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Review of the use of oregano *spp*. oil in animal health and production

Revisión del aceite de orégano *spp.* en salud y producción animal

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ABSTRACT

The use of essential oil extracted from oregano is relevant if we take into account the high concentrations of thymol, flavonoids, tannins, triterpenes and carvacrol, which are substances with antioxidant capacity, since they counteract the formation of free radicals, in addition to having antibacterial, antifungal, antiparasitic, antimicrobial, antiviral, antiallergic, vasodilator, and estrogenic, anti-inflammatory, spasmolytic, antitumor properties, among others. The objective of this review was to conduct a preliminary analysis of the use of oregano oil *spp.* in animal health and production. In conclusion, it can be said that the use of essential oils of oregano mainly of the subspecies *vulgare* and *Lippia* have been an alternative as feed additives in the production of domestic animal species. The digestive system in chickens has been improved its functionality due to this, also it has been possible to reduce enteric methane emissions in ruminants and reduce bad odors in pigs.

Keywords: Oregano, essential oil, animal production.

RESUMEN

El uso de los aceites esenciales extraído del orégano es relevante si tomamos en cuenta sus cantidades de timol, flavonoides, taninos, triterpenos y carvacrol contenido, las cuales le dan su capacidad antioxidante, para disminuir la formación de radicales libres. Además, tiene propiedades antibacteriales, antifúngicas, antiparasitarias, antimicrobianas, antivirales, antialérgicas, vasodilatadoras, estrogénicas, antiinflamatorias, espasmolíticas, antitumorales, entre otras. El objetivo de la revisión fue hacer un análisis preliminar del uso del aceite de orégano spp. en la salud y la producción animal. A manera de conclusión se puede decir que el uso de los aceites esenciales de orégano, principalmente de las subespecies *vulgare* y *Lippia*, han sido una alternativa como aditivos en la alimentación en la producción de especies de animales domésticos donde se ha podido mejorar la funcionalidad del sistema digestivo en pollos, se ha logrado reducir las emisiones de metano entérico en rumiantes y reduce malos olores en eses de los cerdos.

Palabras clave: Orégano, aceite esencial, producción animal

INTRODUCTION

Oregano is a plant that is widely distributed in the European Mediterranean, Asia and America (Castillo *et al*., 2017; Zou *et al*., 2016; Huerta, 1997). Currently, more than 40 species of the *Verbenaceae*, *Lamiaceae*, *Compositae* and *Leguminoseae* families are known, the most important being the oregano, *Origanum vulgare* and the Mexican oregano *L. graveolens*, *L. palmeri*, *L. alba* (Castillo *et al*., 2017; Huerta, 1997). These plants are easy to obtain and because of their aromatic characteristics, it is commonly as a condiment in culinary recipes used (Albado *et al*., 2001). Therefore, oregano is located as a plant of economic importance; in addition, its essential oils are beneficial for human health and they can be as natural additives in food for production animals used (Hyldgaard *et al*., 2012).

Oregano oils are a complex mixture of hundreds of individual volatile aromatic compounds that are derived from the various oregano species Monu *et al*., 2016). These oils are known for their anti-inflammatory, antibacterial and antioxidant properties, due to their carvacrol and thymol content (Govaris *et al*., 2010); even at low concentrations, oregano oil has biological activity (Ali *et al*., 2015). It has been shown to have an inhibitory effect on a variety of bacteria and has a broad spectrum of antibacterial properties (Gonçalves *et al*., 2013). In this sense, the natural property of oregano oil has allowed it to be used to preserve food (Viuda *et al*., 2011), as an acaricide for parasite control, such as *Varroa* in bees (Loeza *et al.,* 2018).

The use of essential oils of oregano becomes more relevant if we consider the prohibition of growth-promoting antibiotics, stimulating the search for alternative nutritional supplements in the production of various animal species (Botsoglou *et al*., 2002). Therefore, the objective of the research was to conduct a preliminary analysis of the use of oregano oil *spp*. in animal health and production.

