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Oregano Essential Oil in Animal Production

Alma Delia Alarcon-Rojo,
Hector Janacua-Vidales and
Ana Renteria-Monterrubio

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Abstract

There is an increasing interest in the use of natural additives in food production such as the use of phytogenic feed additives especially for use in swine and poultry. Essential oils are a natural alternative that can be used in animal feed due to their potential health benefits, improved performance and meat production. Oregano essential oil minimises meat downgrading due to transport stress or the modification of the ruminal microorganisms. This review suggested a promising development of food natural preservative against spoilage microorganisms in food systems by the use of oregano essential oil. The addition of oregano essential oil is a good way of preserving meat and could replace the synthetic antioxidants. Moreover, oregano oil and modified atmosphere packaging exhibit an additive preservation effect in fresh meat. Oregano essential oil is effective for controlling the growth of microorganisms. However, for meat quality, special attention should be put on the optimal oregano essential oil dose and meat handling to control or improve the physical, chemical and sensory properties of meat.

Keywords: oregano essential oil, animal production, meat, animal health, packaging, pathogens, sensory, meat quality

1. Introduction

Antimicrobial growth promoters (AGP) were used for decades to increase performance in animal production. However, the link between them and the development of antibiotic resistant microorganisms added to consumer pressure caused major changes. In January 2006, the European Union banned AGP in animal production, which in turn emphasised the importance of researching alternative compounds to promote general health and increase performance in animals [1, 2]. Due to their natural origin and reduced side effects, studies have been mainly focused on herbs, spices and their extracts [3]. The effect of the aromatic plants is

primarily based on their essential oils (EO) and other metabolites [4], for example, vitamins, flavonoids, terpenoids, carotenoids, phytoestrogens, minerals, etc. [6]. Among the activities and applications of EO reported in animal and meat production are antioxidant, preservative, antimicrobial and coccidiostatic and they enhance production of digestive enzymes, stimulate blood circulation and improve immune status. [5, 6–9]. Even though there are 3000 estimated EOs, only 300 of them are of commercial use [10]. However, the EO from oregano (OEO) has been one of the most widely studied due to its content of carvacrol and thymol, and to a lesser extent γ -terpinene, p-cymene and myrcene [11]. Some *in vitro* and *in vivo* properties of OEO are antioxidant, antimicrobial, digestive stimulant, etc. [12–14].

2. Oregano essential oil in animal production

2.1. Poultry and egg production

Results of the effect of OEO in poultry and egg production cannot be considered conclusive or consistent, as they can differ even within researches of the same authors [15, 16]. Studies supporting the positive effects of OEO suggest that they increase performance [17], daily and final body weight in broilers [18] and laying hens [15, 19], nutrient utilisation [20, 21], egg weight and production [15, 19, 22] and feed intake [23]. Improvement in feed efficiency and growth performance might be related with changes in the intestinal morphology, like the increment in villus height to crypt depth ratio [18] or enzyme activity as in the protein digestibility due to the chymotrypsin role [21] and the prevention of coccidiosis [24]. It has been implied that antioxidants from the OEO might transfer into the body of the laying hen, which in turn inhibit the chain reaction associated with lipid oxidation and thus reducing the oxidation in egg yolk [11]. In contrast, several authors have suggested that OEO have no effect on animal performance [21, 25, 26]. For example, Arpášová et al. [16] reported that the addition of thyme and OEO did not significantly influence the body weight, feed consumption and conversion, egg production, mass and weight in laying hens.

2.2. Pig production

As in poultry production, results of the effects of the inclusion of OEO in the diets are contradictory in terms of productive performance [27, 28]. However, positive effects link to dietary inclusion of OEO might be clearer in other areas, for example, immunomodulation [28] and changes in blood counts [29]; in sows, it increases their reproductive performance [30] and causes a reduction in the oxidative stress status and enhances the performance of their litters [31]. Oregano essential oil can be used as well to alleviate stress due to transportation as it improved the antioxidant status [32, 33]. Finally, animals fed 1000 ppm of OEO produced meat of good quality with minimum lipid oxidation [34].

2.3. Milk production and ruminant nutrition

The use of EOs in ruminants and milk production is lightly documented and many of these studies are laboratory based [35]. Several essential oils and their components display antimicrobial

properties that may affect rumen metabolism [36] and influence milk production parameters. Many of these compounds (e.g. flavonoids) have distinct flavours and aromas, which if fed to animals, might change the sensory characteristics of the milk; however, this effect might be temporal [37]. The organoleptic quality of the milk can be affected by feeding EO due to a direct transfer of aromatic compounds from the feed (and environment) to the milk [37], formation of aromatic compounds during digestion of the feed [38] and excretion of the EO in the milk. Ruminant microorganisms utilise nutrients to produce volatile fatty acids; however, this process has energy and protein losses, which render the performance inefficient. These losses might be controlled with the inclusion of EO in the diet to limit the growth of Gram-positive and Gram-negative bacteria [39].

