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THE EFFECT OF NATURAL ANTIOXIDANTS ON THE OXIDATIVE PROCESSES IN BEEF

Małgorzata Karwowska, Zbigniew J. Dolatowski
Agricultural University of Lublin

Abstract. Addition of natural antioxidants is one of the ways to extend the durability of meat and meat products. The effects of added pepper extracts on the colour and potential redox changes of beef patties during storage were studied. There were four types of ethanol based extracts of two types of pepper (sweet and hot), compacted at different temperatures: 35 and 50°C. Experimental material consisted of meat samples produced from lean beef 24-hours postmortem. The colour in a CIE L*a*b* systems was examined using an X-Rite reflection spectro-colorimeter. Oxidation-reduction potential was determined using a pH meter (CPC-501) set to the milivolt scale and equipped with a redox electrode ERPt--13. The results indicate the influence of extracts of different types of pepper added on oxidation-reduction potential values. Meat samples with pepper extract compacted at 35°C addition had a lower oxidation-reduction potential compared with the samples with pepper extract compacted at 50°C addition. Oxidation-reduction potential values of meat samples increased during storage. No significant effects of type of a particular pepper extract on redox potential values were observed. Pepper extracts increased redness (a* value) of meat samples compared to the control, but had no effects on L* values (lightness). During storage of meat samples slight changes of CIE a* parameters were noted.

Key words: pepper extract, beef, potential redox, colour

INTRODUCTION

Food lipid oxidation is considered to be a risk factor for human health. Some lipid products are considered atherogenetic agents and appear to have mutagenic, and carcinogenic properties. Lipid oxidation is responsible for the development of unpleasant tastes and odours, as well as changes in colour, reological properties and formation of toxic compounds [Addis and Park 1989, Bartosz 2003]. The relationship between haem pigments oxidation and lipid oxidation in meat and meat products was noted [Baron and Andersen 2002, Gorelik and Kanner 2001]. The studies concerning meat haem pigments initiate and catalyze the oxidation of muscle tissue lipids which results in a rancid odour

Corresponding author – Adres do korespondencji: Dr inż. Małgorzata Karwowska, Department of Meat Technology and Food Quality of Agricultural University of Lublin, Skromna 8, 20-704 Lublin, Poland, e-mail: malgorzata.dudek@ar.lublin.pl

and flavour. Free radical, produced during lipid oxidation, can oxidize haem pigments, causing discolouration of meat and meat products. Moreover, myoglobin catalyzes lipid oxidation; iron ions (Fe^{2+}, Fe^{3+}) present in haem are better prooxidants than as free ions [Münch 2004, Renerre 1999].

The search for alternative methods to retard oxidative processes in meat and meat products has led researchers to investigate natural antioxidants. Addition of antioxidants to meat products is known to be effective in metmyoglobin formation and lipid oxidation. The application of vitamin E [Mc Carthy et al. 2001], rutin [Bekhit et al. 2003], ascorbate acid [Sánchez-Escalante et al. 2003], rosmaryn [Sebranek et al. 2005] to meat products is well documented.

The aim of the current study was to investigate the ability of antioxidants present in pepper extracts to provide protection against oxidative processes in beef during chilling storage.

MATERIALS AND METHODS

Meat samples preparation

Experimental material consisted of meat samples produced from lean beef 24 hours postmortem. The meat was ground (3 mm plate), then cured using 0.05% sodium nitrite and left at 4°C for 24 hours. After this time, it was chopped using a laboratory appliance (Ronic) at the speed of 1500 cuts per minute. Ice water (10%) and pepper extracts (2%) were added during this process. Four types of ethanol based extracts of two types of freeze-drying peppers (hot – 'Capel Hot' and sweet – 'Red Knight'), compacted at different temperatures: 35 and 50°C were used. The pepper extracts were prepared in the Department of Biochemistry at the Agricultural University of Lublin [Perucka and Materska 2003]. Meat batters were heated in water (75°C) until a final internal temperature of 72°C was reached. Then the samples were cooled with water until reaching the temperature of 20°C and stored at 4°C. Five options of the samples were obtained:

