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Antioxidant and antimicrobial properties of oregano extract (*Origani vulgaris herba* L.)

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Abstract:
Introduction. Some ingredients of plant origin possess both antioxidant and bacteriostatic properties. If used in the food industry, they can inhibit microbiological and oxidative damage, thus increasing the shelf life of meat products. Oregano extract is one of such substances, which means that it can be used as an antioxidant and preservative. Therefore, the study of this plant has a significant theoretical and practical potential for the food industry.
Study objects and methods. The present research featured ground trimmed beef. The samples with 20% of fat tissue were used to determine the microbiological parameters, while the samples with 30% of fat were used to obtain data on oxidative stability. The control sample contained no additional ingredients. The sample with food additives was pre-treated with acidity regulators and antioxidants, namely sodium acetate E262, ascorbic acid E300, sodium ascorbate E301, sodium citrate E331, and rosemary extract E392. The sample with oregano extract was pre-treated with oregano extract (*Origani vulgaris herba* L.) in the ratio of 5 g of extract per 1 kg of meat. The extract had been dissolved in 100 g of water. The samples were stored at 4 ± 2°C for 12 days. A CM5 spectrophotometer (Konica Minolta, Japan) was used to determine the color characteristics. The induction period of oxidative stability was determined using an Oxitest oxidative stability analyzer (Velp Scientifica, Italy). The studies were conducted in Austria, Linz.
Results and discussion. Oregano extract stabilized the redness rating. For the sample with oregano extract, the induction period of oxidative stability was twice as long as for the control sample and the sample with antioxidants. In addition, oregano inhibited the growth of aerobic and anaerobic microorganisms.
Conclusion. The antioxidant and antimicrobial properties of oregano extract prolong the shelf life of ground beef, which makes it possible to reduce the amount of food additives.

Keywords: Meat, *Origani vulgaris herba* L., antioxidants, colour stability, oxidative stability, antimicrobial properties

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INTRODUCTION

For many years specialists of the global meat industry have been trying to solve the problem of safety of meat products and to find optimal ways to preserve its consumer properties throughout the entire shelf life. They have come up with various methods of increasing the shelf life of the finished product, e.g. barrier packaging, low temperatures, preservatives and antioxidants, etc. Most damage during storage of meat products is of microbiological and oxidative nature. Microorganisms and oxidation lead to irreversible negative consequences. The biological value of the product deteriorates, so do its consumer properties, i.e. color, smell, and taste. Most importantly, such meat becomes unwholesome. Oxidative damage is caused by three different reactions: 1) enzymatic oxidation; 2) non-enzymatic, or free-radical (peroxide) lipid oxidation; 3) non-enzymatic, or non-radical oxidation. The resulting products of lipid degradation reduce the nutritional value of the finished product during storage [1–3]. The rate of oxidative changes is determined by the composition and quantity of pro-oxidants and antioxidants that are natural to the meat or were introduced during the production process.

Traditionally, meat industry exploits various food additives of bacteriostatic action, e.g. lactic or acetic acid and their salts, as well as antioxidants, e.g. ascorbic acid and its derivatives, tocopherols, etc. These additives either slow down the growth of microorganisms or reduce lipid oxidation. Therefore, the meat industry

needs complex mixes to extend shelf life and preserve the quality and safety of meat products.

However, current trends in the food industry demand that the amount of food additives should be reduced. This trend resulted in a whole new area in the food industry. This area develops ingredients from natural raw materials. They improve and preserve consumer properties of finished products, thus being able to substitute food additives [4]. Sources of such functional components range from vegetables, fruit, and berries, e.g. cabbage, grapes, plums, apples, pomegranates, wild rose, etc., to herbs and spices, e.g. thyme, cinnamon, rosemary, oregano, mint, etc. [5].

The antioxidant properties of plant extracts can be explained by various factors: the presence of natural ascorbic acid (vitamin C), alfatocopherol (vitamin E), beta-carotene (a precursor of vitamin A), flavonoids, and other phenolic compounds [6, 7].