3. Oregano essential oil in the meat industry

3.1. Introduction

This section provides an overview of the applications of OEO in raw and processed meat and fish products. It is well known that raw and minimally processed meat is easily targeted by spoilage microorganisms. Moreover, the interest of the industry to replace synthetic chemicals by natural products with bioactive properties is increasing. The need to reduce the use of additives in foods has highlighted the importance of natural antimicrobials such as essential oils. A wide range of antimicrobial agents derived from essential oils have the potential to be used in food processing and preservation since their antimicrobial activity is well recognised.

3.2. Antioxidant activity

The effects of OEO to extend shelf life by controlling lipid oxidation and improving the sensory qualities of meat and meat products are well documented. Kodal Coskun et al. [40] studied the effectiveness of soy-based edible films incorporated with essential oils from oregano or thyme applied on oxidative stability of ground beef patties. The incorporation of OEO or thyme into the edible films reduced the redness value to an acceptable level, but within the appropriate range. The authors concluded that the addition of OEO and thyme EO into edible films retarded the oxidative changes in meats. The potential application of EOs as natural antioxidants has been studied as well in meat products. OEO (alone or in combination) added to fermented meat products as, according to Tunisian [41] and Spanish [42], sausages did not affect proteolysis and rendered a higher unsaturated fatty acid content without affecting the lipolysis. Even more, OEO-added sausages have a better texture due to an increased hardness. Sausages showed a lower number of enterobacteriaceae, coliforms, *Staphylococcus aureus* and moulds. As in beef, the colour of ground poultry meat (breast and thigh) is stabilised due to the effect of OEO [43]. The combination of (200 ppm) and tannic acid (10 ppm) had the highest effect on TBARS, total carbonyl and off-odours volatiles. Hence, OEO might be a proper replacement for synthetic antioxidants in several types of ground meat [44]. The antioxidant effect of OEO included as well cooked meat. Nieto et al. [45] demonstrated that OEO and rosemary EO retarded the loss of thiols under modified atmosphere packaging (MAP, 70% O₂: 20% CO₂:10% N₂) and aerobic conditions. However, this effect was not observed with

garlic essential oil. Even though the antimicrobial activity against pathogens is well reported, flavour changes have been reported. However, these changes are acceptable [46].

3.3. Bioactive films

Antimicrobial-releasing edible films in food packaging are a form of bioactive packaging. A large number of studies have been focused on this topic. Oregano essential oil has been used in active packaging systems to protect foods from microbial contamination. Studies have shown that OEO in milk protein-based is highly effective against pathogen and spoilage bacteria even when compared with other EOs [47]. OEO not only helps control the growth of microorganisms but it can modify positively the characteristics of the bioactive film [48]. The best balance of mechanical, barrier, thermal, antioxidant and antimicrobial properties is achieved when 9% of OEO is incorporated in poly (lactic acid)/polytrimethylene carbonate films. OEO on alginate-based edible films have the potential to limit lipid oxidation, decrease shear forces, colour and water losses. Oregano added bioactive films also modify consumer perception in terms of odour, flavour and overall acceptance [49–51]. OEO not necessarily need to be included in the wrapping film, as it can be spray in meat exudate absorbent pads to extend shelf life for two more days [52]. Studies showed that oregano essential oil-blend film was an effective antimicrobial suitable for the potential food packaging applications. It has also been demonstrated the effectiveness of oregano oil containing whey protein films to increase the shelf life of fresh beef [53]. They incorporated different levels of oregano oil (0.5, 1.0 and 1.5% w/w in the film forming solution) into sorbitol-plasticised whey protein isolate films and evaluated beef quality. Wrapping of beef cuts with the antimicrobial films resulted in smaller changes in colour in chilled storage. The maximum specific growth rate of total flora and pseudomonads were significantly reduced by a factor of 2 with the use of antimicrobial films (1.5% w/w), while the growth of lactic acid bacteria was completely inhibited. However, interesting results were obtained by Emiroğlu et al. [54] who did not find significant effects on total viable counts, lactic acid bacteria and *Staphylococcus* spp. when oregano was applied on ground beef patties. They evaluated the antibacterial activity of soy protein edible films incorporated with 1, 2, 3, 4 and 5% oregano or thyme essential oils against *Escherichia coli*, *E. coli* O157:H7, *S. aureus*, *Pseudomonas aeruginosa* and *Lactobacillus plantarum*. *E. coli*, *E. coli* O157:H7 and *S. aureus* were significantly susceptible to antimicrobial films; meanwhile, *L. plantarum* and *P. aeruginosa* were more resistant. In the study of Seydim and Sarikus [55], antimicrobial properties of whey protein isolate films containing 1.0–4.0% (wt/vol) ratios of oregano, rosemary and garlic essential oils were tested against *E. coli* O157:H7, *S. aureus*, *Salmonella enteritidis*, *Listeria monocytogenes* and *L. plantarum*. As mentioned before, films containing OEO are more effective than those containing other EOs.