In recent years, essential oils have had an impact on animal production, because they have proven to be a good alternative to reduce the use of chemical compounds (Martínez *et al*., 2015). Therefore, it has been in broilers used, with the purpose of improving ileal digestibility. In addition, they stimulate the appetite of birds and increase their weight gain (Isabel y Santos, 2009). In turkeys, it has managed to increase the stability of its raw and cooked meat, as well as lipid oxidation (Botsoglou *et al*., 2003). In pigs, it reduces the emission of gases, fecal coliforms and anaerobic bacteria (Varel, 2002); In addition, in pregnant sows it reduces the mortality of its piglets (Allan y Bilkei, 2005). In bees, it used for the alternative control of *Varroa* destructor (Itzá *et al*., 2007). In ruminants the presence of carvacrol, ρ-cymene, linalool, terpenene and thymol, have used it to reduce methane emissions in the rumen of sheep, goats and cattle (Talebzadeh *et al*., 2012); and in fish the use of oregano essential oil during transport reduced oxidative stress in fish tissues (Azambuja *et al*., 2011).

Despite the benefits obtained from the different species of oregano in animal production, they have achieved disease prevention, the response of the animal's immune system and the productivity of the various production systems (Martínez *et al*., 2015). Its functionality in the reproduction of various species has been set aside; this based on mainly the high amounts of antioxidant present in the essential oils of oregano. They can improve the seminal quality of fresh semen and the sperm's resistance to thermal shock during the cryopreservation process (Alvarez y Storey, 1992).

The inclusion of thymol extracted from oregano plants to the diets of bees inoculated with *Nosema* has reduced infection (Van den *et al*., 2016; Costa *et al*., 2010; Maistrello *et al*., 2008). However, these investigations carried out in the laboratory, controlling thymol intake. Its efficiency is not in the field or in natural conditions known; therefore, precautions should be when using thymol for the eradication of *Nosema* taken, until the appropriate doses and the correct method of application are found. The benefits depend on the species of oregano used or the combination of essential oils.

Barreto *et al*. (2008) indicate that the effect of oregano essential oil can be by adding essential oils from other plants enhanced; however, Hernandez *et al*. (2004) they combined it with cinnamon and pepper; but it did not increase weight gain or feed conversion in birds. Oetting *et al*. (2006) mixed it with thyme and clove in diets for 28-day piglets, but the animals lost weight and the feed conversion was higher, compared to the antibiotic.

At present, many benefits of oregano essential oils are described but the adverse effects are not when used indiscriminately known; therefore, the implementation and generation of new knowledge that can describe the plant and how it can be used is necessary.

LITERATURE REVIEW

Oregano plant

The name of the genus *Oreganum* comes from the Greek word, *oros* that means mountain and *ganos* in reference to the beautiful aspect that this plant gives to the regions where it grows. Oregano is native to Asia and Europe, but it is in temperate regions grown, of several countries. The plants are also cultivated for their therapeutic, pharmaceutical and beekeeping properties; they consume it widely for its tonic, digestive, stomach and anti-asthmatic properties (INFOAGRO, 2006).

Image 1. Varieties of oregano.

1: Italian oregano (*Origanum majoricum*); 2: Eastern Mediterranean oregano, (*Origanum majorana*); 3: Turkish oregano (*Origanum onites*); 4: Mexican oregano (*Poliomintha longrflora*); 5: Greek oregano (*Origanum heracleoticum*); 6: oregano of the Iberian Peninsula and the Balearic Islands (*Origanum vulgare*). Source: http://vsaduidoma.com/es/2016/06/27/dushica-i-majoran-foto-otlichiya-i-raznost-v-posadke-i-uhode/

Oregano species

Oregano belongs to the family *Lamiaceae silver*, especially aromatic; its taxonomy is described in table 1 (WCSP, 2014). Currently, 61 oregano species reported, contained in 17 genera of six families under this name. The genus *Origanum* (Labiatae family), known as European oregano, it is considered the most important (table 2); however, in the American continent the genera *Lanata* and *Lippia* (Verbenaceae family) are the most abundant Mexican oregano; but there are other families (*Rubiaceae*, *Scrophulariaceae*, *Apiaceae* and *Asteraceae*) that have no productive impact (WCSP).

Botanical description

The different varieties of oregano are herbaceous, perennial plants in the form of a small cramped shrub, about 45 cm to 60 cm tall. The whole plant is with glandular hairs covered; its stem acquires a reddish hue, they branch off at the top and tend to defoliate at the bottom. The upper leaves are smaller than the lower ones; opposite leaves on the margins have ciliated glands full of essential oils. The flowers are pink, purple or violet, depending on the species, and the fruits are usually tetraquenia and dry (Fonnegra, 2007).