The antimicrobial and antioxidant properties of plant extracts have long been the focus of scientific research. Grape seed extract was found to reduce total bacterial count in semi-finished chopped beef [8]. Rosemary extract with cloves slowed down the oxidation of chicken meat [9]. Meat oxidation could be inhibited by extracts of broccoli powder, lotus seeds, red grape husks, peanut skin, tomato processing by-products, olives, pomegranate, and other plant ingredients [10–15].

Lipid oxidation is not the only problem that might occur during production and storage of meat products. The process is also accompanied by protein oxidation, including myoglobin protein, which is responsible for the color of raw meat and meat products. In addition, oxidation processes of proteins and lipids can be interconnected, while heme/non-heme iron can cause oxidative changes in lipids [16]. According to Johns *et al*., heme iron has a greater prooxidised effect than free iron [17]. These data are consistent with those in [18], according to which the concentration of heme iron has a greater effect on the oxidation rate than the amount of non-heme iron. However, some other studies indicated that non-heme iron had a stronger catalyzing effect on the oxidation of meat products than heme iron [19, 20]. Plant extracts can inhibit both lipid oxidation and myoglobin oxidation, thus preserving the attractive color of meat and meat products.

Extracts of rosemary, garlic, ginger, onion, etc., have successfully been tested as antimicrobial plant components [21–24].

Oregano is a promising natural antioxidant. It is obtained by drying the leaves and flowers of common oregano (*Origanum vulgare* L.). This component is multifunctional: oregano extract can inhibit both oxidative and bacterial changes in meat [25–28].

The research objective was to justify the feasibility of using ethanol oregano extract in the production of chopped semi-finished products to substitute antioxidant and preservative food additives.

STUDY OBJECTS AND METHODS

The microbiological research featured samples of trimmed beef with 20% of fat tissue. To determine the oxidative stability and color characteristics, we used trimmed beef with a 30% fat content. The raw meat was ground using a meat grinder with the plate hole diameter of 2–3 mm.

Raw meat with no additional ingredients served as the control sample. The sample with food additives was pre-treated with acidity regulators and antioxidants that are traditionally used in meat industry to increase shelf life, i.e. sodium acetate E262, ascorbic acid E300, sodium ascorbate E301, sodium citrate E331, and rosemary extract E392. The additives were applied without prior preparation. The sample with oregano extract was pre-treated with oregano extract in the ratio of 5 g per 1 kg of meat. The extract had been dissolved in 100 g of water, as recommended by the manufacturer.

The prepared samples were stored at 4 ± 2°C for 12 days.

After production and throughout the whole storage period, we conducted studies to determine the color characteristics, microbiological parameters, and the induction period of oxidative stability.

Color characteristics included the indices of lightness, redness, and yellowness. They were determined using a CM5 spectrophotometer (Konica Minolta, Japan).

The induction period of oxidative stability was determined using an Oxitest analyzer (Velp Scientifica, Italy). The Oxitest analyzer monitors the change in absolute pressure in two autonomous thermostatically controlled chambers, which occurs during oxidation. The reaction proceeds at temperature = 90°C, pressure = 6 atm, oxygen purity = 99.9%.

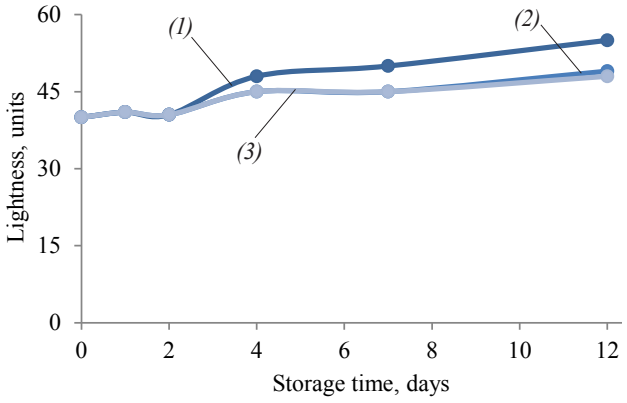
The microbiological analysis was performed using standard procedures described in the Bacteriological Analytical Manual (BAM) of the Food and Drug Administration (FDA).

