ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 14, Issue, 07, pp.21891-21894, July, 2022
DOI: https://doi.org/10.24941/ijcr.43717.07.2022

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

REVIEW ARTICLE

THE ANTIFUNGAL POTENTIAL OF ESSENTIAL OILS

Flores-Encarnación, M.[1*], Martínez-Alvarado K.[1], Arellano-López K.[1], Valentín-Aguilar I.[1], Aguilar-Gutiérrez G.R.[2], Cabrera-Maldonado C.[3] and Carreño-López R.[4]

[1]Laboratorio de Microbiología Molecular y Celular. Biomedicina, Facultad de Medicina, Benemérita Universidad Autónoma de Puebla. Puebla. Puebla, México
[2]Centro de Investigación sobre Enfermedades Infecciosas, Instituto Nacional de Salud Pública. Cuernavaca, Morelos. México
[3]Facultad de Ciencias Químicas, Benemérita Universidad Autónoma de Puebla. Puebla. Puebla, México.
[4]Centro de Investigaciones Microbiológicas. ICUAP, Benemérita Universidad Autónoma de Puebla. Puebla. Puebla, México

ARTICLE INFO

Article History:
Received 19th April, 2022
Received in revised form
05th May, 2022
Accepted 14th June, 2022
Published online 26th July, 2022

Key words:

Essential, Oil, Bacteria,
Fungi, Antifungal, Antimicrobial.

Corresponding Author:
Flores-Encarnación, M.

ABSTRACT

Antibiotic resistance has been a widespread problem in the world. Today there are many cases of bacteria resistant to antibiotics. Similarly, many cases of resistance to antifungal agents have been reported. Alternative strategies are currently being sought to combat fungal infections. One of these strategies is the use of substances obtained from plants, such as essential oils, which have shown important antimicrobial properties.

Citation: ***Flores-Encarnación, M., Martínez-Alvarado K., Arellano-López K., Valentín-Aguilar I., Aguilar-Gutiérrez G.R., Cabrera-Maldonado C. and Carreño-López R.. 2022***. "The antifungal potential of essential oils*". International Journal of Current Research*, 14, (07), 21891-21894.

INTRODUCTION

Antibiotic resistance has been a widespread problem in the world. Today there are many cases of bacteria resistant to antibiotics (Canul-Chulim *et al*., 2021; Zhu *et al*., 2022). Cases of multi and extreme-resistance are also known, as is the case of *Mycobacterium tuberculosis* (Allué-Guardia *et al*., 2021). Similarly, many cases of resistance to antifungal agents have been reported (Fisher *et al*., 2022). Of the best known cases, infections caused by strains of *Candida* sp. can be cited. *Candida* species are commensals, they are part of the normal human flora and are localized on skin and gastrointestinal and genital tracts (Bhattacharya *et al*., 2020; Pfaller and Diekema, 2007). However, *Candida* sp. can also cause various infections in susceptible patients; it is one of the most common fungal infections globally with multiple mechanisms of antifungal resistance (Bhattacharya *et al*., 2020). On the other hand, it has been reported the use of biologically active organic compounds (extracted from plants) with antimicrobial properties (Flores-Encarnación *et al*., 2016; Marston *et al*., 2016). Such is the case of essential oils extracted from different plants with high antibacterial activity (Flores-Encarnación *et al*., 2018; Nazzaro *et al*., 2013). Therefore, this work shows the most relevant aspects of some essential oils and the antifungal potential.

ACTIVITY OF ESSENTIAL OILS

The essential oils are volatile multicomponent substances presents in many plants, slightly soluble in water. This characteristic is considered the main reason for the variability in the effectivity and potency of each essential oil. These substances have been found in leaves, flowers, bark tree, seeds, and root of the plants (Klimek-Szczykutowicz *et al*., 2020; López, 2004; Mancianti and Ebani, 2020). Some examples of essential oils: lemon, clove, oregano, thyme, eucalyptus oils. It has been reported that terpenes, terpenoids, aldehydes, alcohols, phenols, esters, low molecular weights aromatic and aliphatic substances are the main compounds in essential oils (Gucwa *et al*., 2018). For example, Table 1shows main constituents of *Citrus limonum* essential oil (lemon).

Table 1. Components of *Citrus limonum* essential oil.