3.4. Antimicrobial effects in packaged raw meat

Foodborne pathogens are commonly associated with raw meats. EOs of spices can be used as biopreservatives due to their antimicrobial properties [56]. Authors have demonstrated that OEO might be more effective against pathogens when used in combination with other natural compounds and technologies. Examples of these combinations include OEO and N,O-carboxymethyl chitosan [57], caprylic acid and vacuum packaging (VP) [58], VP [59] and MAP [60–62]. These treatments might extend shelf life of up to 8 days in different types of raw and

cooked meat [59–61]. The treatments also control the growth of Gram-positive and Gram-negative bacteria, and pathogens, such as *L. monocytogenes* and *Salmonella typhimurium* [58, 59, 61, 62]. The minimum inhibitory concentration for OEO against *S. enteritidis* has been reported as 3.90 µl/ml [63]. A longer shelf life (9 days) than the previously reported was observed in the combination MAP and OEO and thyme EOs [64]. Mixed treatment (OEO, orange dietary fibre and MAP) caused a decrease in TBA values and in microbial counts. This combination did not affect the sensory attributes [65]. OEO and sodium lactate not only reduces the number of microbes but render them more susceptible to heat treatments [66]. These studies showed that OEO, by itself or in combination can be used in raw and processed meats to control pathogens and extend shelf life during chill storage.

3.5. Antimicrobial effects in fish products

The demand for natural alternatives to synthetic additives increases also includes raw and minimally processed fish. The effect of VP and OEO in Mediterranean octopus increases as the concentration of EO increased. The highest concentration of EO increases the shelf life to 20 days, meanwhile half the concentration had only an 11-day shelf life or 3 days when VP was by itself [67]. The effect of EOs is also observed with other EOs, as clove. Clove essential oil incorporated in a gelatin-chitosan film decreased the numbers of Gram-negative bacteria, mainly enterobacteriaceae in chilled-stored fish [68]. In rainbow trout fillets, as in other meats, OEO in combination with MAP decreased the numbers of lactic acid bacteria, H₂S-producing bacteria, enterobacteriaceae and *Pseudomonas* spp. This combination avoided lipid oxidation, however, in contrast with other meats, the highest concentration of OEO impact negatively the sensory traits [69]. The concentration of OEO must be considered in order to balance microbial inhibition and sensory characteristics, because in order to obtain the highest inhibition the sensory traits might be negatively affected [70].

4. Conclusions

Even though some results are contradictory, it seems that the use of OEO as a feedstuff in live animals and production has a positive effect. Some of the effects are indirect or might not be evident, as the use of OEO to minimise meat downgrading due to transport stress or the modification of the ruminal microorganisms. The use of EO is still very much under review, as the doses are not fully developed; however, the antimicrobial action of these compounds is fully studied *in vivo* and *in vitro*. It might be of relevance to study not only the inclusion of EO, but also the inclusion of by-products that result from the production of EO. This review suggested a promising development of food natural preservative against spoilage microorganisms in food systems by the use of oregano essential oil. The effectiveness of oregano essential oil in retarding oxidative changes in meats has been widely demonstrated. The addition of oregano essential oil is a good way of preserving meat and could replace the synthetic antioxidants. Also, oregano oil and modified atmosphere packaging exhibit an additive preservation effect in fresh meat. The oregano essential oil is effective by controlling the growth of microorganisms without detrimental changes in sensory and acceptability attributes.

Author details

Alma Delia Alarcon-Rojo^{1*}, Hector Janacua-Vidales² and Ana Renteria-Monterrubio¹

*Address all correspondence to: aalarcon@uach.mx

¹ Autonomous University of Chihuahua, Chihuahua, Mexico

² Autonomous University of Ciudad Juarez, Ciudad Juarez, Mexico

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