RESULTS AND DISCUSSION

Figs. 1–3 present data on the change in color indices of beef during storage. The indices of lightness and yellowness showed no significant differences by the end of the shelf life. However, both food additives and oregano extract had a significant effect on the retention of redness. In addition, oregano extract made it possible to obtain the same effect as complex food additives that are based on acidity regulators and antioxidants.

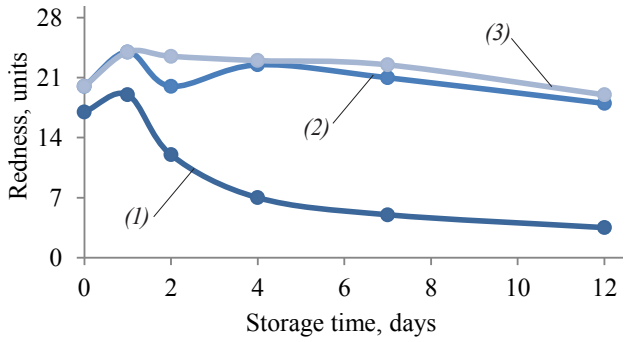
Oregano extract proved to be able to inhibit the oxidation of myoglobin in meat. Chemical changes in myoglobin are known to be associated with fat oxidation. The obtained data on color characteristics were consistent with the results of determining the antioxidant activity of oregano extract.

The antioxidant properties of oregano can be seen from the results of determining the induction period of



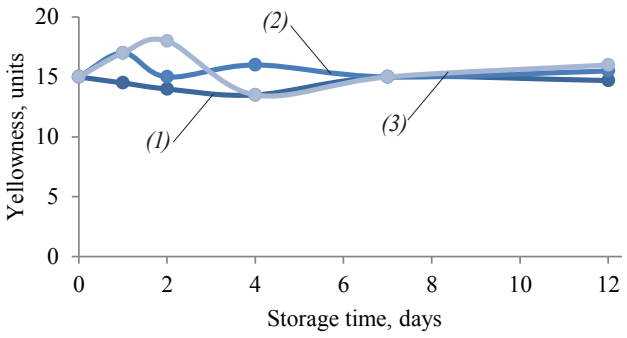
(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 1 Dynamic pattern of lightness index during storage



(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 2 Dynamic pattern of redness during storage



(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 3 Dynamic pattern of yellowness during storage

