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EFFECT OF DIFFERENT PHYTOGENIC ADDITIVES ON OXIDATION STABILITY OF CHICKEN MEAT

Marek Bobko, Peter Haščík, Martin Mellen, Alica Bobková, Jana Tkáčová, Peter Czako, Adriana Pavelková, Lenka Trembecká

ABSTRACT

The aim of the study was to evaluate the oxidative stability (TBARS method) of breast and thigh muscle after application of feed mixtures enriched by phytogenic additives. The experiment started with 150 pieces one-day-old chicks of Cobb 500 hybrid combination. They were divided into one control (C) and two experimental groups (1st EG and 2nd EG). Each group included 50 chicks. In experimental groups, feed additives were applied as followed: 100 mg.kg^{-1} Agolin Poultry (in the 1st EG) and 500 mg.kg^{-1} Agolin Tannin Plus (in the 2nd EG). Experimental broiler chickens were fed during 42 days by *ad libitum.* Chicken meat samples of breast and thigh muscle were analysed in the 1st day, 1st, 2nd, 3rd, 4th, 5th and 6th month of storage in frozen storage at -18 °C. We recorded positive influence on chicken meat oxidative stability in all experimental groups with application of phytogenic feed additives. Obtained results showed that applied phytogenic additives had positive influence on oxidative stability of breast and thigh muscles. At the end of frozen storage (in 6th month), we found higher malondialdehyde (MDA) values and lower oxidative stability (p <0.05) of breast muscle in control group (0.167 mg.kg^{-1}) compared to experimental groups (from 0.150 mg.kg^{-1} in 1. EG to 0.155 mg.kg^{-1} in 2. EG). In the thigh muscle, we found similar tendency of oxidative changes as in the breast muscle. At the end of frozen storage (in the 6th month), MDA average values of thigh muscle were higher (p <0.05) in control group (0.181 mg.kg^{-1}) compared to experimental groups (1. EG 0.164 mg.kg^{-1} and 2. EG 0.169 mg.kg^{-1}). Significant differences (p <0.05) between the control and experimental groups were found from the 5th month of storage in thigh and breast muscle. Obtained results indicate positive influence of phytogenic additives applied in chicken nutrition, namely on stabilization of fatty substance to degradation processes.

Keywords: phytogenic additives; chicken meat; oxidative stability

INTRODUCTION

Phytogenic feed additives (PFA) are commonly defined as plant-derived compounds incorporated into diets to improve the productivity of livestock through amelioration of feed properties, promotion of the animal's production performance, and improving quality of food derived from those animals. Although this definition is driven by purpose of use, other terms are commonly used to classify the vast variety of phytogenic compounds, mainly with respect to origin and processing, such asherbs (flowering, nonwoody, and nonpersistent plants), spices (herbs with intensive smell or taste commonly added to human food), essential oils (volatile lipophilic compounds derived by cold expression or by steam or alcohol distillation), or oleoresins (extract derived by nonaqueous solvents). Within phytogenic feed additives, the content of active substance in products may vary widely, depending on the plant part used (e.g. seeds, leaf, root, or bark), harvesting season, and geographical origin. The technique for processing (e.g. cold expression, steam distillation, extraction with nonaqueous solvents, etc.) modifies the active substances and associated compounds within the final product **(Windisch et al., 2008; Jacela et al., 2010)**. This is class of feed additives is at present used to a great extent as alternatives to the antibiotic growth promoters in poultry and swine nutrition **(Wati et al., 2015)**.

Aromatic plants, also known as herbs and spices, have been used in the Middle East since approximately 5000 BC for their preservative and medical properties, in addition to enhancing the aroma and flavour of foods **(Chang, 2000)**. Their use continues undiminished today and according to the World Health Organization (WHO) nearly 80% of the planet population, especially in developing countries still depends on plant produced medicines for their healthcare **(Grubik-Fakim, 2006)**. Currently, there is an increasing interest in using herbs and spices in animal nutrition, in order to replace the use of antibiotics and ionophore anticoccidials, especially after the ban of antibiotics feed additives within the European Union countries in 2006 and discussions to restrict their use outside Europe **(Greathead, 2003; Windisch et al., 2008; Hashemi and Davoodi, 2010; Yitbarek, 2015)**.