P0 – control samples (without pepper extracts addition),
P1 – meat samples with addition of 2% ethanol based extracts of freeze-drying sweet pepper (Red Knight), compacted at 50°C,
P2 – meat samples with addition of 2% ethanol based extracts of freeze-drying hot pepper (Capel Hot), compacted at 50°C,
P3 – meat samples with addition of 2% ethanol based extracts of freeze-drying sweet pepper (Red Knight), compacted at 35°C,
P4 – meat samples with addition of 2% ethanol based extracts of freeze-drying hot pepper (Capel Hot), compacted at 35°C.

The studies were conducted 1, 15 and 30 days since the production time. The experiment was carried out in three replications.

Measurement of pH

The pH of the samples was measured using pH-meter CPC-501 equipped with a pH electrode ERH-111.

Oxidation-reduction potential (ORP)

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

Colour measurements

Hunter colour lightness (L*), redness (a*) and yellowness (b*) values were measured on freshly cut surfaces of each sample using X-Rite reflection spectro-colorimeter, using illuminant D65 and 10° observer angle. The instrument was standardized using a standard white plate (L* = 95.87; a* = –0.49; b* = 2.39). Readings were obtained from three locations of each product randomly selected to obtain a representative reading of the colour of the products.

Statistical analysis

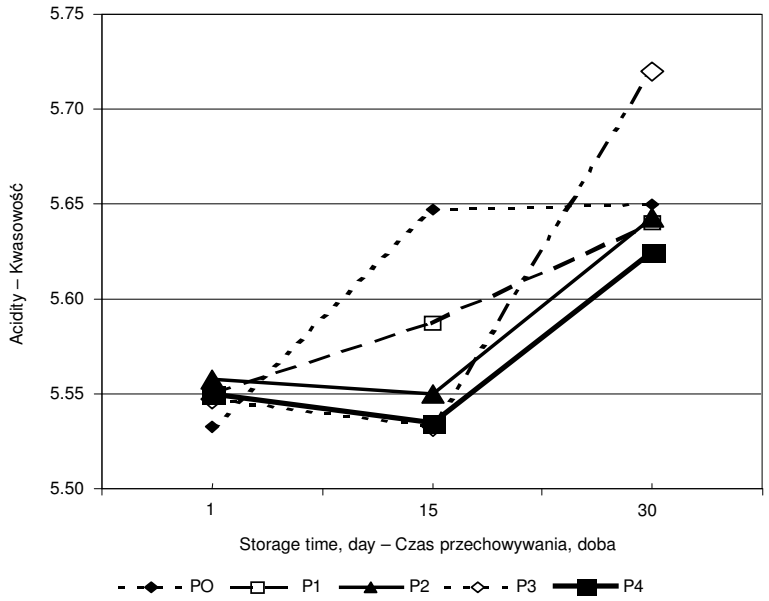
Results were subjected to statistical analysis. The correlations between the ORP values and colour parameters (L*a*b*) were calculated. T-Tukey's test ($\alpha \geq 0.05$) was applied to verify the difference significance.

Table 1. Correlation coefficient between potential redox values (ORP) and colour parameters L*a*b*
Tabela 1. Współczynniki korelacji dla zależności pomiędzy potencjałem oksydoredukcyjnym (ORP) a parametrami barwy L*a*b*

Parameter Parametr	Colour parameter – Parametry barwy					
	L*		a*		b*	
ORP, mV	r	R^2	r	R^2	r	R^2
P0	–0.33	0.11	–0.57	0.33	–0.98	0.96
P1	0.53	0.28	–0.77	0.60	0.07	0.01
P2	–0.25	0.06	0.92	0.85	0.99	0.98
P3	–0.36	0.13	–0.51	0.97	0.76	0.58
P4	–0.99	0.99	0.94	0.88	–0.71	0.50

