The effect of essential oils on the color stability of minced meat

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Abstract. Meat color is one of the important characteristics for consumers. There are various ways to reduce color deterioration in meat. Among them is application of antioxidants from different sources: fruits, vegetables, herbs and spices. The aim of this study was to conduct a comparative study of the effects of essential oils (peppermint Mentha spicata L., citrus (orange) Citrus sinensis, cinnamon Cinnamomum zeylanicum, rosemary Rosemarinus officinalis) on color stability of minced meat. The essential oils at the level of 1.0% were added to minced meat. Meat was held (1) for 15 min under a ultraviolet lamp, or; (2) packaged under vacuum and held for 5 days at 6°C. Then, packages were opened and meat was held for 15 min under the ultraviolet lamp. Ultraviolet light had a great effect on reducing redness of control minced meat. Addition of essential oil promoted protection of the color indicators from deterioration under ultraviolet. However the use of natural antioxidants did not have a significant effect on the stability of yellowness in the meat. The color stability of meat decreased as a result of storage under vacuum mainly due to reduction, except for yellowness. Cinnamon and rosemary oil showed the greatest effect on color stability compared to other antioxidants.

1. Introduction
Meat safety and increasing its shelf life are important research tasks. There are various ways to increase the shelf life of products – protective packaging materials, modern types of processing (pasteurization, high pressure) as well as food additives with antimicrobial and antioxidant effects. The oxidation of heme pigments significantly affects the overall acceptability of the finished product, causing the loss of the attractive color of meat and meat products. Meat color is a very important characteristic for consumers, so color assessment is an integral part of meat quality research.

There are many factors that influence the lipid and protein oxidation in meat products: the degree of grinding, temperature storage, the presence of light, the type of packaging, the duration of storage, the presence of antioxidants, etc. In recent years, much research has been focused on the study of natural antioxidants, especially of plant origin and prepared using different extraction methods [1,2]. Plant food ingredients often have a whole range of functional properties: they can inhibit oxidative changes and the growth of microorganisms, while giving the desired color and flavor. Lipid and myoglobin oxidation can be inhibited by the use of essential oils as antioxidants. There are many different sources of natural antioxidants such as fruits (grapes, apple, plum, pomegranate, dog-rose), vegetables (cabbage, radish, broccoli, curry), herbs and spices (rosemary, tea, cinnamon, thyme, mint, oregano) [3-6]. The main components of essential oils are terpenoids and phenylpropanoids [7]. However, some essential oils can have a pro-oxidant effect when they are used in meat in higher concentrations. Antioxidants show significant differences in their effectiveness depending on the type of food product and the conditions of its processing and storage. In this regard, the purpose of this work was to study the effectiveness of the effect of essential oils with antioxidant properties – peppermint, rosemary, cinnamon and citrus on the color characteristics of minced meat.
2. Materials and Methods

Pork, *M. Longissimus dorsi*, was taken from female 2-year-old Large White pigs from Russia. Meat was ground through a meat grinder (Vitek, Russia) with a hole diameter of 2-3 mm. The essential oils of peppermint (*Mentha spicata* L.), citrus (orange) (*Citrus sinensis*), cinnamon (*Cinnamomum zeylanicum*), rosemary (*Rosemarinus officinalis*) at 1.0% of the weight of the meat were added to the minced meat. The prepared minced meat was divided into two parts: One part was held for 15 min under an ultraviolet lamp; the second part was packaged under vacuum and held for 5 days at 6±2°C. Then, packages were opened and the minced meat was held for 15 min under the ultraviolet lamp.

Determination of the color characteristics of meat products within the CIELab system was carried out using a spectrocolorimeter (Spectroton, Russia) while simultaneously measuring the reflection coefficients of the samples at 24 fixed wavelengths in increments of 13 nm in the visible spectral range from 380 to 720 nm. Then, mathematical processing of measurement results was carried out by a microprocessor controller in the measuring unit.