Essential oil	Common name (oil)	Component	Reference
Citrus limonum	Lemon	Limonene (32%) Sabine (16%) Citronella (12%) Linalool (5%) Nerol (5%) Geraniol (5%) β-ocimene (4%) Myrcene (3%) Citronellol (2%) β-caryophyllene (2%) Terpen-4-ol (1%) α- pinene (1%) Thymol (49%)	Rajkowska *et al.*, (2019)

Another example is the the essential oil of *Thymus vulgaris* (thyme) which contains monoterpenes as thymol (49%), ρ-cimene (18%), carvacrol (6%), γ- terpinene (9%), linalool (3%), car-3-eno (2%), β- mirceno (2%), α- pinene (1%), limonene (1%) and camphane (0.5%) (Ben *et al*., 2019; López, 2004; Sakkas and Papadopoulou, 2007). The phenol monoterpene derivatives (thymol and carvacrol) are the major ingredients in thyme essential oil with antimicrobial and pharmacological properties such as anti-metastatic activity, anti-oxidative, and anti-inflammatory (Kianersi *et al*., 2021; Powers *et al*., 2018). Fig. 1 shows the structure of some monoterpene components of essential oil of *T. vulgaris*. The antimicrobial activity of *T. vulgaris* has been reported against Gram-negative bacteria such as uropathogenic *E. coli, Salmonella enteritidis, Salmonella choleraesuis, S. typhimurium, Vibrio cholerae, Proteus mirabilis, P. vulgaris, Pseudomonas aeruginosa*, and Gram-positive bacteria as *S. aureus, S. epidermidis, Enterococcus faecalis and Bacillus cereus* (Al-Shuneigat *et al*., 2014; Flores-Encarnación *et al*., 2018; Hussein *et al*., 2014; Kon and Rai, 2012; Mohsenipour and Hassanshahian, 2015). Gram-negative bacteria are more resistant to essential oils than Gram-positive bacteria. This feature is related to structure of the cell walls of Gram-positive and Gram-negative bacteria due 90%–95% of the cell wall of Gram-positive bacteria consists of peptidoglycan and other molecules such as teicoic acid and proteins (Nazzaro *et al*., 2013; Trombetta *et al*., 2005). In addition, it has been observed that efficacy of essential oils depends on its components having synergistic effect. There is evidence about antimicrobial activities attributed to specific compounds related to thyme, carvacrol, α- pinene, linalool, methyl salicylate, eugenol and geraniol (Monzote-Fidalgo *et al*., 2004; Prasanth *et al*., 2014; Scalas *et al*., 2018; Wińska *et al*., 2018). In addition to the above, it has been reported that the composition of essential oils depends on multiple factors as environmental conditions, stress during plant growth, use of fertilizers, ground composition, ecotypic variety plant, cultivation method, region weather, humidity in the environment and the extraction method used for the treatment of the plant (Bona *et al*., 2016; Sakkas and Papadopoulou, 2017). Other authors have reported that, in addition to the bactericidal properties, essential oils can inhibit or slow the growth of yeasts and molds (Perczak *et al*., 2019). As will be shown later, the essential oils have a variety of targets affecting cytoplasm and the cell membrane and altering the morphology of yeasts and molds.

THE ANTIFUNGAL POTENTIAL OF ESSENTIAL OILS: In the past, essential oils have been used for different purposes so some plant species like oregano, thyme, basil, and lemon has been used in traditional medicine for their multiple effects. However, due to the diversity of its composition, the mechanism of action of each component is not known (Bona *et al*., 2016; Fani and Kohanteb, 2017; Prasanth *et al*., 2014; Sakkas and Papadopoulou, 2017). Currently, studies are known that have shown that essential oils inhibit or slow the growth of yeasts and molds. Maness and Zubov (2019) reported that essential oils of *Rosmarinus officinalis, Cinnamomum verum* and *Citrus paradisi*inhibited the growth of *Trichophyton mentagrophytes, Microsporum gypseum*and *Rhizopus stolonifer*.

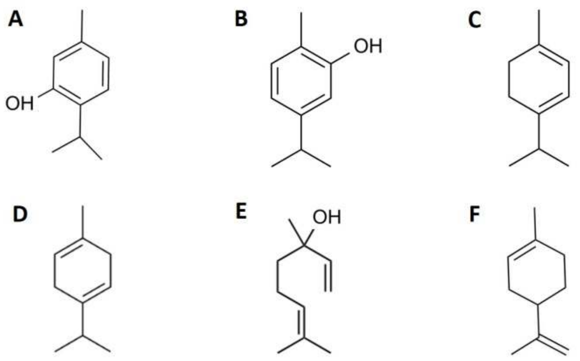

Fig. 1 The structures of some monoterpene components of essential oils. A. Thymol; B. Carvacrol; C. α- Terpinene; D. γ-Terpinene; E. Linalool; F. Limonene.