The nutritional properties of poultry meat are highly valued; it is a meat with low fat content and less saturated fatty acid than the most ruminant tissues **(Starčevič et al., 2015)**. At average broilers have from 3.5 to 5.0% of fatty tissuses. Poultry fat contain higher amount of polyunsatured fatty acids than fatty tissues other slaughtered animals. Exactly, polyunsatured fatty acids are the most sensible fractions to oxidation processes. Lipid oxidation oxidation in meat is one of the reasons for quality degradation during storage. This process is associated with the presence of free radicals that lead to

the production of aldehydes responsible for the development on rancid flavours and changes in the colour of meat **(Fasseas et al., 2007)**. The rate of oxidation increases in result of the following: (1) high intake of oxidized lipids and prooxidants; (2) deterioration of sensitive polyunsaturated fatty acids (polyunsatured fatty acids); and (3) low intake of antioxidative nutrients. In muscle foods, oxidative reactions continue postmortem and are a leading cause of quality deterioration during processing and storage. With a relatively high proportion of PUFA, poultry meat is more susceptible to oxidative processes, specifically lipid oxidation, than beef or pork **(Smet et al., 2008)**. Lipid oxidation is a major cause of meat quality deterioration which lowers the functional, sensory and nutritive values of meat and neat products; and therefore, consumer's acceptability **(Bou et al., 2004)**. Oxidative stability of poultry meat is influenced not only by bird genotype but also feeding, rearing practices and the degree of muscle tissue damages during preslaughter, e.g. physical damage, early post-mortem conditions, pH and carcass temperature **(Morissey et al., 1998; Zamora and Hildago, 2001)**. These factors could by manipulated by supplementing the animal diet with phytogenic compounds such as different essential oils and polyphenols to improve animal productivity and the quality of food derived from those animals **(Lee et al., 2003; Jang et al., 2004; Okuda, 2005)**.

Phytogenic feed additives are often applied into the feed mixtures, because they improve the taste and odour of feed and subsequently, body weight gain and feed intake are increased and feed conversion is improved, too **(Angelovičová et al., 2010)**. Phytogenic feed additives enhance productivity through the improvement of digestibility, nutrient absorption and elimination of pathogens residents in the animal gut **(Athanasiadou et al., 2007)**. Digestive stimulation by phytogenic additives is achieved through stimulation of salvia secretion, liver, pancreas and intestine enzymes activities, intestine function and morphohistology and metabolism **(Perič et al., 2010)**. Antioxidant effects of plant extracts may be used to slow or prevent the fat oxidation in food products **(Rababah et al., 2004)**. Application of oils and plant extracts in poultry nutrition is important for health state of animals and animal performance as well as for oxidative stability of produced meat **(Frankič et al., 2009)**. Antioxidant activity of plants and their extracts is directly correlated with phenols content **(Chrpová et al., 2010)**. Several studies about phytogenic additives in poultry nutrition were published, mainly about application of aromatic herbs like a cloves **(Isabel and Santos, 2009)**, a rosemary **(Šperňáková et al., 2007)**, a cinnamon **(Ciftci et al., 2010)**, an anise **(Al-Kassie, 2008)**, an oregano **(Fiková et al., 2009)** and a salvia **(Hernandez et al., 2004)**.

The aim of the experiment was to determine the oxidative stability in the most valuable parts of chicken carcasses (Cobb 500 hybrid combination) during the frozen storage (6 months) after application of phytogenic feed additives Agolin Poultry, Agolin Tannin Plus, in their diet.

MATERIAL AND METHODOLOGY

Animals and diets

The experiment was undertaken in poultry test station Zamostie Company. The experiment started with 150 pieces of one-day-old hybrid chicks Cobb 500, which were divided into 3 groups (n = 50): control (C) and 2 experimental groups (1st EG and 2nd EG).

Experimental broiler chickens were fed during 42 days by *ad libitum* system with feed mixtures: BR1 starter feed mixture (until the 10th day of age), BR2 growth feed mixture (from 11th to 20th day of age), BR3 growth feed mixture (from 21st to 35th day of age) and BR4 final feed mixture (from 36th to 42nd day of age). Feed mixtures were produced with coccidiostats in powder form.

Nutritional value (Table 1) of feed mixture was the same in each group during the whole experiment. However, the diet of broiler chickens in experimental groups were supplemented by feed additives on base of acids and plant essential oils: Agolin Poultry at a dose of 100 $mg.kg^{-1}$ (1st EG); Agolin Tannin Plus at a dose of 500 $mg.kg^{-1}$ (2nd EG).

Sample analysis

At the end of feeding (day 42th) from each group were selected 10 pieces of chicken for slaughter analysis. Slaughtering and cutting of chickens were undertaken in the Department of animal products evaluation and processing. To determine changes in lipid degradation (determination of thiobarbiturates numbers, TBA) the samples of chickens were boned and thigh and breast muscle packed into polyethylene bags and stored for 6 months at -18 °C.

