.68 ^{B}	0.90	11.93 ^{bB}	0.43	11.43 ^{B}	0.82
2	12.22 ^{aB}	0.56	13.23 ^{bC}	0.30	12.02 ^{acB}	0.71	12.52 ^{C}	0.39
3 hours	12.05 ^{aB}	0.58	12.62 ^{aC}	0.34	12.19 ^{aB}	0.52	12.72 ^{aC}	0.14
NI								
0	1.19	0.01	1.16	0.01	1.17	0.01	1.16	0.01
1	1.14	0.02	1.10	0.01	1.11	0.01	1.11	0.00
2	1.14	0.00	1.09	0.00	1.09	0.01	1.09	0.01
3 hours	1.13	0.01	1.09	0.01	1.08	0.01	1.09	0.00
RSI								
0	0.43	0.01	0.42	0.02	0.39	0.01	0.42	0.01
1	0.52	0.02	0.54	0.02	0.52	0.02	0.52	0.01
2	0.56	0.01	0.55	0.01	0.57	0.01	0.57	0.02
3 hours	0.58	0.01	0.57	0.02	0.58	0.02	0.58	0.01

Means followed by different capital letters $^{A-C}$ within the same sample or by small letters $^{a-c}$ within different samples are significantly different ($p \leq 0.05$).

$\bar{x}$ – average value.

SD – standard deviation.

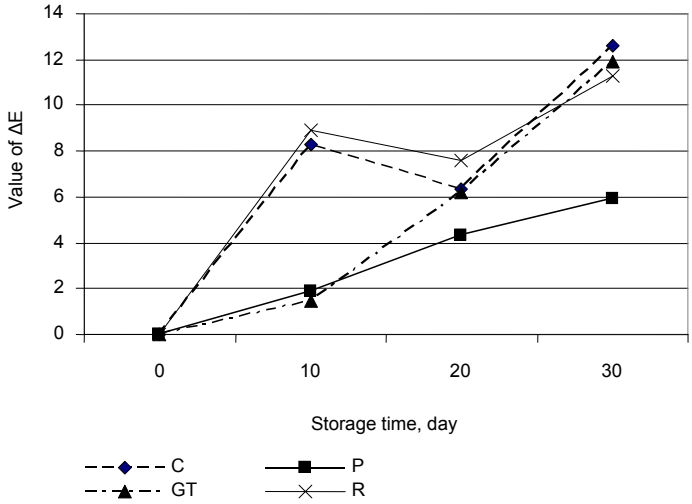

Fig. 4. Changes in the value of ΔE during chilling storage

to the other samples. There was significantly ($p \leq 0.05$) lowest lightness of sample with pepper extract compared to the control sample and samples with green tea and rosemary extracts during exposure to light period. Only the sample with green tea extract had significantly ($p \leq 0.05$) lower L* values compared to the control sample.

In all samples redness values had consistently decreased during the 3 hours of light activity. Sample with pepper extract had significantly ($p \leq 0.05$) highest a* values compared to the rest of samples in 0 and 2 hours of exposure. Samples with pepper, green tea and rosemary extracts had significantly higher ($p \leq 0.05$) mean a* values than the control sample after every hour of exposing samples to light.

In all samples yellowness values weren't significantly ($p \leq 0.05$) different after 1st and 2nd hour of exposure to the light. Significantly ($p \leq 0.05$) highest b* values were observed in sample with rosemary extract and in sample with pepper extract compared to the control sample. In all samples yellowness decreased as the exposure on the light time was progressing. In all samples pigment discoloration index (RSI) was increasing during the 3 hours of light activity. This means that metmyoglobin formation probably was increasing during exposing probes to light [Ercoşkun et al. 2010]. The smallest pigment discoloration index was observed for probe with red pepper extract (Table 3).