Table 1. Taxonomic classification of Oregano

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Lamiales
Family:	Lamiaceae
Subfamily:	Nepetoideae
Tribe:	Mentheae
Gender:	*Origanum*
Species:	*O. vulgare*
Scientific name	*Origanum vulgare L*
Common name:	Orégano

Source: National Library of Medicine

Table 2. Oregano species used worldwide

Family	Subspecies	Scientific name
• *Labiatae*	• ***glandulosum***	• *Origanum glandulosum*
	• ***gracile***	• *Origanum gracile* • *Origanum tyttanthum* • *Origanum kopetdaghense* • *Origanum glaucum*
	• ***Hirtum***	• *Origanum hirtum* • *Origanum megastachyum* • *Origanum smyrnaeum* • *Origanum heracleoticum* • *Origanum neglectum* • *Origanum illyricum* • *Origanum latifolium* • *Majorana neglecta*
	• ***Virens***	• *Origanum virens* • *Origanum macrostachyum* • *Origanum virescens* • *Origanum viridulum* • *Origanum heracleoticum*
	• ***Viridulum***	• *Origanum minus* • *Origanum oblongatum* • *Origanum parviflorum* • *Origanum normale* • *Origanum wallichianum* • *Origanum angustifolium* • *Origanum pruinosum* • *Origanum semiglaucum* • *Origanum viride* • *Origanum gussonei* • *Origanum strobilaceum*
	• ***Vulgare***	• *Origanum creticum* • *Origanum majus* • *Origanum latifolium* • *Origanum orientale* • *Origanum anglicum* • *Origanum purpurescens* • *Origanum officinale* • *Origanum floridum* • *Origanum micranthum*

		• *Origanum heracleoticum* • *Origanum stoloniferum* • *Origanum thymiflorum* • *Origanum laxiflorum* • *Origanum loureiroi* • *Origanum decipiens* • *Origanum americanum* • *Origanum capitatum* • *Origanum nutans* • *Origanum venosum* • *Oroga heracleotica* • *Origanum serpylliforme* • *Origanum albiflorum* • *Origanum megastachyum* • *Origanum watsonii* • *Origanum barcense* • *Origanum elegans* • *Micromeria formosana* • *Origanum dilatatum* • *Origanum puberulum* • *Mentha formosana*
	• *Lanata*	• *Lantana citrosa* • *Lantana glandulosissima* • *Lantana involucrata* • *Lantana purpurea* • *Lantana trifolia* • *Lantana velutina*
• *Verbenácea*	• *Lippia*	• *Lippia myriocephala* • *Lippia affinis* • *Lippia alba* • *Lippia berlandieri* • *Lippia cardiostegia* • *Lippia formosa* • *Lippia geisseana* • *Lippia graveolens* • *Lippia helleri* • *Lippia micromera* • *Lippia micromera* • *Lippia origanoides* • *Lippia palmeri* • *Lippia palmeri*
• *Rubiaceae*		• *Borreria sp.*
• *Scrophulariaceae*		• *Limnophila stolonifera*
• *Apiaceae*		• *Eryngium foetidum L*
• *Asteraceae*		• *Coeosanthus veronicaefolius* • *Eupatorium macrophyllum L.*

Source: WCSP

Oregano production in Mexico

Mexican oregano is an important source of income for marginalized populations in the expanding country, due to its demand (Cazares-Alonso *et al*., 2010). The 90% of the production is wildly in 24 states of the Mexican Republic distributed, with an annual production of 4,000 tons (García-Pérez *et al.*, 2012; Casillas-Alcalá, 1992).In recent years, commercial crops have been in Durango, Guanajuato, Jalisco, Querétaro, San Luis Potosí Coahuila, Tamaulipas, Nuevo León and Zacatecas states installed (García *et al*., 2012).

Mexican oregano exports are destined for the United Kingdom, Germany, France and Canada. In recent years, it has been recorded that sales of Mexican oregano have increased to 2 million dollars (CONAFOR, 2009). The increase in its price attributed to both national and international demand, stimulating the development of technology for the establishment of more efficient crops (Cazares-Alonso *et al*., 2010).