These filamentous fungi produce dermatophytic fungal diseasesand are opportunistic fungi. *T. mentagrophytes* and *M. gypseum* cause athlete's foot, ringworm, and nail infections, while *R. stolonifer* is an opportunistic fungus that causes respiratory infections, sinusitis, and otomycosis. Gucwa *et al*., (2018) reported that *T. vulgaris, Citrus limonum, Pelargonium graveolens, Cinnamomum cassia, Ocimum basilicum,* and *Eugenia caryophyllus* essential oils showed both fungistatic and fungicidal activity toward *Candida albicans* and *C. glabrata* isolates, resulting that *C. cassia* essential oil have the highest activity. The study also showed that *T. vulgaris* and *C. limonum* affected the cell membranes; *T. vulgaris* produced a potassium ion efflux. In addition it was observed that all of the tested oils showed the ability to inhibit the transition of yeast to mycelium form. Candidiasis (frequently caused by *C. albicans*, *C. glabrata*, *C. tropicalis*, *C. krusei,* or *C. parapsilosis*) is associated with the formation of biofilms on the surface of medical devices and tissues (Feyaerts *et al.*, 2018; Ramage *et al*., 2006). Rajkowska *et al*., (2019) demonstrated that clove and thyme essential oils can be efficiently used preventing the formation of biofilm in abiotic surfaces (glass, polyethylene terephthalate, polypropylene) by *Candida* sp.; clove and thyme essential oils showed anti-biofilm activity. Ghasemi *et al*., (2020) reported that *Thymus kotschyanus* essential oil contained thymol (60.48%), carvacrol (3.08%), p-cymene (5.56%), and γ-terpinene (6.67%). Those authors concluded that *T. kotschyanus* essential oil tested used of ≥500 ppm resulted in a fungicidal effect against important phytopathogenic fungi: *Botrytis cinerea*, *Aspergillus niger* and *Penicillium expansum*. Kohiyama *et al*., (2015) reported that *T.*

vulgaris essential oil showed antifungal and antiaflatoxigenic properties against *Aspergillus flavus*. In that study, inhibition of ergosterol biosynthesis was detected at a concentration of 100 µg/mL of essential oil, while morphological changes were detected starting at a concentration of 50 µg/mL. The inhibition in production of aflatoxins B1 and B2 was observed at a concentration of 150 µg/mL. Kumari *et al.*, (2017) reported the effect of six components of essential oils: carvacrol, cinnamaldehyde, citral, eugenol, menthol and thymol against three infectious forms of *Cryptococcus neoformans* and *C. laurentii*: planktonic cells, forming biofilm and preformed-biofilm cells. Cryptococcosis caused by encapsulated basidiomycetes yeast *Cryptococcus* species is an opportunistic fungal infection prominent in the immunocompromised individuals (Martinez and Casadevall, 2015). Kumari *et al.*, (2017) reported that the essential oils tested showed antibiofilm activity in the order: thymol>carvacrol>citral>eugenol=cinnamaldehyde>menthol.

Little is known about the mechanisms of action of the antifungal activity of essential oils. Some authors have reported that hydrophobicity of essential oils allows them to insert themselves between the lipids of the cell membrane of fungi and also in the membranes of mitochondria, thus increasing permeability and causing the release of intracellular constituents and interfering in different biological processes (Cristani *et al*., 2007; da Silva Bomfim *et al.*, 2015; Paul *et al*., 2011; Wang *et al*., 2019). Wang *et al*., (2019) found that high concentration of essential oil led to the membrane permeability increased and nucleic acid released from *C. gloeosporioides*, as well as a marked decrease in the protein content of fungal cells by increasing the concentration of essential oil, indicating the disruption to the permeability barrier of cell membrane and wall.

Other proposals related to the mechanisms of action of essential oils and their antifungal activity are known. So, it has been reported that essential oils could produce filamentation inhibition, disappearance of extracellular matrix, biofilm destruction, ergosterol inhibition, cytoplasm leak, and generation of reactive oxygen species (Daniellia *et al.*, 2018; Jeong- Eun *et al*., 2019; Rajkowska *et al*., 2019). As can be seen, essential oils are potential agents with antifungal activity. It is necessary to carry out more studies to know about the mechanisms of action of its antifungal activity.