RESULTS AND DISCUSSION

An examination of the acidity of meat samples (Fig. 1) indicated that the addition of pepper extracts did not affect the pH values. For 1 day of storage, all the samples had similar pH values, approximately 5.5. The highest differences were observed after 15 days since the production time. The meat samples with extracts addition characterized lower pH values compared to the control. The acidity, measured after 30 days of storage was similar for the most of the samples (5.63-5.65), except P3 sample; higher pH value (5.72) was observed for this sample containing extract of sweet pepper compacted at 35°C.



Acidity Kwasowość	Options – Warianty				
	P0	P1	P2	P3	P4
After 1 day of storage time Po 1 dobie chłodniczego przechowywania	ab	a	a	a	a
After 15 days of storage time Po 15 dobach chłodniczego przechowywania	b	a	b	b	a
After 30 days of storage time Po 30 dobach chłodniczego przechowywania	a	a	ab	ab	a

Fig. 1. Influence of storage time on the acidity of meat products. Averages marked with the same letters differ statistically significantly ($\alpha \geq 0.05$)
Rys. 1. Wpływ czasu przechowywania na kwasowość wyrobów mięsnych. Średnie oznaczone tymi samymi małymi literami w obrębie tej samej próby różnią się statystycznie istotnie. Nie stwierdzono różnic statystycznie istotnych pomiędzy różnymi próbami ($\alpha \geq 0,05$)

Extracts of two types of pepper had an effect on potential redox of meat samples (Fig. 2). The samples P1 and P2 (with addition of extracts of sweet and hot pepper compacted at 50°C) stored for 1 day had higher ORP values compared to control samples. The extracts of sweet and hot pepper compacted at a lower temperature (35°C) addition decreased potential redox values compared to control at about 15 mV. Potential redox of the most meat samples increased during the whole storage period. The examination taken 30 days after the production indicated that ORP values of all variants of experimental samples were similar (~365 mV).

Hunter colour values of samples are given in Figure 3, 4, 5. Storage time (1, 15 and 30 days) had no significant effect ($\alpha \geq 0.05$) on L* values of the most of meat samples (Fig. 3).

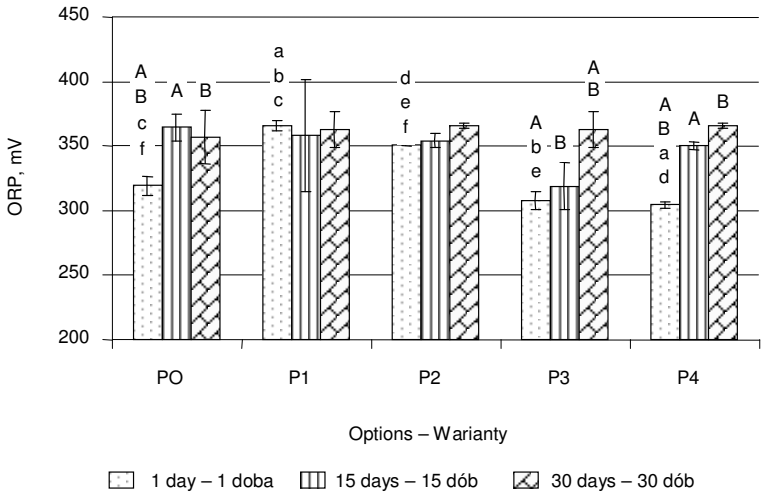


Fig. 2. Changes in the value of potential redox during the storage of meat products. Averages marked with the same letters differ statistically significantly ($\alpha \geq 0.05$)
Rys. 2. Zmiany wartości potencjału oksydoredukcyjnego próbek mięsnych w czasie ich przechowywania. Średnie oznaczone tymi samymi wielkimi literami A-B w obrębie tej samej próby i małymi literami a-f pomiędzy różnymi próbami różnią się statystycznie istotnie ($\alpha \geq 0,05$)