TBARS analysis

TBA value expressed in number of malondialdehyde (MDA) was measured in the process of first storage day of 1st, 2nd, 3rd, 4th, 5th and 6th months. TBA number was determined according to **Marcinčák et al., (2006)**. Absorbance of samples was measured at a wavelength of 532 nm on UV-VIS spectrophotometer T80 (PG Limeted Instruments, UK). Results were calculated as the amount of MDA in 1 kg of sample.

RESULTS AND DISCUSSION

The lipids in poultry exhibit a higher degree of unsaturation compared with red meat, because of a relatively high content of phospholipids. The degree of unsaturation of phospholipids in subcellular membranes is an important factor in the determination of oxidative stability of meats. The oxidative potential increases as the degree of unsaturation of lipids in meat increases **(Coetzee and Hoffman, 2001)**. The oxidation of lipids is influenced by the addition of antioxidant substances. The practical application of antioxidants can be difficult from the point of view of hygiene and technology. It is much better when natural antioxidants are incorporated in feed mixes **(Kušev et al., 1996)**.

Table 1 Composition of the diets.

Ingredients (%)	Starter (1st to 10th day of age)	Grower I (11th to 20th day of age)	Grower II (21st to 35th day of age)	Finisher (36th to 42nd day of age)
Maize	46.33	48.50	50.05	50.91
Wheat	14.00	15.00	15.00	15.00
Soybean meal (45% CP[1])	30.00	26.60	28.00	26.70
Fish meal (72% CP[1])	2.50	2.00	-	-
Dried blood	2.00	2.00	-	-
Soybean oil	1.00	1.80	2.80	3.00
Monocalcium phosphate	1.60	1.25	1.30	1.48
Calcium carbonate	1.37	1.55	1.50	1.56
Fodder salt	0.20	0.30	0.35	0.35
Lysine	0.27	0.15	0.15	0.16
Methionine	0.27	0.18	0.17	0.20
Threonine	0.09	0.10	0.08	0.07
Vitamin premix	0.05	0.04	0.04	0.03
Micromineral premix	0.04	0.04	0.04	0.04
Enzyme phytase	0.015	0.015	0.015	0.015
Wheat meal	0.215	0.12	0.10	0.135
Maxiban (Narasin+Nicarbasin)	0.05	-	-	-
Sacox (salinomycin sodium)	-	0.055	0.055	-
Analysed composition (g.kg^{-1})				
Crude protein	220.00	207.00	197.00	188.00
Fibre	20.00	24.00	28.00	29.00
Lysine	14.00	12.50	12.50	11.50
Methionine	6.00	5.20	5.20	5.00
Ca	9.00	8.50	8.50	8.50
P (non-phytate)	4.20	4.00	4.00	4.00
Na	1.60	1.60	1.60	1.60
$^{2}ME_N$ (MJ kg^{-1})	12.30	12.75	13.15	13.15

Legend: ^{1}CP – Crude protein, $^{2}ME_N$ – Metabolizable energy.

Table 2 Effect of frozen storage (-18 ºC) on the concentration of MDA (mg.kg^{-1}) in breast muscle (mean ±*SD*).

Time of storage	Group		
	Control	1. EG	2. EG
Day – 1	0.108 ±0.009^{a}	0.101 ±0.010^{a}	0.098 ±0.008^{a}
Month – 1	0.119 ±0.009^{a}	0.117 ±0.0009^{a}	0.117 ±0.009^{a}
Month – 2	0.127 ±0.009^{a}	0.124 ±0.010^{a}	0.126 ±0.009^{a}
Month – 3	0.137 ±0.015^{a}	0.131 ±0.006^{a}	0.131 ±0.008^{a}
Month – 4	0.143 ±0.006^{a}	0.139 ±0.012^{ab}	0.137 ±0.010^{b}
Month – 5	0.155 ±0.006^{a}	0.144 ±0.006^{ab}	0.147 ±0.013^{b}
Month – 6	0.167 ±0.010^{a}	0.150 ±0.018^{b}	0.155 ±0.011^{b}

The results of the oxidation stability determined in breast muscle of chickens COBB 500 during 6 months storage at -18 °C are shown in Table 2. Immediately after slaughtering and processing of poultry samples we recorded low values of MDA. Obtained results indicate that addition of antioxidants had effect on reducing of oxidation processes in meat. Process of production of meat products (cutting, grinding, and mixing) causes degradation of muscle membrane system and has a strong influence on oxidation of intracellular fat, primarly phospolipids **(Bystrický and Dičáková, 1998)**. During freeze storage of the breast muscles (6 months) were detected increased content of MDA in comparison to the first day of storage. During whole period of freeze storage were higher values of MDA determined in control group compare to experimental groups. The higher average MDA value determined in breast muscles of broiler chicken hybrid combination COBB 500 was in samples of control group (0.167 mg.kg^{-1}) compared to experimental groups E2 (0.155 mg.kg^{-1}) and E1 (0.150 mg.kg^{-1}) after 6-month of freezing storage. Significantly higher values of MDA were determined in control group compare to experimental group from fifth month to the end of storage. Reached results oxidation stability breast muscle during freeze storage are in accordance with **Ahadi et al., (2010)**; **Marcinčák et al., (2010)**.