CONCLUSION

Essential oils have been used since ancient times for various purposes. One of them has been food preservation for its antimicrobial properties. At present, it has been possible to study the components of essential oils and the impact they have had as antifungal agents. In this context, several examples of essential oils and their components that act by inhibiting the growth of opportunistic fungi such as *C. albicans, Aspergillus* sp., *C. neoformans,* etc. It is important that more studies be carried out to learn about the mechanisms of action of essential oils.

ACKNOWLEDGEMENTS

Thank to Facultad de Medicina-BUAP and Grupo de Académicos de Puebla SC for the facilities provided for the development of this work.

REFERENCES

Al-Shuneigat J., Al-Sarayreh S., Al-Saraireh Y., Al-Qudah M. and Al-Tarawneh I. 2014. Effects of wild *Thymus vulgaris* essential oil on clinical isolates biofilm-forming bacteria. J. Dental Med. Sci. 13:62-66.

Allué-Guardia A., García J.I. and Torrelles J.B. 2021. Evolution of Drug-Resistant *Mycobacterium tuberculosis* Strains and Their Adaptation to the Human Lung Environment. Front. Microbiol. 12:612675.

Bhattacharya S., Sae-Tia S. and Fries B.C. 2020. Candidiasis and mechanisms of antifungal resistance. Antibiotics. 9:312-341.

Ben G., Herrera R., Lengliz O., Abderrabba M. and Labidi J. 2019. Effect of the chemical composition of free-terpene hydrocarbons essential oils on antifungal activity. Mol. 24:1-11.

Bona E., Cantamessa S., Pavan M., Novello G., Massa N., Rocchetti A., Berta G. and Galamero E. 2016. Sensitivity of *Candida albicans* to essential oils: are they an alternative to antifungal agents?. *J. Appl. Microbiol*., 121:1530-1545.

Canul-Chulim L.E., Flores-Encarnación M., Aguilar-Gutiérrez G.R., Carreño-López R., García-García S.C. 2021. Importance of the bacterial extended-spectrum beta lactamases. Internat. J. Curr. Res. 13:19709-19712.

Cristani M., D'Arrigo M., Mandalari G., Castelli F., Sarpietro M.G., Micieli D., Venuti V., Bisignano G., Saija A. and Trombetta D. 2007. Interaction of four monoterpenes contained in essential oils with model membranes: implications for their antibacterial activity. J. Agric. Food Chem. 55:6300-6308.

da Silva Bomfim N., Nakassugi L.P., Oliveira J.F.P., Kohiyama C.Y., Mossini S.A.G., Grespan R., Nerilo S.B., Mallmann C.A., Alves Abreu Filho B. and Machinski M. 2015. Antifungal activity and inhibition of fumonisin production by *Rosmarinus officinalis* L. essential oil in *Fusarium verticillioides* Sacc. Nirenberg. Food Chem. 166:330-336.

Daniellia L.J., Pippib B., Duartec J.A., Maciela A.J., Lopesd W., Machadoc M.M., Oliveira L.F.S., Vainsteind M.H., Teixeira M.L., Bordignon S.A.L., Fuentefriaa A.M. and Apela M.A. 2018. Antifungal mechanism of action of *Schinus lentiscifolius* Marchand essential oil and its synergistic effect in vitro with terbinafine and ciclopirox against dermatophytes. J. Pharm. Pharmacol. 70:1216-1227.

Fani M. and Kohanteb J. 2017. In vitro antimicrobial activity of *Thymus vulgaris* essential oil against major oral pathogens. J. Evid. Based Complem. Altern. Med. 22:660-666.

Feyaerts A.F., Mathé L., Luyten W., De Graeve S., Van Dyck K., Broekx L. and Van Dijck P. 2018. Essential oils and their components are a class of antifungals with potent vapour-phase - mediated anti-*Candida* activity. Scient. Report. 8:1-10.

Fisher M.C., Alastruey-Izquierdo A., Berman J., Bicanic T., Bignell E.M., Bowyer P., Bromley M., Brüggemann R., Garber G., Cornely O.A., Gurr S.J., Harrison T.S., Kuijper E., Rhodes J., Sheppard D.C., Warris A., White P.L., Xu J., Zwaan B. and Verweij P.E. 2022. Tackling the emerging threat of antifungal resistance to human health. Nat. Rev. Microbiol. s41579.

