

The effect of herbal preparation on the change in colour and acidity of pork during storage

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The material consisted of 80 samples of meat from *longissimus lumborum* derived from hybrid pigs (topigs 20 ♀ x tempo York ♂) of the two dietary groups. All animals were fed the full-ration mixtures; on the other hand, the pigs from the experimental group received supplement of the herbal preparation in amount of 5 g x kg⁻¹ of diet. It has been shown that the acidity of *musculus longissimus lumborum* did not depend on the type of the employed mixtures, and the extended storage time up to 2 and 4 days significantly ($P \leq 0.01$) reduced its pH. Meat from pigs fed the herbal preparation was characterized by a darker color ($P \leq 0.05$), lower degree of saturation towards the red ($P \leq 0.01$) and yellow ($P \leq 0.05$), and lower ($P \leq 0.01$) index of color saturation (C^*).

KEY WORDS: *m. longissimus lumborum* / herbal preparation / colour / acidity / storage

Meat is a food product of limited shelf life. It spoils rapidly, due to its high water content, which together with proteins and carbohydrates constitutes a medium promoting microbial growth, while fat undergoes oxidation and rancidity processes. A major quality attribute of meat, on which consumers focus when making purchase decisions is meat colour [12, 16]. Its intensity is influenced by meat acidity and fat content, the so-called marbling [7, 13]. The degree of muscle tissue acidification is a trait indicating the rate of post-slaughter glycolysis and is the primary cause for diversification of meat quality [1, 15]. Excessive acidification and a pale colour of meat (i.e. pale, soft, exudative - PSE) or high pH at slaughter and a dark colour of meat (i.e. dark, firm dry - DFD) frequently result in a deterioration of meat eating quality [2, 25].

Animal nutrition is a factor affecting the quality of animal origin products, for this reason compound feeds for pigs are increasingly often supplemented with preparations improving eating quality and dietary value of meat [18]. Herbal preparations, containing biologically active substances, exhibit a broad spectrum of activity. These bioactive com-

pounds (e.g. phytosterols, flavonoids, essential oils, tannins, terpenes, aroma compounds, vitamins) are defined as safe additives improving quality attributes of meat. Many studies [5, 6, 9] have shown antioxidant properties of herbs (rosemary, thyme, oregano, chamomile, sage, garlic) thanks to their abundant contents of phenolic compounds. The use of herbs as natural products in supplementing feed mixtures for fatteners is advisable in view of their multifaceted effects [8, 14, 17]. Consumer safety concerns are connected with the need to extend shelf life and ensure an adequate microbiological quality of meat and its processed products.

The aim of this study was to assess the effect of the herbal preparation on changes in colour and acidity of meat during storage.

Material and methods

The experimental material comprised the *longissimus lumborum* muscles collected from 40 hybrid fatteners from Holland (topigs 20 ♀ x tempo York ♂). The feeding experiment was conducted on two groups of animals – the control (K) and the experimental (D), with 20 animals in each.

Fattening was conducted in two periods: 1 (33 days) from 40 to 70 kg body weight, in which the animals received the grower compound feed, and 2 (48 days) from 70 to 110 kg body weight, in which the animals were fed the finisher feed. The feed composition (%) and the nutritive value of the feed mixtures are given in Table 1.

Animals from the experimental group in both fattening periods received an addition of a herbal preparation. The preparation contained coriander, caraway, mint, chamomile, garlic, thyme, savory and milk thistle and it was added at 5 g x kg⁻¹ feed.

Fatteners were slaughtered when they reached approx. 110 kg body weight. The pH value was measured 45 minutes (pH₁) after slaughter in *musculus longissimus lumborum*, behind the last rib on a hanging carcass using a Testo 205 pH-meter equipped with a gel electrode. Prior to the measurements the pH-meter was calibrated in buffers with pH 4 and pH 7. After 24h cooling at +4°C two slices of 0.5 cm in thickness were cut from each right half-carcass from the *longissimus lumborum* muscle, and its colour and pH (pH₂) were recorded. All the samples were stored in sealed bags in a refrigerator at 4°C. The first 40 samples (with 20 samples per group) were stored for 2 days, while the other 40 samples were stored for 4 days. After storage measurements of muscle tissue acidification (pH₃ and pH₄) and colour (CIE L*a*b*) were recorded. Colour was determined in the Hunter system using a CR-310 Chroma Meter by Minolta. The measurement consisted in recording of reflection of light from the tested sample within the wavelength range of 340-900 nm. The device provides readings of the results and print-outs of the angle of light reflection. Each measurement of pH value and colour lightness (L*) was performed in two replications, assuming the mean as the recorded measurement value.

The change in meat colour during storage was calculated from equation [4]:

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

Coordinate L* defines lightness, a* – chromaticity in the red-green range, b* – chromaticity in the yellow-blue range.