The most cultivated oregano genera in Mexico, highlight *Lantana* and *Lippia* (with three and two species, respectively); This is because they are the most exploited in our country; possibly because they are found in much of the national territory in a wild way, in arid and semi-arid regions of Mexico (García *et al*., 2012). However, despite its economic importance, its exploitation is not included in the basic management and agronomic improvement programs, since commercial production of Mexican oregano demands homogeneity, volume and quality; factors that are opposed to the type of collection, since this is carried out in marginalized and low-income areas, generating excessive exploitation that jeopardize its biodiversity and sustainability.

For these reasons, it is necessary to ensure a rational management of this resource, in order to influence positively the socioeconomic level of families in the regions where it occurs (Huerta, 1997). Due to the needs mentioned above, the bases for the agronomic management of oregano have been highlighting the collection of seeds established, before harvest to renew the populations. Propagation through stakes has been, using indole-butyric acid (2000 ppm) as a root, proposed. It has been suggested that the plant be cut until it reaches maturity and after flowering. The quality of the plant grown under this scheme is optimal for exploitation up to 3 years, and finally it has been determined that the best time to plant oregano, in the agro-climatic conditions of the mountains, is between the months of September to December (time which presents favorable temperatures) and the beginning of rains (Corella y Ortega, 2013).

Commercial value of oregano

The world production of oregano generates an approximate value of $ 22.5 million dollars; however, the National Forestry Commission estimated that in 2005 total sales of oregano

totaled more than $ 75 million (Koksal *et al.,* 2010). In Mexico, oregano production represents an economic spill of 5.6 million pesos, making this activity an impact for the rural sector and a source of employment in areas of high marginalization.

Mexico is located as the second largest oregano producing country in the world, contributing between 35 and 40% of total production worldwide (Soto *et al.,* 2007; García *et al.,* 2012). The 85% of production is to the US exported and 5% to European and Asian countries (Castillo *et al.,* 2017). From the five commercial oregano species in Mexico, the *Lippia graveolens H.B.K*. and *Lippia Berlandieri* Schauer are the most exploiting and economically important oregano, because these two oregano species are displacing products that come from Greece and Turkey. Mexican oregano contains a better chemical composition of its essential oils, which has allowed it, to commercialize in recent years. The average cost of dried oregano leaf per kg varies from 8 to 11 Mexican pesos (Nieves *et al.,* 2010).

Chemical composition

Oregano essential oil is rich in thymol, beta-bisabolene, cariophilene, p-cymene, borneol, linalool, linalyl acetate, alpha and beta-pinenes, alpha-terpinen, phenol carboxylic acids, such as caffeic, chlorogenic and rosmarinic. It contains flavonoids, such as derivatives of apigenol, luteolol, kenferol and diosmetol. It also contains some triterpenes, such as derived from ursolic and olenaolic acids in addition to tannins (Fonnegra, 2007).

Oregano nutritional value

Oregano is used in human food and as an additive in animal diets, due to proteins, iron, calcium, potassium, magnesium, zinc, phosphorus, niacin, vitamin A, thymol and carvacrol (Table 3) (Moreiras *et al.,* 2013).

Medicinal properties of oregano essential oil

The commercial value of oregano is due to its characteristics, such as spice, seasoning and medicinal properties. However, the most important industrial and pharmaceutical importance of the plant is its essential oil used as a fragrance in soaps, perfumes, cosmetics and flavorings, mainly (Koksal *et al*., 2010). In addition, oregano oil contains flavonoids, important substances in the pharmacological area, due to its antioxidant capacity in the formation of free radicals. Its influence has properties such as antibacterial, antifungal, antiparasitic, antimicrobial, antioxidant, antiviral, antiallergic, vasodilator, anti-inflammatory, antimicrobials, among others (Cáceres *et al.,* 2014, Soto *et al.,* 2012; Meneses *et al.,* 2009; Gonzalez *et al*; 2009; Güereca *et al.,* 2007; García *et al.,* 2006).

