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THE EFFECT OF OREGANO (*ORIGANUM VULGARE L.*) OLEORESIN AND GREEN TEA (*CAMELLIA SINENSIS*) EXTRACT ON SELECTED QUALITY ATTRIBUTES OF COLD-STORED PORK

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Key words: *antioxidants, green tea, oregano, meat quality.*

Abstract. *The objective of this study was to compare the effects of natural antioxidants on lipid peroxidation, and the physicochemical and sensory properties of ground pork. The experimental materials comprised samples of m. longissimus dorsi collected from the carcasses of crossbred [♀(Polish Large White x Polish Landrace) x ♂Duroc] pigs. The samples were divided into 5 groups: fresh meat before storage, control – without additives; with the addition of 0.02% encapsulated oregano oleoresin; with the addition of an aqueous extract made from 5 g of dry green tea leaves; with the addition of an aqueous extract made from 10 g of dry green tea leaves. Samples of fresh meat were immediately subjected to laboratory analyses, whereas the control sample (without additives) and the remaining samples (thoroughly mixed with the additives) were vacuum-packaged and evaluated after 14 days of cold storage.*

It was found that control samples (without additives) and pork samples supplemented with oregano oleoresin and cold-stored for 14 days were characterized by lower pH and lower water-holding capacity compared with samples supplemented with 5 and 10 g of green tea extract, and fresh meat samples analyzed before storage. The tested natural antioxidants influenced meat color. Meat without antioxidants, evaluated before storage, was darkest (L) and had the lowest contribution of redness (a*) and yellowness (b*). Oregano oleoresin contributed to the highest increase in color lightness, and green tea extract contributed to the highest increase in redness (a*). Oregano and an aqueous extract made from 10 g of dry green tea leaves most effectively inhibited lipid peroxidation (TBARS) in pork. The concentration of green tea extract was correlated with its antioxidant activity. Meat samples with the addition of 5 g of green tea extract received the lowest score for aroma desirability, which most probably resulted from the highest rate of lipid peroxida-*

tion. A comparison of the tested natural antioxidants revealed that pork samples supplemented with oregano oleoresin had the most desirable sensory properties (aroma, taste, color).

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Introduction. Cold storage extends the shelf-life of meat. However, low temperature slows down but does not inhibit lipid peroxidation. Prolonged cold storage leads to undesirable changes in meat, including lipid autoxidation and hydrolysis, which decreases the nutritional value of meat and deteriorates its sensory quality [Karre et al. 2013, Shah et al. 2014]. As a result, meat products subjected to prolonged cold storage may pose a potential risk to the health of consumers due to the formation of toxic compounds (peroxides, free radicals and polymerization products).

Therefore, continuous efforts have been made to limit the extent of undesirable changes that occur in foods during storage. Research has shown than even small amounts of synthetic antioxidants can effectively inhibit lipid peroxidation. Synthetic antioxidants are relatively inexpensive and readily available, but they are also reportedly harmful to human health, which makes them unacceptable to consumers [Sierżant et al. 2012]. Doubts about the safety of synthetic antioxidants have contributed to the growing interest in natural compounds with antioxidant properties, which are generally considered safe and, in consequence, are preferred by consumers. Plant antioxidants are widely accepted by consumers not only due to their natural origin but also because they are believed to deliver health benefits. The use of natural antioxidants is not subject to legal restrictions, which is another important consideration.

The inhibitory effects of natural antioxidants added to animal feeds [Simitzis et al. 2010, Mathlouthi et al. 2012, Alarcon-Rojo et al. 2013] or meat [Hernández-Hernández et al. 2009, Macura et al. 2011, Hoyle Parks et al. 2012, Mathlouthi et al. 2012] on lipid peroxidation during storage have been reported by many authors. Natural antioxidants should be added to meat in appropriate form, and their effectiveness should be evaluated in meat and variously processed meat products.

The aim of this study was to compare the effects of oregano oleoresin and green tea aqueous extracts on lipid peroxidation, and the physicochemical and sensory properties of ground pork after 14-day cold storage.

Materials and Methods. The experimental materials comprised crossbred [♀(Polish Large White x Polish Landrace) x ♂Duroc] pigs (1:1 sex ratio). The animals were fattened from 30 kg BW to approximately 115 kg BW in the same fattening house. They were fed wet diets and had free access to water. Complete diets contained 15.0% of total protein, 0.81% of total lysine and approximately 12.9 MJ of metabolizable energy per kg of feed. The ration was composed of ground grain (barley, wheat), soybean meal and 00-rapeseed meal, faba bean seeds, and feed additives including mineral and vitamin supplements and synthetic amino acids (lysine, methionine, threonine).