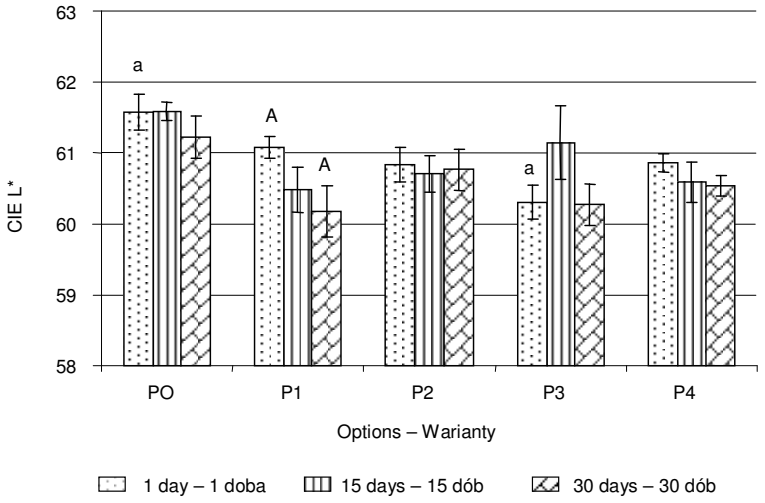


Fig. 3. Values of colour parameter L* (lightness) during meat products storage. Averages marked with the same letters differ statistically significantly ($\alpha \geq 0.05$)
Rys. 3. Wartości parametru L* (jasność) barwy próbek mięsnych w czasie ich przechowywania. Średnie oznaczone tą samą wielką literą A w obrębie tej samej próby i małą literą a pomiędzy różnymi próbami różnią się statystycznie istotnie ($\alpha \geq 0,05$)

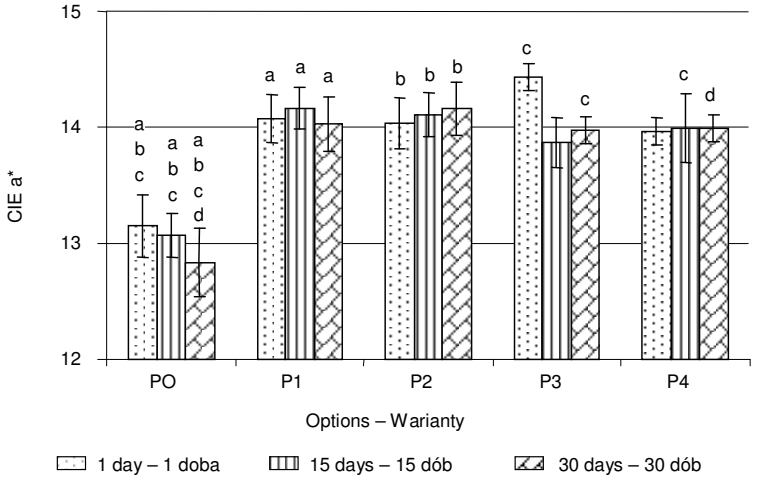


Fig. 4. Values of colour parameter a* (redness) during meat products storage. Averages marked with the same letters differ statistically significantly ($\alpha \geq 0.05$)
Rys. 4. Wartości parametru a* barwy próbek mięsnych w czasie ich przechowywania. Średnie oznaczone tymi samymi małymi literami a-d pomiędzy różnymi próbami różnią się statystycznie istotnie ($\alpha \geq 0,05$)