Table 3. Nutritional composition per 100 gr of dried oregano

Composition	Quantity (gr)	CDR (%)
K calories	308	16.1%
Carbohydrates	21.63	7%
Protein	11	23%
Fiber	42.8	142.7%
Fat	10.25	19.3%
Sodium	15	0.9%
Sodium	15	0.9%
Calcium	1576	131.3%
Iron	44	550%
Magnesium	0	0%
Phosphorus	200	28.6%
Potassium	1669	83.5%
A Vitamin	0.69	76.7%
B1 Vitamin	0.34	28.3%
B2 Vitamin	0.32	24.6%
B3 Vitamin	6.22	0%
B12 Vitamin	0	0%
C Vitamin	50	55.6%

Antioxidant activity

Currently, studies have been on the antioxidant activity of oregano conducted, where authors such as Soto *et al*. (2012) indicate that oregano has antioxidant activity, which increases as the extract concentrations increase without having a toxic effect *in vitro* and *in vivo*. Antioxidant concentrations between plants vary, due to differences in the composition and quantity of secondary metabolites. However, there are factors such as geographical area, climate, altitude, harvest time and its growth status that affect its content (Güereca *et al.,* 2007). Many spices and herbs of the *Lamiaceae* family to which oregano belongs have been as antioxidants and preservatives in foods evaluated, because it has been shown that oregano manages to keep various foods at low temperatures. It is that thymol and Carvacrol act as lipid antioxidants known (Yanishlieva *et al.,* 1999); that is, its antioxidant activity is associated with several mechanisms; furthermore, its high reactivity against active free radicals is the main mechanism considered (Cervato *et al*., 2000).

The importance of oregano in the food industry increased by its use as an alternative additive for food preservation (Dorman *et al*., 2003). It has been shown that the substances responsible for the antioxidant activity of oregano are phenolic compounds because of their molecular structure, especially the degree of hydroxylation and the position of the oxyhydrils they contain (Kulisic *et al*., 2004). In addition, its active ingredients can act in one or several stages of the oxidative sequence, constituting one of the main classes of secondary metabolites of plants, which perform various physiological functions (Gotsiou *et al*., 2002). Oregano can inhibit the oxidation of biomolecules (proteins and DNA), preventing the initiation or propagation of reactive oxygen species (ROS), which are related to the incidence of various human pathologies,

including cancer, heart disease, neurodegenerative problems, such as Alzheimer's, Parkinson's; In addition to aging processes (Aiyegoro y Okoh, 2009).

Antimicrobial Activity

There are multiple studies on the antimicrobial activity of extracts of different types of oregano oil; have activity against *gram* negative bacteria, such as: *Salmonella typhimurium*, *Escherichia coli*, *Klebsiella pneumoniae* , *Yersinia enterocolitica* and *Enterobacter cloacae*; and gram positive, such as: *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Listeria monocytogenes* and *Bacillus subtilis* (Elgayyar *et al*., 2001). Essential oils obtained from oregano species contain a potential antimicrobial power, since they evaluated and showed to be effective against several different microorganisms (Arcila *et al.,* 2004).

The effectiveness of oregano oil as an antimicrobial attributed to two compounds present: carvacrol and thymol, which inhibit pathogenic microorganisms, since they prevent the development of the microbial activity of gram-negative microorganisms, (Santoyo *et al*., 2006; Yano *et al*., 2006). The antimicrobial activity depends on the chemical composition of the oregano essential oil, which is related to the oregano species, geographical conditions, harvest periods, extraction method and minimum inhibitory concentrations (MIC), which have been established between 0.28 -1.27 mg/ml for bacteria (Hazzit *et al*., 2006; Aligiannis *et al*., 2001).

Antifungal activity

In recent studies, oregano essential oil in a concentration of 0.3%, 0.5%, 0.7% and 1.0% presented a 100% mycelial growth inhibition, compared to isolated phytopathogenic fungi. It and has been shown to have antifungal ability against: *Candida albicans*, *C. tropicalis*, *Torulopsis glabrata*, *Aspergillus Niger*, *Geotrichum* and *Rhodotorula*; *Botrytis cinerea*, *Rhizopus stolonifer*, *Colletotrichum* sp., *Penicillium italicum*, *Penicillium digitatum*, *Fusarium moniliforme*, *Aspergillus flavus*, *Aspergillus parasiticus*, *Fusarium graminearum*, *Aspergillus ochraceus*, among others. The inhibitory effect of oregano essential oil on the development of various fungi has been *in vitro* reported. In addition, it was determined that with 2000 ppm of oregano oil, the mycelial growth of these fungi can be controlled. Likewise, the essential oil of oregano efficiently controls *in vivo* the development of endogenous fungi in wheat was demonstrated (Cáceres *et al*., 2014; García *et al*., 2006); These capacities to the fungicidal activity of oregano essential oils, especially to the presence of thymol and carvacrol in these substances are attributed (Madsen y Bertelsen, 1995).