Table 1
Composition (%) and nutritive value of mixtures

Components	Type of full-ration mixture	
	Grower	Finisher
Ground barley	53.0	42.0
Mix grain (wheat, barley, oats)	15.0	22.0
Ground triticale	10.0	20.5
Extracted soybean meal	18.5	13.0
Monocalcium phosphate	0.5	–
Limestone	0.5	–
Premix	2.5	2.5
Total	100	100
1 kg mixture contained:		
metabolizable energy (MJ)	12.30	12.51
crude protein (g)	170.0	150.7
lysine (g)	11.0	9.3
methionine + cystine (g)	6.2	5.5
calcium (g)	7.9	6.1
phosphorus (g)	5.6	4.3
sodium (g)	1.5	1.5

Composition of premix grower: vitamin A – 420 000 IU, vitamin D₃ – 80 000 IU, vitamin E – 4000 mg, vitamin B₁ – 60 mg, vitamin B₂ – 150 mg, vitamin B₆ – 100 mg, vitamin B₁₂ – 1050 µg, calcium – 16%, phosphorus – 2.5%, lysine – 12%, methionine – 2.5%, magnesium – 1%

Composition of premix finisher: vitamin A – 400 000 IU, vitamin D₃ – 70 000 IU, vitamin E – 2500 mg, vitamin B₁ – 60 mg, vitamin B₂ – 150 mg, vitamin B₆ – 75 mg, vitamin B₁₂ – 1000 µg, calcium – 21%, phosphorus – 2%, lysine – 10%, methionine – 1%, magnesium – 1%

Based on the experimental data (parameters of colour L*a*b*) psychometric saturation (intensity) of colour, i.e. parameter C*, was calculated from equation [22]:

$$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$$

The results were analysed statistically using the STATISTICA ver. 6 software package [21], applying the two-way analysis of variance, according to the following mathematical model:

$$Y_{ijk} = \mu + a_i + b_j + ab_{ij} + e_{ijk}$$

where:

Y_{ijk} – value of the investigated trait,

μ – grand mean,

a_i – effect of nutrition,

b_j – effect of storage time,

ab_{ij} – effect of interaction of controlled factors,

e_{ijk} – error.

Significance of differences between means was verified using Tukey's test.

Results and discussion

Meat aging rate, and thus the rate of decrease in pH, depends on the animal species and muscle type. In poultry this process is progressing faster than in cattle and pigs [24]. Results concerning changes in acidity of the muscle tissue during 2- and 4-day cold storage are presented in Table 2. No effect of the addition of the herbal preparation to feed was observed on the acidification of tested meat. In contrast, a significant effect ($P \leq 0.01$) on pH value was found for storage time. After 2 days of storage a significant ($P \leq 0.05$) decrease was observed in pH of the examined muscle, while extension of storage by two successive days no longer had any effect on its further acidification.

As it was reported by Pospiech [19], in meat, in which glycolysis progresses properly, active acidity should be around 5.6-5.8. In contrast, in the case of an atypical course of glycolysis in meats after slaughter various quality defects may develop, such as e.g. PSE and DFD. According to Honikel [10], meat after 24h cooling should have pH within the range of 5.3-5.8. In turn, Skrökki [20] was of an opinion that meat with pH values above 6.0 or below 5.3 is of inferior quality. A decrease in pH is a consequence of the formation of lactic acid produced as a result of degradation of glycogen and phosphoric acid from adenosine triphosphate (ATP) during meat storage. Results recorded in this study show that after 24h storage tested meat had normal pH values, while further cold storage caused an increase in acidification (pH below 5.3) and thus it may be classified as meat with the PSE defect.

The pH value to a considerable degree influences meat colour evaluated within the CIE L*a*b* system [22]. Changes in colour of *musculus longissimus lumborum* during storage are presented in Table 3. It was shown that the herbal addition significantly ($P \leq 0.05$) reduced lightness (L*) of meat colour. In the initial cooling period meat of experimental animals (receiving the herbal supplement) was darker, while after 4 days of storage it was slightly lighter than meat of control animals.

Table 2
Changes in acidity of meat during storage

Feeding group	Value of pH											
	pH ₁ 45 min after slaughter		pH ₂ 24 h after slaughter		pH ₃ after 2 days		pH ₄ after 4 days		Feeding average			
	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD
Control	6.08	0.26	5.71	0.14	5.19	0.08	5.25	0.14	5.56	0.40		
Experimental	6.09	0.15	5.67	0.21	5.21	0.06	5.29	0.13	5.56	0.38		
Time average	6.08 ^{Aa}	0.21	5.69 ^{ABab}	0.17	5.20 ^{Bc}	0.07	5.27 ^{Bbc}	0.13	—	—		

A, B — values in row marked with different letters differ significantly at $P \leq 0.01$

a, b, c — values in row marked with different letters differ significantly at $P \leq 0.05$