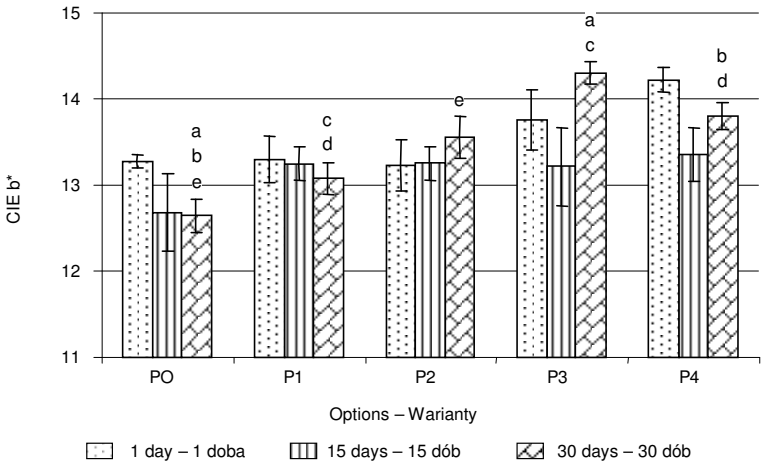


Fig. 5. Values of colour parameter b* (yellowness) during meat products storage. Averages marked with the same letters differ statistically significantly ($\alpha \geq 0.05$)
Rys. 5. Wartości parametru b* barwy próbek mięsnych w czasie ich przechowywania. Średnie oznaczone tymi samymi małymi literami a-e pomiędzy różnymi próbami różnią się statystycznie istotnie ($\alpha \geq 0,05$)

Extracts of pepper decreased lightness compared to control, but differences were not significant. The statistical analysis indicated the correlation between L* and potential

redox values. Correlation coefficients that are given in Table 3 showed that with the increase of ORP values L* values decreased in the case of most variants of experimental samples. No correlation between L* and potential redox values for the sample P2 with extracts of hot pepper compacted at 50°C addition was noted (r = –0.25). A high minus correlation between lightness and ORP of P4 sample (with extracts of hot pepper compacted at 35°C addition) was obtained. The correlation coefficient r = 0.53 obtained for P1 sample indicates that with the increase of the ORP value the lightness increased too.

A great difference in redness (a* value) of the samples with pepper extracts addition compared to the control sample was noted (Fig. 4). Experimental meat samples with sweet pepper extracts (P1 and P3) and hot pepper extracts (P2 and P4) addition had significantly higher ($\alpha \geq 0.05$) mean a* values than the control sample. Storage time did not affect the redness of the experimental samples. The sample with addition of sweet pepper extracts compacted at 35°C (P3) was characterized by the highest a* parameter values (a* = 14.43) after 1 day since the production time; the control sample had the lowest redness value (a* = 12.84) 30 days after production.

The analysis of the correlation coefficients between oxidation-reduction potential and a* parameter values indicates the high positive correlation between the mentioned parameters for the meat samples with the addition of hot pepper extracts (P2 and P4). In the case of the meat samples that contain sweet pepper extracts, with the increase of potential redox, the redness decreased.

The changes of yellowness values depended on the type of pepper extracts and time of chilling storage. The values of b* parameter range from 12.64 for the control sample (P0) to 14.30 for the sample with sweet pepper extract compacted at 35°C addition (P3) after 30 days of storage. No correlation between ORP values and b* parameter was noted for P1 sample (k = 0.07). The high minus correlation between the mentioned parameters was obtained for the control samples (k = –0.98) and the P4 sample with the addition of hot pepper extracts addition prepared at 35°C (k = –0.71). In comparison, the high positive correlation between potential redox and yellowness was observed for P2 and P3 samples.

The results obtained during the present studies indicate that on the first day of storage meat samples with pepper extracts compacted at 35°C addition had lower oxidation-reduction potential compared to control and meat samples with the addition of pepper extracts compacted at 50°C. After 15 days since the production all the experimental samples containing pepper extracts characterized lower potential redox values than control samples. The effects of pepper extracts on meat quality that was noted during the present studies may result from antioxidants presence. Pepper is a rich source of vitamin C, E and β-carotene [Simonne et al. 1997]. Moreover, hot pepper contains specific alcaloides – capsaicinoids – compounds that have antioxidant effect [Lee at al. 1995]. The results obtained by Kogure et al. [2002] support the capsaicinoids antioxidants activity. The research of Perucka and Materska [2006] showed that pepper extracts prepared at a lower temperature (35°C) had higher antioxidant vitamins and phenolic compounds content compared to the extracts compacted at a higher temperature (50°C).