Table 3 Effect of frozen storage (-18 ºC) on the concentration of MDA (mg.kg^{-1}) in thigh muscle (mean ±*SD*).

Time of storage	Group		
	Control	1.EG	2.EG
Day – 1	0.129 ±0.013^{a}	0.125 ±0.011^{a}	0.120 ±0.008^{a}
Month – 1	0.132 ±0.009^{a}	0.129 ±0.005^{a}	0.128 ±0.009^{a}
Month – 2	0.139 ±0.004^{a}	0.135 ±0.005^{a}	0.136 ±0.010^{a}
Month – 3	0.148 ±0.011^{a}	0.143 ±0.011^{a}	0.146 ±0.015^{a}
Month – 4	0.160 ±0.012^{a}	0.151 ±0.012^{ab}	0.156 ±0.015^{b}
Month – 5	0.171 ±0.011^{a}	0.159 ±0.014^{ab}	0.163 ±0.008^{b}
Month – 6	0.181 ±0.021^{a}	0.164 ±0.013^{b}	0.169 ±0.009^{b}

Trend of thigh muscle oxidation stability of chicken hybrid combination COBB 500 was during 6 months of freeze storage similar than in breast muscle. The results of the oxidation stability determined in thigh muscle of chickens COBB 500 during 6 months storage at -18 °C are shown in Table 3. The higher average MDA value determined in thigh muscles was in samples of control group (0.181 mg.kg^{-1}) compared to experimental groups E1 (0.164 mg.kg^{-1}) and E2 (0.169 mg.kg^{-1}) after 6-month of frozen storage. Significantly higher values of MDA were determined in control group compare to experimental groups from fifth month to the end of storage. Higher amount of MDA in thigh muscle compare to breast muscle is due to by higher amount of fat occurred in thigh muscle **Botsoglou et al., (2002)**.

Reached results of oxidation stability determined in chicken meat of hybrid combination COBB 500 after phytogenic additives addition in their diet are in accordance with **Imik et al., (2010)** and **Rahimi et al., (2011)**. The possibilities of using alternative feed supplements containing various antioxidant active substances for poultry which increase the oxidation stability of the meat during its period of freeze storage are showen in works of **Skřivan et al., (2010)**; **Karaalp and Genc (2013)**.

Botsoglou et al., (2007) reported that a higher concentration of antioxidants in poultry meat has the effect of reducing lipid oxidation, i.e. there is a reduction in MDA values during chilling and refrigeration storage, which was confirmed by our findings. Also **Samouru et al., (2007)** and **Ramos Avila et al., (2013)** state that the degradation pathways of fatty substances play one of the main causes of foods deterioration and unpleasant odours. This factor is also responsible for the loss of flavour, texture, appearance, nutritional value of food, increases the drop losses, pigment, polyunsaturated fatty acids, fat-soluble vitamins, reduces the quality of meat intended for human consumption and ultimately reduces its stability, shelf life and safety.

CONCLUSION

Results achieved in the experiment show that the addition of different phytogenic feed additives (Agolin Poultry and Agolin Tannin Plus) in feed mixture for broiler chickens had a significantly ($p \leq 0.05$) positive impact on the reduction of oxidative processes in the breast and thigh muscles during 6 months freeze storage at -18°C.

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Contact address:

Marek Bobko, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Evaluation and *Processing* of *Animal* Products, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: marek.bobko@uniag.sk.

Peter Haščík, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Evaluation and *Processing* of *Animal* Products, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: peter.hascik@uniag.sk.

Martin Mellen, Hydina Slovensko s.r.o., Nová Ľubovňa 505, 065 11 Nová Ľubovňa, Slovakia, E-mail: martin.mellen@gmail.com.

Alica Bobková, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Hygiene and Food Safety, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: alica.bobkova@uniag.sk.

Jana Tkáčová, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Evaluation and Processing of Animal Products, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: jana.tkacova@uniag.sk.

Peter Czako, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Plant Processing and Storage, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: peter.czako@uniag.sk,

Adriana Pavelkova, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Evaluation and *Processing* of *Animal* Products, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: adriana.pavelkova@uniag.sk.

Lenka Trembecká, Slovak University of Agriculture, Faculty of Biotechnology and Food Sciences, Department of Evaluation and Processing of Animal Products, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: lenka.trembecka@uniag.sk.