From examination of Table 3 it is concluded that pigment nitrosation (NI) was on the level 1.20-1.08 and pigment discoloration (RSI) on the level of 0.39-0.58. This result were similar than those described by Űren and Babayiğit [1996] and Ercoşkun et al. [2010] in traditional sucuks sausage. During all time of exposure sample on light nitrosation index decreased and pigment discoloration index consistently increased. Űren and Babayiğit [1996] suggested that decrease of nitrosation index indicated an increase in the nitrosomyoglobin form of haem pigments.

CONCLUSION

1. Addition of the plant extracts (pepper, green tea, rosemary) to the pork meat samples does not change significantly acidity of the samples during chilling storage.

2. Addition of pepper extract and green tea extract in curing meat process helped with nitrosomyoglobin formation and curb prevention of metmyoglobin formation which stabilized colour of product during chilling storage.

3. All plants extracts effectively reduce lipid oxidation in cooked pork meat compared to the control sample.

4. Pepper extract was effective in maintaining redness because of its reduction activity (low potential redox value in sample) and low TBARS values in sample during chilling storage. Pepper extract stabilized TBARS values and retarded lipid oxidation and colour discoloration during 30 days of storage better than other extracts.

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WPŁYW DODATKU WODNYCH EKSTRAKTÓW ROŚLINNYCH NA STABILNOŚĆ OKSYDACYJNĄ PRZETWORÓW MIĘSNYCH

Wstęp. Ekstrakty roślinne zawierają w składzie wiele substancji o działaniu antyoksydacyjnym: katechiny, epigallokatechiny (zielona herbata), rozmarynochinon, rozmarynodifenol (rozmaryn), kapsantynę (czerwona papryka). Celem badań była próba określenia wpływu dodatku ekstraktów: zielonej herbaty, papryki lub rozmarynu, dodanych podczas procesu peklowania na barwę i stabilizację oksydacyjną wyrobów mięsnych podczas przechowywania chłodniczego.

Materiał i metody. Mięso wieprzowe było rozdrabniane (siatka 10 mm), a następnie dzielone na cztery równe części. Do pierwszej części (próba kontrolna – C) dodano mieszankę peklującą (99,4-99,5% chlorku sodu, 0,5-0,6% azotynu sodu) w ilości 2,2% w stosunku do masy mięsa, rozpuszczoną w wodzie. Do pozostałych części dodano taką samą

ilość mieszanki peklującej rozpuszczoną w odpowiednim ekstrakcie roślinnym: zielonej herbaty (GT), czerwonej papryki (P), rozmarynu (R). Wszystkie próby zostały pozostawione w temperaturze 4°C przez 24 h. Farszem napełniono osłonki i obrabiano cieplnie w wodzie aż do osiągnięcia temperatury 70°C wewnątrz prób. Wszystkie próby były przechowywane przez 30 dni w temperaturze 4°C. Analizę kwasowości, potencjału oksydacyjno-redukcyjnego, wskaźnika TBARS, barwy (wskaźnik L, a, b) przeprowadzono bezpośrednio po produkcji oraz w 10, 20 i 30 dobie przechowywania chłodniczego.
Wyniki. Dodatek wodnych ekstraktów roślinnych (zielonej herbaty, papryki, rozmarynu) do mięsa wieprzowego nie zmienił statystycznie istotnie kwasowości wyrobów podczas przechowywania chłodniczego. Wszystkie próby z dodatkiem ekstraktów roślinnych hamowały peroksydację lipidów efektywniej niż próba kontrolna. Najbardziej stabilną czerwoną barwę podczas przechowywania chłodniczego, najniższy potencjał redoks oraz wskaźnik TBARS stwierdzono w próbie z dodatkiem papryki.
Wnioski. Dodatek ekstraktu papryki oraz ekstraktu zielonej herbaty podczas peklowania mięsa wspomógł proces peklowania (tworzenie nitrozylomioglobiny) oraz zahamował wytwarzanie metmioglobiny, co sprawiło, iż produkt mięsny charakteryzował się bardziej stabilną barwą podczas przechowywania.

Słowa kluczowe: zielona herbata, papryka, rozmaryn, barwniki hemowe, wodne ekstrakty, oksydacja

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