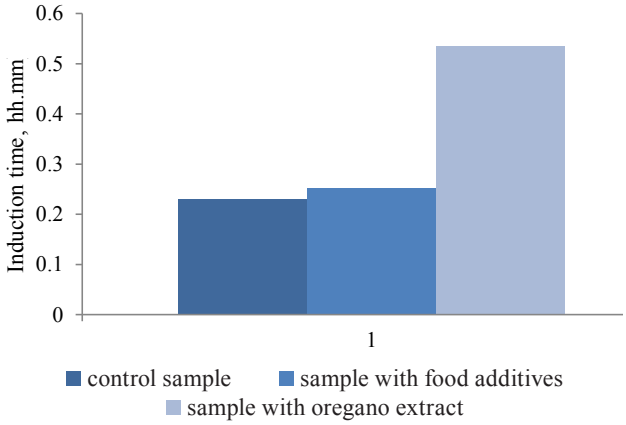
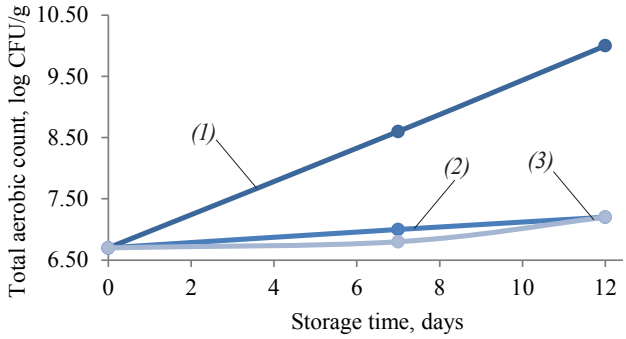
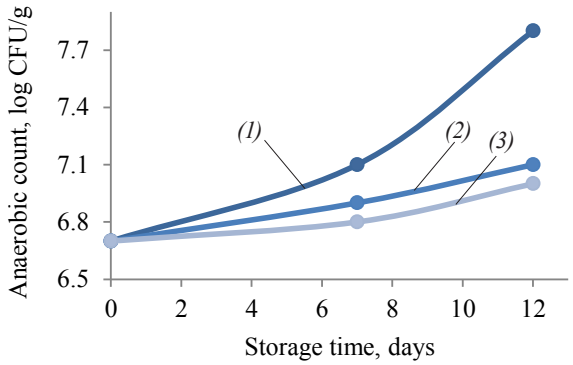


Figure 4. Induction period of oxidative stability of beef



(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 5 Dynamic pattern of aerobic count in beef during storage



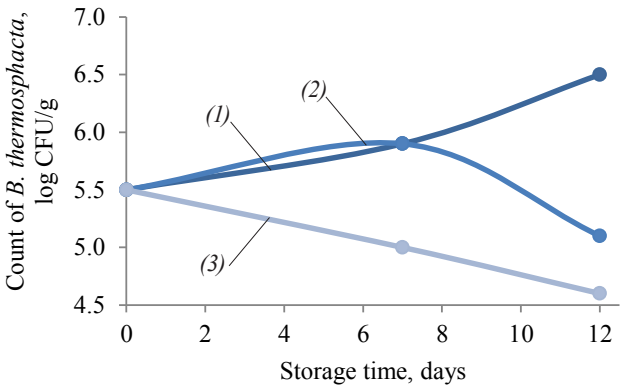
(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 6 Dynamic pattern of anaerobic count in beef during storage

oxidative stability (Fig. 4). Oregano extract was able to double the oxidative stability of meat compared with the control sample and the sample pre-treated with additives.

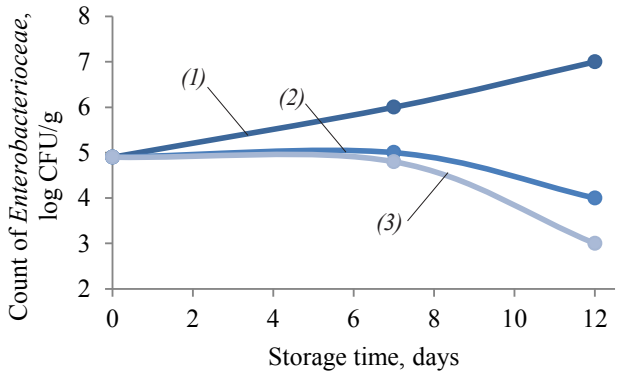
The obtained results were partially consistent with [29], where poultry was treated with a combination of clove, cinnamon, and oregano extracts, which decreased the total bacteria count and increased lightness and redness.

Similar data were obtained by Trindade *et al.*, who proved that 400 mg of oregano extract per 1 kg of meat reduced the amount of secondary decomposition products of fatty acids in beef burgers [26].