Forty-five min post mortem, the carcasses were stored in a cold room at 2-4°C for around 24 hours. After chilling, the right half-carcasses were divided into primal cuts. During carcass dressing, 36 samples for laboratory analyses were collected from the longissimus dorsi (LD) muscle in the area between the last but one and the last thoracic vertebrae, and the second lumbar vertebra. The samples were vacuum-packaged and transported to the laboratory in isothermal containers. In the laboratory, the samples were ground in an electric meat grinder to pass through a 2.7 mm mesh screen. Each sample was divided into 5 equal subsamples. The first subsample (fresh meat) was analyzed before storage. The second subsample (control) contained no additives. The third subsample was supplemented with 0.02% of encapsulated oregano (*Origanum vulgare L.*) oleoresin. The fourth subsample was supplemented with an aqueous extract made from 5 g of dry green tea (*Camellia sinensis*) leaves. The fifth subsample was supplemented with an aqueous extract made from 10 g of dry green tea leaves. Aqueous extracts were made from 5 or 10 g of dry green tea leaves and 200 ml of distilled water with a temperature of 80°C. Extraction was carried out for 5 min. The infusion was filtered through filter paper and chilled to 4°C. Fresh meat was analyzed immediately, upon arrival at the laboratory (before storage). The control sample and the samples with additives were vacuum packaged in barrier bags using the PP15 (MGO) Tepro Vacu Tronic 2000 vacuum packaging machine (Tepro S.A.). Vacuum-packaged samples were stored in a refrigerated cabinet at 2°C and relative air humidity of 50% for 14 days.

The following laboratory analyses were performed: pH [PN-ISO 2917:2001/Ap1:2002] – in meat homogenates, with the Double Pore electrode (Hamilton) and the 340i pH meter equipped with the TFK 150/E temperature sensor (WTW); water-holding capacity (forced drip) – by the Grau and Hamm method [Oeckel van et al. 1999]; color – based on the values of parameters L^*, a^* and b^* in the CIELAB system [CIE 1978] by the reflectance method, with the HunterLab MiniScan XE Plus spectrocolorimeter; the extent of lipid peroxidation - based on thiobarbituric-acid-reactive substances (TBARS) values [Pikul et al. 1989]. Absorbance was measured with the Specord 40 spectrophotometer (Analytik Jena AG, Jena, Germany) at a wavelength of *532 nm. TBARS values were expressed as milligrams of malondialdehyde (MDA) per kg of meat.* The sensory attributes (aroma, taste and color) of meat [PN-ISO 4121:1998] were evaluated after cooking (96°C, 90 min) by six trained panelists on a 9-point hedonic scale (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).

Arithmetic means ($\bar{\times}$) and standard deviations (SD) were calculated for the analyzed parameters. The results were processed statistically by one-way analysis of variance (ANOVA) for orthogonal designs using the STATISTICA data analysis software system ver. 9.0 [STATSOFT, INC. 2009]. The significance of differences between means in groups was determined by Duncan's multiple range test [Żuk 1989].

Results and Discussion. The physicochemical properties of meat are presented in Table 1. The pH of all meat samples remained in the normal range of 5.4 – 5.8, but significant (P≤0.01) differences were found between groups. The highest pH was noted in samples supplemented with 10 g of green tea extract (5.71), and the lowest pH was noted in samples containing oregano (5.44) and control samples (5.45). In a study by Michalczyk et al. [2015], who investigated the effect of oregano essential oil, garlic and tomato concentrate on the quality of minced pork stored at 6°C for 16 days, oregano-supplemented samples had the lowest (P≤0.05) values of pH (5.25) and TBARS (1.76 mg MDA/kg). Mustafy [2013] noted a significant (P≤0.05) increase in the pH of ground beef with the addition of 0.5, 1.0, 1.2 and 2.0% of green tea extract, stored at 4°C for 12 days, compared with control samples. In the cited study, the pH of beef was in the normal range (5.80 to 5.87), typical of high-quality meat, which is consistent with our observations.

The water-holding capacity of meat, determined based on juice drip (Grau and Hamm method), varied across groups (Table 1). Drip loss was significantly (P≤0.01) higher in pork samples supplemented with oregano (7.29 cm^2) than in samples evaluated before storage (6.00 cm^2), control samples (6.51 cm^2) and samples containing 10 g of green tea extract (6.18 cm^2) and 5 g of green tea extract (6.57 cm^2) (P≤0.05). Salejda et al. [2011] demonstrated that the addition of 5 and 15 g of green tea extract to meat products had no significant influence on cooking loss, whereas green tea extract added at 25 g to meat samples significantly (P≤0.05) increased cooking loss.

