Oxidative Stability of Chicken Thigh Meat after Treatment of Fennel and Savory Essential Oils

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Abstract

In the present work, the effect of the fennel and savory essential oils on oxidative stability of chicken thigh muscles during chilled storage was investigated. In the experiment were used chickens of hybrid combination Cobb 500 after 42 days of the fattening period. The obtained fresh chicken thigh with skin from left half-carcass were divided into five groups (n = 5): C - control air-packaged group; A1 - vacuum-packaged experimental group; A2 - vacuum-packaged experimental group with EDTA solution 1.50% w/w; A3 - vacuum-packaged experimental group with fennel (*Foeniculum vulgare*) essential oil at concentrations 0.2% v/w and A4 - vacuum-packaged experimental group with savory (*Satureja hortensis*) essential oil at concentration 0.2% v/w. The essential oils were applicate on surface chicken thighs. The chicken thighs were packaged using a vacuum packaging machine and stored in refrigerate at 4±0.5 °C. The value of thiobarbituric acid (TBA) expressed as amount of malondialdehyde (MDA) in 1 kg sample was measured during storage in 1st, 4th, 8th, 12th and 16th day. The treatments of chicken thighs with fennel and savory essential oils show statistically significant differences between all testing groups and control group, where higher average value of MDA measured in thigh muscle of broiler chickens was in samples of control group (0.359 $mg.kg^{-1}$) compared to experimental groups A1 (0.129 $mg.kg^{-1}$), A2 (0.091 $mg.kg^{-1}$), A3 (0.084 $mg.kg^{-1}$) and A4 (0.089 $mg.kg^{-1}$) after 16-day of chilled storage. Experiment results show that the treatment of chicken thigh with fennel and savory essential oils had positive influence on the reduction of oxidative processes in thigh muscles during chilling storage and use of essential oil is one of the options increase shelf life of fresh chicken meat.

Keywords: chicken meat; essential oil; *Foeniculum vulgare*; oxidative stability; *Satureja hortensis*.

1. Introduction

For chicken meat products, freshness, as one of the most important quality attributes, has attracted attention from producers and consumers and has a strong relationship with product sales and consumption [1]. Lipid oxidation is a major cause of meat quality deterioration, resulting in rancidity and the formation of undesirable odours and flavours, which lowers the functional, sensory and nutritive values of meat products; and therefore, consumer acceptability [2].

Chicken meat has many desirable nutritional characteristics such as a low lipid content and relatively high concentration of polyunsaturated fatty acids (PUFAs) which can be further increased by specific dietary strategies [3].
However, a high degree of polyunsaturation accelerates oxidative processes leading to deterioration in meat flavour, colour, texture and nutritional value [4].
Lipid oxidation causes degradation of polyunsaturated fatty acids (PUFA) and generation of residual products, such as malondialdehyde (MDA) and lipid-derived volatiles leading to sensory and nutritional deterioration of meat [5].

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Oxidative reactions in foodstuffs are enhanced after cooking and refrigerated storage through the increase of their oxidative instability due to the degradation of natural antioxidants and the release of free fatty acids and iron from the haem molecule [6-8].

Recently, the interest in using natural antioxidants in livestock production has increased because they are viewed to be safer than synthetic antioxidants and have greater application potential for consumers acceptability, palatability, stability, and shelf-life of meat products [9-11]. As a result, the search for natural antioxidants, especially of plant origin, has notably increased in recent years.

In practise, the addition of antioxidants, which are organic molecules of either synthetic or natural origin capable of scavenging the active forms of oxygen involved in the initiation step or progression of oxidation is the major preventive measure against lipid oxidation in meat and meat products [12]. Antioxidants get incorporated within cell membranes and protect tissues against oxidation from reactive oxygen species, thus maintaining the overall quality of meat [13]. In the same manner, phenolics or flavonoids in plants have the affinity to bind to biological polymers and heavy metal ions, terminating free radical chain reactions [12,14,15]. As a result, research on antioxidants has focused on naturally occurring molecules and numerous medicinal herbs currently being suggested to eliminate consumers' concerns about the safety and toxicity of their synthetic counterparts [14].

Essential oil of fennel is used as flavouring agents in food products. The main components of fennel essential oil is trans-anthole, fenchone and estragole [16-18] which trans-anthole contains both antioxidants and antimicrobial activities [19].

Satureja hortensis L. (summer savory) is well known aromatic and medicinal plant. Leaves, flowers and stem of *Satureja hortensis* are frequently used as tea or additive in commercial spice mixtures for many foods to offer aroma and flavour [20].