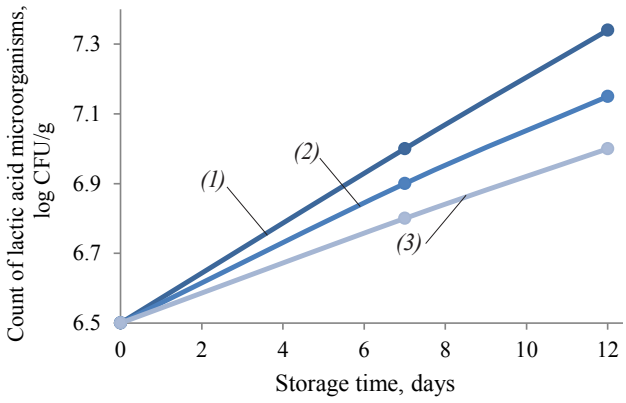
(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 7 Dynamic pattern of *B. thermosphacta* count in beef during storage



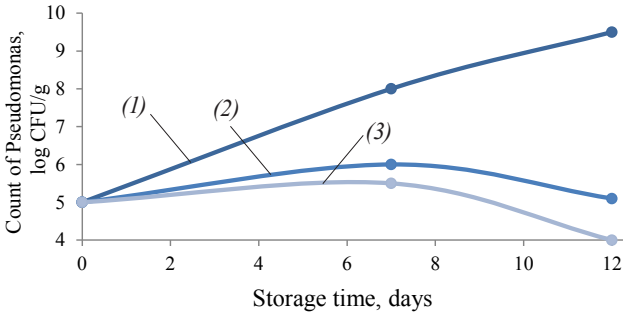
(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 8 Dynamic pattern of *Enterobacterioceae* count in beef during storage



(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 9 Dynamic pattern in the count of lactic acid microorganisms in beef during storage



(1) control sample *(2)* sample with food additives
(3) sample with oregano extract

Figure 10 Dynamic pattern of *Pseudomonous* count in beef during storage

Another study showed that grape seed extract, rosemary oleoresin, and oregano extract had antioxidant properties when used in high fat meat products [30].

In addition to its antioxidant properties, oregano extract can be used in the meat industry for its bacteriostatic effect.

A set of experiments showed that oregano extract significantly slowed down the growth of both aerobic and anaerobic microorganisms (Figs. 5 and 6).

Similar data were obtained by Skandamis and Nychas, who revealed a decrease in the initial microflora of beef when 0.8% of oregano essential oil was added [27]. The same team of scientists also registered a reduction in the total bacterial count in ground beef by 1 log CFU/g when they added 1% oregano oil [28].

The obtained data are consistent with the results about the antibacterial properties of oregano described in [31]. Oregano was found to improve the permeability of *S. aureus* cell membranes [32].

The antimicrobial properties of oregano essential oil appeared to have a bacteriostatic effect on *Salmonella Enteritidis* in mutton [33].

Cui *et al.* established the mechanism of the antibacterial properties of oregano essential oil [34]. They studied the effect of oregano essential oil on respiratory and energy metabolism of *Staphylococcus aureus*. The oil proved efficient against this methicillin-resistant microorganism.

The antimicrobial effect of oregano on *Salmonella* and *S. aureus* has been proven by a number of studies [31–34]. Therefore, the present research focused on the bacteriostatic effect of oregano on various microorganisms that cause meat spoilage (Figs. 7–10). According to the obtained data, oregano extract proved more effective in comparison with the control sample and the sample pre-treated with food additives. The antimicrobial properties of oregano extract, however, did not affect lactic acid microorganisms that can inhibit the development of putrefactive microflora (Fig. 9).

The antimicrobial properties of oregano were also confirmed by Agrimonti *et al.* [36, 37]. They put absorbent cellulose wipes saturated with oregano essential oil emulsion in packages with ground meat. The emulsion proved to have antimicrobial effect against psychrophilic microorganisms in ground beef. In addition, such oregano adsorbent wipes were efficient against certain types of microorganisms that can affect raw meat, namely *Pseudomonas putida*, *Pseudomonas fragi*, *Pseudomonas fluorescens*, *Enterococcus faecalis*, and *Lactococcus lactis*. It also decreased the count of some common foodborne pathogens, such as *Salmonella enterica*, *Campylobacter jejuni* and *Staphylococcus* [35]. The bacteriostatic properties of oregano are sometimes explained by the high content of thymol and carvacrol, i.e. compounds with documented antimicrobial activity [36, 37].