The average TBARS value was significantly (P≤0.01) lower in fresh meat analyzed before storage than in control pork samples (without additives) and samples with the tested additives (Table 1). The TBARS values noted in our study indicate that antioxidants of plant origin significantly inhibited lipid peroxidation during storage. An aqueous extract made from 10 g of dry green tea leaves exerted a stronger antioxidant effect (0.23 mg MDA/kg of meat) than an aqueous extract made from 5 g of dry green tea leaves (0.34 mg MDA/kg of meat). Pork samples supplemented with oregano and 10 g of green tea extract were characterized by similar TBARS values (0.26 mg and 0.21 mg MDA/kg of meat, respectively). The average TBARS value of control samples without additives (0.35 mg MDA/kg of meat) was comparable with the TBARS value of meat samples supplemented with 5 g of green tea extract, and significantly (P≤0.01) higher than the TBARS values of meat samples supplemented with oregano and 10 g of green tea extract. In an experiment conducted by Bozkurt [2006], green tea extract and the synthetic antioxidant butylated hydroxytoluene (BHT) were added to Turkish dry-fermented sausage. The extract made from 20 g of green tea leaves was more effective (P≤0.05) in slowing down lipid peroxidation (TBARS) than BHT. Jongberg et al. [2013] observed high antioxidant activity of green tea and rosemary extracts added to Bologna-type sausage, and noted lower TBARS values in the products containing green tea extract. Lorenzo et al. [2014] compared the antioxidant activity of BHT and natural extracts from green tea, grape, chestnut and seaweed added to pork patties that were stored for 20 days under chilled conditions. In the cited study, grape and tea extracts were the most effective antioxidants. The TBARS values of pork patties supplemented with plant antioxidants were comparable with those noted in products containing BHT. Hęś et al. [2011] investigated the effect of BHT and ethanol extracts of thyme, green tea and rosemary on the oxidative stability of meat lipids. The above authors found that all additives significantly reduced TBARS values (P≤0.05), but green tea and thyme extracts were the most powerful antioxidants.

An analysis of color parameters in the CIELAB system revealed that fresh meat samples evaluated before storage were darker (L^*=53.57) (P≤0.01) than the remaining samples (63.54, 62.41, 60.38 and 60.06, respectively). Control samples and oregano-supplemented samples were characterized by the highest L^* values. Fresh meat samples (before storage, without additives) had a lower (P≤0.01) contribution of redness (parameter a^*) and yellowness (parameter b^*) than control samples supplemented with oregano and extracts made from 5 and 10 g of green tea leaves. Salejda et al. [2011] reported a decrease in the color lightness of thermally processed pork with increasing inclusion levels of green tea extract. Similarly to our study, products made of pork containing green tea extract were characterized by higher values of parameter a^* than meat samples before storage, and the noted values were higher after 30-day storage than immediately after the production process. Lorenzo et al. [2014] demonstrated that the pH and a^* values of pork patties supplemented with green tea extract were lower (P≤0.01) than those of control samples (without additives). In a study by Wójciak et al. [2011], the addition of pepper and green tea extract to corned meat inhibited the synthesis of metmyoglobin, which contributed to higher color stability during storage.

The results of sensory analysis of meat are shown in Table 3. Meat samples without additives, evaluated before storage, received the highest scores (9-point hedonic scale) for aroma (7.43 points). Pork samples supplemented with 5 g of green tea extract and control samples were characterized by the least desirable aroma (5.50 and 5.61 points, respectively, P≤0.01). Control samples (6.35 points) as well as samples supplemented with 5 g of green tea extract (6.00 points) and 10 g of green tea extract (6.31 points) had a less desirable taste (P≤0.01) in comparison with meat analyzed before storage (6.97 points) and oregano-supplemented samples that received the highest taste scores (7.13 points). The lower desirability of aroma and taste, noted in samples with the addition of 5 g of green tea extract, could result from lipid peroxidation reflected in the highest TBARS value. Pork evaluated before storage and oregano-supplemented pork were characterized by the most desirable color (7.36 and 7.15 points, respectively), followed by meat samples supplemented with green tea extract. Over 14-day cold storage, the greatest changes were observed in the aroma of meat samples. In the work of Salejda et al. [2011], meat products supplemented with green tea extract were characterized by more desirable consistency. The addition of 5 g of green tea extract did not induce significant changes in the taste or aroma of the analyzed meat products, but it contributed to lower scores for general appearance and color. Khanjari et al. [2013] reported a significant (P≤0.05) improvement in the aroma and taste of raw chicken meat fillets supplemented with 1% oregano essential oil, relative to control samples without additives.