Table 3
Parameters of meat colour during storage

Specification	Storage time						Feeding average	SD	
	0 days		after 2 days		after 4 days				
	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD			
L _a *	control	49.68	2.11	51.64	4.51	49.86	3.98	50.39 ^a	3.67
	experimental	47.75	2.31	48.27	2.31	50.06	2.41	48.69 ^b	2.38
	Time average	48.72	2.22	49.96	3.89	49.06	3.21	–	–
a*	control	8.58	1.28	9.47	0.76	9.19	1.05	9.08 ^A	1.08
	experimental	8.61	1.22	7.51	1.56	8.17	1.69	8.10 ^B	1.52
	Time average	8.59	1.21	8.49	1.56	8.68	1.47	–	–
b*	control	1.53	0.75	2.71	1.34	3.15	0.60	2.46 ^a	1.15
	experimental	1.42	0.96	1.05	0.82	2.76	1.50	1.74 ^b	1.33
	Time average	1.47 ^b	0.84	1.88 ^B	1.37	2.96 ^A	1.13	–	–
ΔE^*	control			2.45	1.52	1.74	0.45	2.09	2.02
	experimental			1.27	0.93	2.71	1.77	1.99	1.28
	Time average			1.86	1.92	2.23	1.42	–	–

A, B – values in row or column marked with different letters differ significantly at $P \leq 0.01$

a, b – values in column marked with different letters differ significantly at $P \leq 0.05$

No statistically significant effect of meat storage time was shown on the value of parameter a^* being a measure of saturation with the red colour in the overall hue. However, the herbal addition was found to have an effect ($P \leq 0.01$) on the value of this parameter. Irrespective of storage time meat of experimental pigs was characterised by a lower share of the red colour. A significant effect ($P \leq 0.05$) of nutrition was found on the yellow colour (b^*), while that of meat storage time was significant at $P \leq 0.01$. Irrespective of the feed mixture composition, extension of meat storage time by 2 successive days caused an increase in the value of parameter b^* , with meat produced by experimental animals showing its lower values. Meat storage and supplementation of compound feeds with the herbal preparation had no effect on the absolute difference in colour ΔE^* .

Storage time (0, 2, 4 days) of *musculus longissimus lumborum* under refrigerated conditions had no significant effect ($P > 0.05$) on the value of parameter C^* (Fig.). A significant effect ($P \leq 0.01$) of nutrition was observed on the colour saturation index (C^*); moreover, the interaction ($P \leq 0.05$) of the herbal preparation addition and 2-day meat storage time was found to be significant ($P \leq 0.05$).

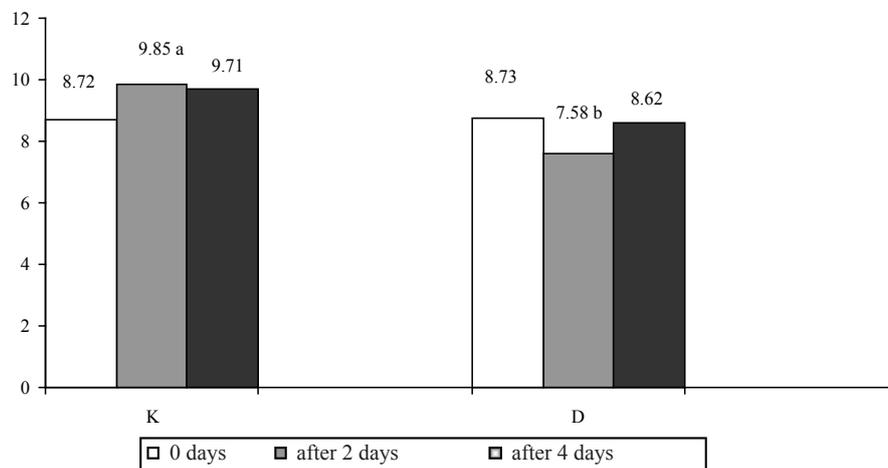


Fig. Changes in the chroma index (C^*) of meat during storage

In his study Swatland [23] reported that at high pH values meat of a darker colour is obtained, while a lighter muscle colour is connected with low pH values. In turn, it results from a study conducted by Kajak et al. [11] that with an increase in meat pH after slaughter the component values of colour L^* decrease. Additionally, Chwastowska and Kondratowicz [3] reported a significant lightening of pork colour with an extension of storage time from 2 weeks to 3 months. However, they showed no significant effect of meat storage time on its acidity. In this study we also observed a non-significant lightening of meat colour as a result of meat storage at a significantly ($P \leq 0.05$) reduced pH of the tested meat.

In summary it needs to be stated that acidification of *musculus longissimus lumborum* was not dependent on the type of used feed mixtures, whereas an extension of storage time to 2 and 4 days significantly ($P \leq 0.01$) reduced its pH. Meat coming from pigs receiving the herbal preparation was characterised by a darker colour ($P \leq 0.05$), a lesser saturation towards the red ($P \leq 0.01$) and yellow colours ($P \leq 0.05$) as well as a lower ($P \leq 0.01$) index of colour saturation (C^*).

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