CONCLUSION

Thus, *Origani vulgaris herba* extract can be used in ground beef production to extend its shelf life, which makes it possible to reduce the amount of food additives. The results of the present study make a significant contribution to the justification of the antimicrobial and antioxidant effects of oregano extract. The multifunctional character of this ingredient was confirmed by its positive effect on the stability of color indexes, which helps to improve the consumer characteristics of the product during storage. Taking into account that the antioxidant effect largely depends on the dose, further studies are needed to determine the optimal amount of oregano extract for various meat products.

CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this article.

REFERENCES

1. Domínguez R, Pateiro M, Gagaoua M, Barba FJ, Zhang W, Lorenzo JM. A comprehensive review on lipid oxidation in meat and meat products. Antioxidants. 2019;8(10). DOI: https://doi.org/10.3390/antiox8100429.
2. Niki E, Yoshida Y, Saito Y, Noguchi N. Lipid peroxidation: mechanisms, inhibition, and biological effects. Biochemical and Biophysical Research Communications. 2005;338(1):668–676. DOI: https://doi.org/10.1016/j.bbrc.2005.08.072.
3. Amaral AB, da Silva MV, Lannes SCS. Lipid oxidation in meat: mechanisms and protective factors – a review. Food Science and Technology. 2018;38:1–15. DOI: https://doi.org/10.1590/fst.32518.
4. Tunieva EK, Gorbunova NA. Possibilities to use natural antioxidants. Meat Industry. 2015;(9):40–44. (In Russ.).
5. Rather SA, Masoodi FA, Akhter R, Rather JA, Shiekh KA. Advances in use of natural antioxidants as food additives for improving the oxidative stability of meat products. Madridge Journal of Food Technology. 2016;1(1):10–17.
6. Pennington JAT, Fisher RA. Classification of fruits and vegetables. Journal of Food Composition and Analysis. 2009;22(1):S23–S31. DOI: https://doi.org/10.1016/j.jfca.2008.11.012.
7. Karre L, Lopez K, Getty KJK. Natural antioxidants in meat and poultry products. Meat Science. 2013;94(2):220–227. DOI: https://doi.org/10.1016/j.meatsci.2013.01.007.
8. El-Zainy AR, Morsy AE, Sedki AG, Mosa NM. Polyphenols grape seeds extract as antioxidant and antimicrobial in beef sausage. International Journal of Current Science. 2016;19(2):112–121.
9. Zhang H, Wu J, Guo X. Effects of antimicrobial and antioxidant activities of spice extracts on raw chicken meat quality. Food Science and Human Wellness. 2016;5(1):39–48. DOI: https://doi.org/10.1016/j.fshw.2015.11.003.
10. Banerjee R, Verma AK, Das AK, Rajkumar V, Shewalkar AA, Narkhede HP. Antioxidant effects of broccoli powder extract in goat meat nuggets. Meat Science. 2012;91(2):179–184. DOI: https://doi.org/10.1016/j.meatsci.2012.01.016.
11. Ham Y-K, Hwang KE, Song D-H, Kim YJ, Shin DJ, Kim KI, et al. Lotus (*Nelumbo nucifera*) rhizome as an antioxidant dietary fiber in cooked sausage: effects on physicochemical and sensory characteristics. Korean Journal for Food Science of Animal Resources. 2017;37(2):219–227. DOI: https://doi.org/10.5851/kosfa.2017.37.2.219.
12. García-Lomillo J, Gonzalez-San Jose ML, Del Pino-García R, Ortega-Heras M, Muñiz-Rodríguez P. Antioxidant effect of seasonings derived from wine pomace on lipid oxidation in refrigerated and frozen beef patties. LWT – Food Science and Technology. 2017;77:85–91. DOI: https://doi.org/10.1016/j.lwt.2016.11.038.
13. Munekata PES, Paseto Fernandes RDP, de Melo MP, Trindade MA, Lorenzo JM. Influence of peanut skin extract on shelf-life of sheep patties. Asian Pacific Journal of Tropical Biomedicine. 2016;6(7):586–596. DOI: https://doi.org/10.1016/j.apjtb.2016.05.002.
14. Andrés AI, Petrón MJ, Adámez JD, López M, Timón ML. Food by-products as potential antioxidant and antimicrobial additives in chill stored raw lamb patties. Meat Science. 2017;129:62–70. DOI: https://doi.org/10.1016/j.meatsci.2017.02.013.
15. Aminzare M, Hashemi M, Ansarian E, Bimkar M, Azar HH, Mehrasbi MR, et al. Using natural antioxidants in meat and meat products as preservatives: A review. Advances in Animal and Veterinary Sciences. 2019;7(5):417–426. DOI: https://doi.org/10.17582/journal.aavs/2019/7.5.417.426.