Antiviral activity

Oregano extracts have been for the properties of their essential oils studied, on the infective activity of the yellow fever virus (Meneses *et al*., 2009). Oregano essential oils were efficient in the inhibition of five DNA viruses (HHV-1, ACVR-HHV-1, BoHV-1, BoHV-2, and BoHV-5) and three RNA viruses (HRSV, RV, BVDV). This inhibitory effect is mainly to the method of oil extraction attributed and the part of the selected plant (Meneses *et al*., 2009). On the contrary, in another study conducted by García-Pérez *et al*. (2012), antiviral inefficiency was determined on the reproduction of influenza A/Aichi/2/68 (H3N2) virus in MDCK cells.

Anti-inflammatory activity

Some of the soluble phytochemicals have recently been for their anti-inflammatory effect re-evaluated. It has been reported that water-soluble oregano extract inhibits the secretion of cyclooxygenase 2 (COX-2), showing an anti-inflammatory activity in human epithelial carcinoma cells. Likewise, an ethanol extract of oregano exhibited anti-inflammatory activity in a mouse model with gastritis, induced by stress and contact hypersensitivity. The main phytochemicals responsible for anti-inflammatory activity are rosmarinic acid, ursolic acid and oleanolic acid (Peralta, 2018; García *et al*., 2012). In the same way, the presence of the flavonoids kampferol, isokampférido and pilosina has been determined; which have an anti-inflammatory, antiulcerogenic and vasoconstrictor biological activity, which justify their medicinal use, as antispasmodic, analgesic, anti-inflammatory and antihemorrhagic (Güereca *et al*., 2007).

Use of oregano essential oil in different animal species

There is currently a worldwide trend to replace synthetic chemicals with the use of essential oils with antiparasitic, antiviral, antifungal and antibacterial activity (Meneses *et al*., 2009; Santoyo *et al*., 2006; Yano *et al*., 2006); It was due to public and political concerns related to the high use of synthetic products, which present potential risks of causing resistance to the various pathogens present in animals for human consumption, which compromises the world production of protein foods (meat, milk , egg) and honey (Cabrera *et al*., 2007).

Birds

The compounds of the essential oils of oregano are an alternative of replacement of the growth promoting antibiotics. It allows enhancing the integral functional performance of the digestive system and the productive expression of the broiler. This is because the inclusion of oregano extracts in the diet improves the ileal and total digestibility of dry matter, ethereal extract and starch (Betancourt, 2012).These functional effects have been to the content of the phenols; carvacrol and thymol attributed, in ranges from 3% to 75%

of the total oil; with the presence of other components such as hydrocarbon monoterpenes, γ-terpene and ρ-cymene (Aligiannis *et al*., 2001).

The essential oil of oregano has also been as an additive in the diets of poultry intended for meat production used. This is because oregano oil has beneficial effects on the antibacterial activity of the intestinal tract of broilers, which it has benefited the production of poultry farms because the addition of essential oil of oregano has improved the quality of the carcass (Betancourt, 2012). In addition, in broilers has been shown that, a mixture of essential oils of clove (*Syzigium aromathicum*) and oregano (*Origanum vulgare*) stimulate the appetite of birds, and in this way the conversion is improved. That is, the inclusion of essential oils in the chicken diet can increase weight gain, improve food conversion and production parameters in general (Isabel y Santos, 2009). As an antioxidant, oregano was tested in turkey meat, and the results showed that in concentration of 200 mg/kg^{-1} of food increased the stability of raw and cooked meat to lipid oxidation, compared to the group that did not contain essential oils (Botsoglou *et al*., 2003).

The use of oregano essential oil showed with 27.67% thymol+11.31% carvacrol managed to inhibit the presence of aerobic and pathogenic mesophiles (*S. typhy*, *S. aureus* and *E. coli*) in turkey meat (Gonzales *et al.,* 2009). Similarly Domínguez *et al.* (2015), showed that the use of 400 mg of oregano oil per kg of feed from broilers, decreased the amount of aerobic mesophiles in fresh and frozen meat of broilers 35 and 42 days old (Oregano contained 43.17% and 29.16% thymol and carvacrol, respectively). According to the above, the use of oregano essential oil is a viable alternative in poultry diets, because food intake, weight gain, food conversion rate and mortality are not affected when such use is made essential oil (Fonseca *et al*., 2017); In addition, mortality decreases with the inclusion of oregano oil in the bird's diet (Escalera *et al*., 2016).