To determine the stability of color during storage, the color stability test criterion (U, %) was used. Stability of lightness, redness and yellowness was calculated by the following equation:

\[
UL = \left(1 - \frac{|L_1 - L_2|}{L_1}\right) \times 100
\]

\[
UA = \left(1 - \frac{|a_1 - a_2|}{a_1}\right) \times 100
\]

\[
UB = \left(1 - \frac{|b_1 - b_2|}{b_1}\right) \times 100
\]

where: \(L_1, L_2\) – lightness value before and after storage under ultraviolet; \(a_1, a_2\) – redness value before and after storage under ultraviolet; \(b_1, b_2\) – yellowness value before and after storage under ultraviolet

Each experiment was carried out in triplicate. Statistical data processing was performed using Microsoft Excel. The statistical significance of differences between indicators was assessed using Student’s t-test.

3. Results and Discussion

The results of color stability determinations of minced meat under the ultraviolet light at the start of the study are given in Figure 1.
According to the results, the effect of ultraviolet on the change in redness was greatest for the control, which is obviously due to the oxidation of myoglobin. The addition of essential oils had a positive effect on the color stability. An increase in the stability of redness by 22.6-24.5% in mince with cinnamon or rosemary oil compared with the control (p <0.05) was recorded. The use of natural antioxidants did not have a significant effect on the stability of yellowness (p > 0.05). Essential oil of peppermint was the least effective on color stability (p > 0.05 compared with the control). The aqueous extract of mint leaf produced a decrease in the lightness and redness values and an increase in yellowness value during meat storage [8].

Storage under vacuum for five days had a negative effect on the color stability of all minces except minced meat with added cinnamon or mint (Figure 2). The most stable indicators of redness were recorded for minced meat with added cinnamon or rosemary (p <0.05). In contrast, the yellowness stability underwent no significant changes during storage. Similar data were obtained by [9], who showed that in meatballs, yellowness values were not modified by storage time. According to Fernandez-Lopez et al., rosemary extract increased the stability of the red color compared with the control [9].

The effect of essential oils on meat color can be explained by their minimizing myoglobin and lipid oxidation. Hashemi Gahruie et al. indicated that cinnamon and rosemary extracts led to reductions in thiobarbituric acid reactive substances and metmyoglobin in beef burgers [10]. Some analogous results have been published by Yu et al., who indicated rosemary extracts showed significant protection of lipid oxidation and color change in cooked turkey [11]. Similar data were obtained by Valentine et al., who showed that the rosemary-treated ground beef remained redder longer and had lower TBARS values than the untreated control [12]. According Formanek et al., color changes during storage were inhibited by the addition of rosemary extract in ground beef [13]. Sánchez-Escalante et al. indicated the powdered rosemary improved the redness of beef patties [14]. In contrast, according Haile, rosemary extract had no significant effect on color stability of liver pate [15]. Yildiz-Turp and Serdaroglu reported no differences during the first days of storage of chicken patties due to the presence of rosemary [16].
The effect of adding rosemary essential oil on the oxidative stability of meat depended on the level of added essential oil. Estevez and Cava found that 150ppm rosemary essential oil showed an antioxidant effect, significantly reducing the generation of lipid and protein oxidation products. At higher levels the essential oil had no effect on lipid oxidation while it significantly enhanced the oxidation of proteins and the release of iron from myoglobin [17].

The addition of citrus (orange) oil had a positive effect on stability of redness compared to control (p<0.05), but it was less effective than cinnamon or rosemary oils. According to Fernandez-Lopez et al., rosemary extract proved to be a more effective antioxidant than did orange or lemon extracts in cooked Swedish-style meatballs [9].

4. Conclusions
The use of essential oil increased color stability in minced meat after storage under ultraviolet light. The stability of color indicators decreased as a result of storage under vacuum, mainly due to redness reduction. The yellowness stability did not significantly change during storage. Application of cinnamon or rosemary oils showed greater effects than did citrus (orange) or mint oils. Peppermint oil has the least effect on redness stability of minced meat, among the essential oils studied. Thus, the use of cinnamon or rosemary oil is recommended to protect the color characteristics of minced meat.

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