16. Lisitsyn AB, Tuniyeva EK, Gorbunova NA. Oxidation of lipids: the mechanism, dynamics, inhibition. All about the meat. 2015;(1):10–15. (In Russ.).
17. Johns AM, Birkinshaw LH, Ledward DA. Catalysts of lipid oxidation in meat products. Meat Science. 1989;25(3):209–220. DOI: https://doi.org/10.1016/0309-1740(89)90073-9.
18. Rhee KS, Ziprin YA. Lipid oxidation in retail beef, pork and chicken muscles as affected by concentrations of heme pigments and non-heme iron and microsomal enzymic lipid peroxidation activity. Journal of Food Biochemistry. 1987;11(1):1–15. DOI: https://doi.org/10.1111/j.1745-4514.1987.tb00109.x.
19. Baron CP, Andersen HJ. Myoglobin-induced lipid oxidation. A review. Journal of Agricultural and Food Chemistry. 2002;50(14):3887–3897. DOI: https://doi.org/10.1021/jf011394w.
20. Tichivangana JZ, Morrissey PA. Metmyoglobin and inorganic metals as pro-oxidants in raw and cooked muscle systems. Meat Science. 1985;15(2):107–116. DOI: https://doi.org/10.1016/0309-1740(85)90051-8.
21. Borella TG, Peccin MM, Mazon JM, Roman SS, Cansian RL, Soares MBA. Effect of rosemary (*Rosmarinus officinalis*) antioxidant in industrial processing of frozen-mixed hamburger during shelf life. Journal of Food Processing and Preservation. 2019;43(9). DOI: https://doi.org/10.1111/jfpp.14092.
22. Mozaffari Nejad AS, Shabani S, Bayat M, Hosseini SE. Antibacterial effect of garlic aqueous extract on *Staphylococcus* aureus in hamburger. Jundishapur Journal of Microbiology. 2014;7(11):1–5. DOI: https://doi.org/10.5812/jjm.13134.
23. Baker IA, Alkass JE, Saleh HH. Reduction of oxidative rancidity and microbial activities of the karadi lamb patties in freezing storage using natural antioxidant extracts of rosemary and ginger. International Journal of Agricultural and Food Research. 2013;2(1):31–42.
24. Koné AP, Desjardins Y, Gosselin A, Cinq-Mars D, Guay F, Saucier L. Plant extracts and essential oil product as feed additives to control rabbit meat microbial quality. Meat Science. 2019;150:111–121. DOI: https://doi.org/10.1016/j.meatsci.2018.12.013.
25. Trindade RA, Mancini-Filho J, Villavicencio ALCH. Natural antioxidants protecting irradiated beef burgers from lipid oxidation. LWT – Food Science and Technology. 2010;43(1):98–104. DOI: https://doi.org/10.1016/j.lwt.2009.06.013.
26. Tsigarida E, Skandamis P, Nychas G-JE. Behaviour of *Listeria monocytogenes* and autochthonous flora on meat stored under aerobic, vacuum and modified atmosphere packaging conditions with or without the presence of oregano essential oil at 5°C. Journal of Applied Microbiology. 2000;89(6):901–909. DOI: https://doi.org/10.1046/j.1365-2672.2000.01170.x.
27. Skandamis PN, Nychas G-JE. Effect of oregano essential oil on microbiological and physico-chemical attributes of minced meat stored in air and modified atmospheres. Journal of Applied Microbiology. 2001;91(6):1011–1022. DOI: https://doi.org/10.1046/j.1365-2672.2001.01467.x.