Pigs

In pigs, the use of 2.5 g of carvacrol or thymol per liter of pig excreta completely inhibits the production of odor-causing compounds has been found, such as valerate, isobutyrate, cresol and isovalerate; reducing the emission of gases, fecal coliforms and anaerobic bacteria (Varel, 2002). In another study, the inclusion of the essential oil of oregano in the diets of sows in pre-school and lactation, presented a lower mortality rate, a higher birth rate, more piglets born alive, less low weight of piglets at birth and a greater voluntary consumption of food (Allan y Bilkei, 2005). In addition, Ariza *et al*. (2011) reported that the inclusion of oregano in sow diets increased the growth rate in piglets, which coincides with the results obtained by Guerra *et al.* (2008). They demonstrated that oregano oil produces better effects on weight gain and final weight, and with the results obtained by Khajarern y Khajarern (2002). They also reported that when oregano essential oil was to the diet added, there was an increase in the daily food intake of lactating sows and the daily weight gain of their offspring, compared to the offspring of sows not fed with oil of oregano.

Besides, the use of oregano reduces the time of permanence of the food in its transit through the gastrointestinal tract, since it was found that a mixture of plant extracts modifies the rate of emptying of the stomach in weaned pigs. Possibly these effects support and explain the best ideal digestibility obtained by Betancourt (2012), with the inclusion of oregano oil.

Bees

In beekeeping, have been organic substances used, such as oregano essential oil; this has been used for the alternative control of *Varroa destructor* and *Nosema.* Due to its effectiveness, easy application and the low risk of contamination of honey and wax produced in the colonies, when they are, to treatment, subjected. In addition, the mites do not show resistance to this alternative product (Romo *et al.,* 2016; Itzá *et al*., 2007). In world beekeeping, thymol is being used in the last decade, which is obtained mainly from oregano plants; in this sense, thymol is one of the most used natural products for varroasis control; however, its effectiveness varies according to the climatic conditions of each region, time of application, concentration, and form of application (in gel, powder or oil). Itzá *et al*. (2007), reported that the efficacy of thymol could vary 66% to 98%. Similarly, Romo *et al*., (2016) suggest that pure oregano oil is a viable alternative to control *Varroa* in honeybees. Besides, the amount of carvacrol found in honey produced during the application of oregano essential oil treatment, did not exceed the taste detection threshold of 0.1 ppm, so it can be as a viable, economical alternative considered, without No environmental impact.

The importance of the use of thymol obtained from oregano, also lies in the harmful effects it causes to *Varroa* mites, since in a study by Loeza *et al*. (2018) were able to observe that when thymol is used in a concentration of 20% for 28 days. *Varroa* mites have a plasticity reason why a significant reduction in the width of the dorsal shield and in length of the *Varroa* genital shield found. However, to carry out more studies is suggested, since the reduction of the length of the genital shield could have adverse effects on the reproduction of the mites, which could be beneficial for beekeepers, since in this way the oviposition of the *Varroa* females, thus decreasing hive infestation levels.

The use of thymol increases its importance in the eradication of pathogens, so that the effect of thymol can reduce both the presence of *Varroa* and *Nosema*, a fact proved Rice (2001) and Maistrello *et al*., (2008); These authors indicate that thymol acts by penetrating the layers of *Nosema* spores, preventing the germination and development of the disease caused by the replication of the sporoplasm, which allows controlling this disease. In consideration of the aforementioned, the essence oil of oregano and its components, mainly thymol, are a solution to the risks caused by the chemicals for the control of *Varroa* and *Nosema* in bees.

Ruminants (sheep, goats and cattle)

In ruminants, oregano oil has been to decrease methane emissions used (Talebzadeh *et al*., 2012). Some authors Benchaar y Greathead (2011) found that oregano oil in high doses (>300mg^{-1} of fluid of bovine ruminal fluid culture) reduces the microbial population (methanogenic bacteria, fungi, protozoa, etc.) and it is due to the *in vitro* reduction of the production of ammonia, microbial biomass and degradability. In addition to the oil (500 mg L^{-1}), they do not inhibit ruminal microbial fermentation; however, it does modify it, increasing the concentration of volatile fatty acids and ammoniacal nitrogen (Geraci *et al*., 2012).