In this study we aimed to investigate the combined effect of ethylenediaminetetraacetate (EDTA) and plant essential oils *(Foeniculum vulgare; Satureja hortensis.)* on the oxidative stability of fresh chicken thighs stored under vacuum packaging (VP), at 4 ±0.5 °C for a period of 16 days.

2. Materials and methods

The experiment was implemented in the local poultry station (Hydinaren a.s., Zamostie). The tested were broiler chickens of hybrid combination Cobb 500 both sexes. All the broiler chickens were fed with the same feed mixtures and were kept under the same conditions. The feed mixtures were produced without any antibiotic preparations and coccidiostatics. At the end of the fattening period (42. day) were chickens slaughtered for analysis in laboratory of Slovak University of Agriculture in Nitra. After slaughtering was dissection obtained fresh chicken thigh with skin from left half-carcass, which were divided into five groups (n = 5):

- Air-packaged (C, control group): chicken thigh fresh meat was packaging to polyethylene backs and stored aerobically in refrigerator;
- Vacuum-packaged (A1, experimental group): chicken thigh fresh meat was packaging to polyethylene backs and stored anaerobically in vacuum and in refrigerator;
- VP with EDTA solution 1.50% w/w (A2, experimental group): chicken thigh fresh meat was treated with EDTA for 1 min and packaging to polyethylene backs and stored anaerobically in vacuum and in refrigerator;
- VP with fennel 2.0% v/w (A3, experimental group): chicken thigh fresh meat was treated with *Foeniculum vulgare* essential oil for 1 min and packaging to polyethylene backs and stored anaerobically in vacuum and in refrigerator;
- VP with savory 2.0 % v/w, (A4, experimental group): chicken thigh fresh meat was treated with *Satureja hortensis* essential oil for 1 min and packaging to polyethylene backs and stored anaerobically in vacuum and in refrigerator.

Immediately after dipping, each sample was packaged using a vacuum packaging machine type VB-6 (RM Gastro, Czech Republic).

Ethylenediaminetetraacetic acid (EDTA) ($C_{10}H_{14}N_2O_8.Na_2.2H_2O$) was 99.5% purity, analytical grade, (Invitrogen, USA). A stock solution of 500 mM concentration was prepared by diluting 186.15 $g.L^{-1}$ distilled water. A final concentration of 50 mM EDTA solution was prepared from the stock solution. The pH of the solution was adjusted to 8.0 with the addition of the appropriate quantity of NaOH solution. The

amount of EDTA added to the treat chicken thighs was 0.28 g.kg^{-1}. Essential oil (Calendula, Nova Lubovna, Slovakia) were added to the coated chicken thigh surface (both sides) of each sample using a micropipette so as to achieve a 0.2 % v/w final concentration of essential oils.

TBA value expressed in number of malondialdehyde (MDA) was measured in the process of first storage day of 1st, 4th, 8th, 12th and 16th day. TBA number was determined by [21]**.** Absorbance of samples was measured on UV-VIS spectrophotometer T80 (PG Limeted Instruments, UK) at a wavelength of 532 nm, the translation results on the amount of MDA in 1 kg samples.

Results of the experiment were evaluated by statistical program SAS 9.3 with using application Enterprise Guide 4.2. The variation-statistical values (mean, standard deviation) were calculated and to determine the significant difference between groups was used variance analyse with subsequent t-test.

3. Results and discussion

Oxidation of lipids can occur in both fresh and cooked meats [22,23], and can have significant impact to meat industry. Meat containing unsaturated fatty acids is very sensitive to lipid oxidation especially during storage, because polyunsaturated fatty acid esters are easily oxidized by molecular oxygen. This kind of oxidation is called autoxidation and proceeds by a free radical chain mechanism [24].

The results of the oxidation stability of fresh chicken thigh muscles of chicken Cobb 500 after application EDTA and plant essential oils (*Foeniculum vulgare* and *Satureja hortensis*) during 16 days storage at 4 °C are shown in Table 1.

The higher average value of MDA measured in thigh muscle in 0 day of experiment was in samples of vacuum-packaged chicken thighs with *Foeniculum vulgare* oil 0.20% v/w group A3 (0.039 mg.kg^{-1}) compared to experimental groups A1 (0.037 mg.kg^{-1}), A2 (0.030 mg.kg^{-1}), A4 (0.036 mg.kg^{-1}) and air-packaged control group (0.035 mg.kg^{-1}). We have not found statistically significant differences between testing groups chicken thighs. During chilled storage of the thigh muscles were detected increased content of malondialdehyde in comparison to the first day of storage.

On the fourth day of storage were measured below the values of malondialdehyde in all experimental groups (0.039 mg.kg^{-1} – group A4 and 0.058 mg.kg^{-1} – group A1) opposite control group C (0.078 mg.kg^{-1}). We have found statistically significant differences ($p \leq 0.05$) between control group C and tested groups A2, A3, A4 and between group A1 and A2, A3 and A4.