Table 1 – Physicochemical properties and TBARS values of meat

Specification	Meat samples before storage	Control group without additives	Meat samples supplemented with oregano	Meat samples supplemented with 5 g of green tea extract	Meat samples supplemented with 10 g of green tea extract
pH	5.65 ^{AaB} ± 0.11	5.45 ^{AC} ± 0.06	5.44 ^{D} ± 0.06	5.63 ^{CD} ± 0.08	5.71 ^{aCD} ± 0.10
Water-holding capacity Grau and Hamm method (cm^2)	6.00 ^{A} ± 0.66	6.51 ^{B} ± 0.85	7.29 ^{AaBC} ± 0.97	6.57 ^{a} ± 1.62	6.18 ^{C} ± 0.69
TBARS (mg malondialdehyde kg meat)	0.16 ^{ABC} ± 0.06	0.35 ^{AC} ± 0.05	0.26 ^{AB} ± 0.04	0.34 ^{BD} ± 0.06	0.21 ^{CD} ± 0.05

Values with the same letters are significantly different: a – P≤0.05; A, B, C, D – P≤0.01

Table 2 – Values of meat color parameters (*L*, a*, b**)

Specification	Meat samples before storage	Control group without additives	Meat samples supplemented with oregano	Meat samples supplemented with 5 g of green tea extract	Meat samples supplemented with 10 g of green tea extract
*L**	53.57 ^{ABCD} ± 2.16	63.54 ^{AB} ± 1.68	62.41 ^{aC} ± 3.61	60.38 ^{aD} ± 1.73	60.06 ^{ABC} ± 2.45
*a**	6.37 ^{ABCD} ± 0.78	8.87 ^{A} ± 0.88	8.44 ^{aB} ± 0.74	8.74 ^{C} ± 0.71	9.20 ^{aD} ± 0.95
*b**	13.32 ^{ABCD} ± 0.62	17.79 ^{A} ± 0.63	17.79 ^{B} ± 0.46	17.46 ^{aC} ± 0.48	17.90 ^{aD} ± 0.36

Values with the same letters are significantly different: a - P≤0.05; A, B, C, D - P≤0.01

Table 3 – Sensory properties of meat (points)

Specification	Meat samples before storage	Control group without additives	Meat samples supplemented with oregano	Meat samples supplemented with 5 g of green tea extract	Meat samples supplemented with 10 g of green tea extract
Aroma	7.43 ^{AB} ± 0.44	5.61 ^{A} ± 0.29	6.81 ^{AB} ± 0.54	5.50 ^{B} ± 0.72	6.19 ^{AB} ± 0.52
Taste	6.97 ^{ABC} ± 0.48	6.35 ^{AD} ± 0.32	7.13 ^{DEF} ± 0.27	6.00 ^{BE} ± 0.95	6.31 ^{CF} ± 0.35
Color	7.36 ^{ABC} ± 0.26	6.65 ^{AD} ± 0.38	7.15 ^{DEF} ± 0.21	6.81 ^{BE} ± 0.45	6.72 ^{CF} ± 0.42

Values with the same letters are significantly different: A, B, C, D, E, F - P≤0.01

Conclusions. It can be concluded that control samples (without additives) and pork samples supplemented with oregano oleoresin and cold-stored for 14 days were characterized by lower pH and lower water-holding capacity compared with samples supplemented with 5 and 10 g of green tea extract, and fresh meat samples analyzed before storage. The tested natural antioxidants influenced meat color. Meat without antioxidants, evaluated before storage, was darkest (*L**) and had the lowest contribution of redness (*a**) and yellowness (*b**). Oregano oleoresin contributed to the highest increase in color lightness, and green tea extract contributed to the highest increase in redness (*a**). Oregano and an aqueous extract made from 10 g of dry green tea leaves most effectively inhibited lipid peroxidation (TBARS) in pork. The concentration of green tea extract was correlated with its antioxidant activity. Meat samples with the addition of 5 g of green tea extract received the lowest score for aroma desirability, which most probably resulted from the highest rate of lipid peroxidation. A comparison of the tested natural antioxidants revealed that pork samples supplemented with oregano oleoresin had the most desirable sensory properties (aroma, taste, color).

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THE IMPACT OF FEEDING SYSTEM ON PERFORMANCE AND CHEMICAL COMPOSITION OF COWS

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***Key words**: dairy cows, feeding system, milk performance, chemical composition of milk*

***Abstract.** The research was undertaken on three farms. On the A-PMR farm research covered dairy cows fed with the PMR system, on the B-TMR farm cows fed with TMR system were examined, whereas in C-TR farm cows fed with the traditional system were examined. Content composition of a feeding dose, milk performance of cattle throughout winter and summer periods were determined in this work. Basing on undertaken research it was stated that cows fed with TMR system were characterised by the highest milk performance in comparison to cows assessed on the other farms. Particularly worthy of attention is also the achievement of high level of milk performance in cows fed in a traditional way. It seems that not only the feeding*