Moreover, the colour evaluation of the meat samples showed that the meat samples that contain pepper extracts had a higher redness values compared to control. This parameter did not change during the chilling storage. A possible explanation for the observed meat colour stability may be due to high ORP values, that could preserve haem pigments at a reduced form. Ahn and Nam [2004] showed that ascorbic acid had an effect on oxidation-reduction potential lowering and improving the colour stability compared to control.

CONCLUSION

1. Application of the extracts of two types of pepper in the meat samples does not alter significantly the acidity of the samples.

2. Pepper extracts compacted at 35°C were characterized by a higher ability to lower potential redox than the extracts compacted at 50°C. Low potential redox value helped to maintain the haem pigments in a reduced form. Thus, pepper extracts incorporated in meat were effective in maintaining redness (a* values).

3. Differential correlation coefficient between potential redox and L*, a* values was noted. With the increase (decrease) of oxidation-reduction potential, lightness and redness values increased (decreased).

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WPŁYW NATURALNYCH PRZECIWUTLENIACZY PAPRYKI NA UTLENIANIE SKŁADNIKÓW WOŁOWINY PODCZAS PRZECHOWYWANIA

Streszczenie. Przedmiotem badań było określenie wpływu dodatku ekstraktów przeciwutleniaczy papryki na przemiany barwy oraz potencjału oksydoredukcyjnego prób mięsnych w czasie przechowywania. Zastosowano cztery rodzaje etanolowych ekstraktów przeciwutleniaczy dwóch odmian papryki, zatężanych w różnych temperaturach: ekstrakt etanolowy papryki słodkiej liofilizowanej, odmiany 'Red Knight', zatężony w 35°C i 50°C oraz ekstrakt etanolowy papryki ostrej odmiany 'Capel Hot', zatężony w 35°C i 50°C. Ekstrakty zostały przygotowane w Katedrze Chemii Akademii Rolniczej w Lublinie. Materiałem badawczym były modelowe próby wyprodukowane z chudego mięsa wołowego. Próby oceniono po 1, 15 i 30 dobach przechowywania. Pomiar parametrów barwy przeprowadzono z użyciem odbiciowego spektrofotometru sferycznego firmy X-Rite. Wyniki wyrażano w systemie L*a*b*. Do pomiaru potencjału oksydoredukcyjnego użyto elektrody zespolonej typ ERPt-13 z wykorzystaniem cyfrowego miernika CPC-501. Badania wykazały, że próby mięsne z udziałem ekstraktów papryki zatężanych w temperaturze 35°C charakteryzowały się niższym potencjałem redoks w porównaniu z próbami, w których zastosowano ekstrakty papryki zatężane w temperaturze wyższej (50°C). Wartości potencjału redoks próbek doświadczalnych wzrastały w miarę upływu czasu przechowywania. Nie zaobserwowano istotnego wpływu odmiany papryki na wartości omawianej cechy modelowych prób mięsnych. Wyniki oznaczeń parametrów barwy nie wykazały wpływu zastosowanych ekstraktów papryki na parametr L* barwy, określający jasność barwy. Stwierdzono natomiast wzrost udziału barwy czerwonej wariantów doświadczalnych z udziałem ekstraktów papryki w porównaniu z próbą kontrolną. Wartości parametru a* barwy próbek doświadczalnych nie zmieniały się istotnie w miarę upływu czasu przechowywania, co świadczy o stabilności barwy.

Słowa kluczowe: ekstrakt papryki, mięso wołowe, potencjał oksydoredukcyjny, barwa

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