A similar trend of improving the oxidation stability after eight days of refrigerate storage in the thigh muscle of hybrid combination Cobb 500 we found in the experimental groups (0.058 mg.kg^{-1} – A3 to 0.078 mg.kg^{-1} – A1) compared with control group C (0.153 mg.kg^{-1}).

Table 1. Effect of essential oils on the concentration of MDA (mg.kg^{-1}) in thigh muscle (mean ±*SD*) (n = 5)

Day	C	A1	A2	A3	A4
0	0.035±0.008	0.037±0.007	0.030±0.008	0.039±0.012	0.036±0.006
4	0.078±0.010^{a}	0.058±0.010^{b}	0.041±0.010^{c}	0.040±0.007^{c}	0.039±0.008^{c}
8	0.153±0.010^{a}	0.078±0.009^{b}	0.061±0.008^{c}	0.058±0.008^{c}	0.066±0.009^{bc}
12	0.207±0.011^{a}	0.101±0.011^{b}	0.074±0.009^{c}	0.071±0.011^{c}	0.079±0.013^{c}
16	0.359±0.018^{a}	0.129±0.011^{b}	0.091±0.011^{c}	0.084±0.012^{c}	0.089±0.011^{c}

Legend: C - air-packaged control group; A1 - vacuum-packaged control group; A2 - vacuum-packaged control samples with EDTA solution 1.50% w/w; A3 - vacuum-packaged experimental group with *Foeniculum vulgare* oil 2.0% v/w; A4 - vacuum-packaged experimental group with*; Satureja hortensis* oil 2.0% v/w.

Mean values in the same lines with different superscripts (a, b, c) are significantly different at $P \leq 0.05$ level

After 12 days of thigh muscle storage was statistic significantly ($p \leq 0.05$) improved the oxidative stability of all test groups chicken thighs (0.071 $mg.kg^{-1}$ – A3 to 0.101 $mg.kg^{-1}$ – A1) compared to the control group C (0.207 $mg.kg^{-1}$). We have found statistically significant differences ($p \leq 0.05$) between control group C and tested groups and between tested group A1 and groups A2, A3 and A4.

During testing period of chilled storage were higher values of malondialdehyde measured in control group C compare to experimental groups. The higher average value of MDA measured in thigh muscle of broiler chickens Cobb 500 was in samples of control group C (0.359 $mg.kg^{-1}$) compared to experimental groups A1 (0.129 $mg.kg^{-1}$), A2 (0.091 $mg.kg^{-1}$), A3 (0.084 $mg.kg^{-1}$) and A4 (0.089 $mg.kg^{-1}$) after 16-day of chilled storage. At the end of the test period we have found statistically significant differences between all testing groups and control group of chicken thighs and between tested group A1 and groups A2, A3 and A4.

[25] manufactured mortadella-type sausages with different levels of sodium nitrate (0, 100, 200 $mg.kg^{-1}$) and winter savory essential oil (7.80, 15.60 and 31.25 $\mu l.g^{-1}$) and stored them at 25 °C for 30 days and observed lower TBARS values in the products containing essential oil alone and essential oil with reduced amounts of sodium nitrate.

The effect of lyophilized water extract of Summer savory (*S. hortensis* L.) (LSHWE) at different concentrations on the shelf life of ground beef was evaluated. Ground beef was treated with various concentrations of LSHWE (0, 100, 250 and 500 ppm) and stored at 4±0.5 °C for 72 h. Depending on LSHWE concentrations, lipid oxidation decreased, and 500 ppm of LSHWE showed the lowest TBARS values (11.57 ± 4.07 μmol malonaldehyde/kg) at the end of storage. LSHWE levels had also significant effects on color values (L*, a* and b*) of the ground beef [26].

Higher concentration of MDA in thigh muscle compare to breast muscle is due to by higher amount of fat passes into thigh muscle [14].

The plant essential oils such as oregano, thyme, sage etc. [27-29], show positive effect on oxidation stability of lipids in meat.

[30] observed that raw poultry meat is less prone to lipid oxidation than beef or pork meat because of its lower iron content.

4. Conclusions

The essential oil as well essential oils from herbs can be used as substitutes to chemical food additives which could prolong of shelf life of the meat and meat products. Results achieved in the experiment show that the treatment of chicken thigh muscles with fennel (*Foeniculum vulgare*) and savoury (*Satureja hortensis*) essential oil in concentration 0.20% v/w with combination vacuum packaging had positive effect on the decrease of oxidative processes in chicken thigh muscles during chilling storage at 4 ±0.5 °C

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