Newbold (2004) and Benchaar (2007) mentioned that essential oils inhibit nitrogen-generating bacteria. The dissemination of proteins decreases, so it has been reported up to 25% reduction of these bacteria when using oregano oil between 30 and 300 mg. In addition, Hristov *et al.* (2013), found *in vivo* that the inclusion of oregano essential oil at levels of 250 g/d, 500 g/d and 750 g/d decreases the concentration of ammonia in ruminants. In this context, the main chemicals in oregano are carvacrol, ρ-cymene, linalool, terpenene and thymol; which have a high antioxidant capacity and their antimicrobial potential, which can affect the development and growth of ruminal bacteria and inhibit methanogenesis. That is way, the inclusion of 300 mg/L and 3000 mg/L of oregano essential oil helps reduce total volatile fatty acids.

Oregano essential oil used in low doses to be able to observe beneficial effects on the digestibility of neutral detergent fiber. An improvement in the availability of energy for ruminal microorganisms observed, compared to the use of high doses, which cause deleterious effects on fiber digestibility due to its antimicrobial effect; that is, in the higher doses negative effects found on the digestibility of dry matter and fiber (Klevenhusen *et al.*, 2011). However, because oregano essential oil has greater benefits than disadvantages, oregano essential oil has been as an option to mitigate enteric methane emissions and improve ruminal fermentation with the production of volatile fatty acids, considered (Durmic *et al*., 2014; Busquet *et al.,* 2006).

Fishes

The use of essential oils has acquired great importance due to the benefits in the feeding, transport, handling and health of the fish. This is because oregano essential oils reduce levels of stress, injury, mortality and disease. Therefore, its use has been shown to improve the productivity of aquaculture systems (Abdollahzadeh *et al*., 2014). In this sense, the use of high amounts of carvacrol containing oregano essential oil is a viable alternative as a complement to commercial antibiotics for the control of *Vibrio* spp. In penetrated shrimp (García *et al.,* 2012). Similarly, it has been shown that the use of oregano essential oil in doses 6%, 2% and 4% manages to inhibit the bacteria *Salmonella* sp, *Proteus* sp and *Staphylococcus aureus* present in sick wild fish (Martínez *et al.,* 2018).

The essential oil of oregano is an alternative for the control of diverse pathogens that could affect the good health of the fish.

The essential oil of oregano in aquaculture is as antioxidants used; this has been possible because oregano constitutes a generous source of antioxidants, due to the high concentrations of thymol and carvacrol naturally present in plants. Due to the above, oregano essential oil is as an economical, plausible, harmless and effective option considered; due to this, the essential oils of oregano are as therapeutic substances used, in aquaculture (Aanyu *et al*., 2018). They also provide a solution for poor growth and stress responses related to intensive culture conditions, as well as immune deficiencies related to oxidative stress (Knight, 2010), as well as growth promoters within the production systems of fry in masculinization phase. The use of oregano essential oil in concentrations of 1% increases the profitability of red tilapia (*Oreochromis spp*) production systems (Coronado, 2019).

The use of oregano essential oil can reduce the damage that occurs in fish during transport and handling to the market, or to places within the farm. These benefits are possible because the essential oil of oregano (*Lippia alba*), when applied in a concentration of 10 µl l^{-1} in fish during transport (5-7 h), reduces oxidative stress in the tissues of the fish (liver, brain and gills). It has also been reported that a concentration of 30 mg l^{-1} of essential oil water is sufficient for anesthetic induction (Azambuja *et al*., 2011), thus reducing the damage caused by the mobility of fish.

Finally, the application of oregano essential oil has proven to be an effective inhibitor of the surface microbiota of hake fillets, especially when they are incorporated into film-forming solutions at concentrations of 3% or higher, increasing the shelf life of fishes. Therefore, the use of oregano essential oil may be present in the development of intensive fish systems, because as mentioned earlier, its efficiency ranges from the development of fry growth, to the end of the production system that is the conservation of fillets.

CONCLUSIONS

The essential oils of oregano of the subspecies *vulgare* and *Lippia*, are an alternative as additives in the feeding of domestic animals; they improve the functionality of the digestive system in monogastrics, reduce the emissions of enteric methane in ruminants and bad odors in the pigs' feces. Scientific evidence shows that oregano essential oils can help solve problems in animal production systems.

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