28. Moreno Y, Arteaga-Minano HL. Natural conservation of guinea pig (*Cavia porcellus*) meat vacuum packed: Oregano essential oil effect on the physicochemical, microbiological and sensory characteristics. Scientia Agropecuaria. 2018;9(4):467–476. DOI: https://doi.org/10.17268/sci.agropecu.2018.04.01.
29. Radha krishnan K, Babuskin S, Azhagu Saravana Babu P, Sasikala M, Sabina K, Archana G, et al. Antimicrobial and antioxidant effects of spice extracts on the shelf life extension of raw chicken meat. International Journal of Food Microbiology. 2014;171:32–40. DOI: https://doi.org/10.1016/j.ijfoodmicro.2013.11.011.
30. Rojas MC, Brewer MS. Effect of natural antioxidants on oxidative stability of frozen, vacuum-packaged beef and pork. Journal of Food Quality. 2008;31(2):173−188. DOI: https://doi.org/10.1111/j.1745-4557.2008.00196.x.
31. Cattelan MG, de Castilhos MBM, Sales PJP, Hoffmann FL. Antibacterial activity of oregano essential oil against foodborne pathogens. Nutrition and Food Science. 2013;43(2):169–174. DOI: https://doi.org/10.1108/00346651311313544.
32. Lambert RJW, Skandamis PN, Coote PJ, Nychas G-JE. A study of the minimum inhibitory concentration and mode of action of oregano essential oil, thymol and carvacrol. Journal of Applied Microbiology. 2001;91(3):453–462. DOI: https://doi.org/10.1046/j.1365-2672.2001.01428.x.
33. Govaris A, Solomakos N, Pexara A, Chatzopoulou PS. The antimicrobial effect of oregano essential oil, nisin and their combination against *Salmonella* Enteritidis in minced sheep meat during refrigerated storage. International Journal of Food Microbiology. 2010;137(2–3):175–180. DOI: https://doi.org/10.1016/j.ijfoodmicro.2009.12.017.
34. Cui H, Zhang C, Li C, Lin L. Antibacterial mechanism of oregano essential oil. Industrial Crops and Products. 2019;139. DOI: https://doi.org/10.1016/j.indcrop.2019.111498.
35. Agrimonti C, White JC, Tonetti S, Marmiroli N. Antimicrobial activity of cellulosic pads amended with emulsions of essential oils of oregano, thyme and cinnamon against microorganisms in minced beef meat. International Journal of Food Microbiology. 2019;305. DOI: https://doi.org/10.1016/j.ijfoodmicro.2019.108246.

36. Burt S. Essential oils: their antibacterial properties and potential applications in foods – a review. International Journal of Food Microbiology. 2004;94(3):223–253. DOI: https://doi.org/10.1016/j.ijfoodmicro.2004.03.022.

37. Karabagias I, Badeka A, Kontominas MG. Shelf life extension of lamb meat using thyme or oregano essential oils and modified atmosphere packaging. Meat Science. 2011;88(1):109–116. DOI: https://doi.org/10.1016/j.meatsci.2010.12.010.

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