Flores-Encarnación M., Nava-Nolazco R.M.., Carreño-López R., Aguilar-Gutiérrez G.R., García-García S.C. and Cabrera-Maldonado C. 2016. The antibacterial effect of plant-based essential oils. Internat. J. Res. Studies Biosci. 4:1-6.

Flores-Encarnación M., Nava-Nolazco R.M., Aguilar-Gutiérrez G.R., Carreño-López R. and García-García S.C. 2018. The effect of *Thymus vulgaris* on growth and biofilm formation of uropathogenic *Escherichia coli*. African J. Microbiol. Res. 12:237-242.

Ghasemi G., Alirezalu A., Ghosta Y., Jarrahi A., Safavi S.A., Abbas-Mohammadi M., Barba F.J., Munekata P., Domínguez

R. and Lorenzo J.M. 2020. Composition, antifungal, phytotoxic, and insecticidal activities of *Thymus kotschyanus* essential oil. Mol. 25:1-18.

Gucwa K., Milewski S., Dymerski T. and Szweda P. 2018. Investigation of the antifungal activity and mode of action of *Thymus vulgaris*, *Citrus limonum*, *Pelargonium graveolens*, *Cinnamomum cassia*, *Ocimum basilicum* and *Eugenia caryophyllus* essential oils. Mol.23:1-18.

Hussein N.H., Rasool K.H. and Hussein J.D. 2014. Effects of *Coriandrum sativum*, *Thymus vulgaris, Borago officinalis* and *Pimpinella anisum* on biofilm *Escherichia coli*. J. Gen. Environ. Res. Conserv. 2:219- 230.

Jeong- Eun K., Ji- Eun L., Min- Jung H., Sung- Chan L., Seon- Mi S., Kwon J.H. and Il- Kwon P. 2019. Fumigant antifungal activity via reactive oxygen species of *Thymus vulgaris* and *Satureja hortensis* essential oils and constituents against *Raffaelea quercus*- mongolicae and *Rhizoctonia solani*. Biomol. 9:1-13.

Kianersi F., Pour-Aboughadareh A., Majdi M. and Poczai P. 2021. Effect of methyl jasmonate on thymol, carvacrol, phytochemical accumulation, and expression of key genes involved in thymol/carvacrol biosynthetic pathway in some iranian *Thyme* Species. Int. J. Mol. Sci. 22:11124.

Klimek-Szczykutowicz M., Szopa A. and Ekiert H. 2020. *Citrus limon* Lemon phenomenon- a review of the chemistry, pharmacological properties, applications in the modern pharmaceutical, food, and cosmetics industries, and biotechnological studies. Plants. 9:1-24.

Kohiyama C.Y., Yamamoto Ribeiro M.M., Mossini S.A., Bando E., Bomfim Nda S., Nerilo S.B., Rocha G.H., Grespan R., Mikcha J.M. and Machinski M. Jr. 2015. Antifungal properties and inhibitory effects upon aflatoxin production of *Thymus vulgaris* L. by *Aspergillus flavus.* Food Chem. 15:1006-1010.

Kon K. and Rai M. 2012. Antibacterial activity of *Thymus vulgaris* essential oil alone and in combination with other essential oils. Nusantara Biosci. 4:50-56.

Kumari P., Mishra R., Arora N., Chatrath A., Gangwar R., Roy P. and Prasad, R. 2017. Antifungal and anti-biofilm activity of essential oil active components against *Cryptococcus neoformans* and *Cryptococcus laurentii*. Frontiers Microbiol. 8:1-14.

López T. 2004. Los aceites esenciales. Offarm. 23:88-91.

Mancianti F. and Ebani V.V. 2020. Biological activity of essential oils. Mol. 25:1-4.

Maness L.R. and Zubov T. 2019. The inhibitory effect of essential oils on *Rhizopus stolonifer, Trichophyton mentagrophytes*, and *Microsporum gypseum*. Lab. Med. 50;e18-22.

Marston H.D., Dixon D.M., Knisely J.M., Palmore T.N. and Fauci A.S. 2016. Antimicrobial resistance. JAMA. 316:1193-1204.

Martinez L.R. and Casadevall A. 2015. Biofilm formation by *Cryptococcus neoformans*. Microbiol Spectr. 3:1-11.

Mohsenipour Z. and Hassanshahian M. 2015. The inhibitory effect of *Thymus vulgaris* extracts on the planktonic form and biofilm structures of six human pathogenic bacteria. Avicenna J. Phytomed. 5:309-318.

Monzote-Fidalgo L., Sariego-Ramos I., Montalvo-Álvarez A.M., Garrido-Lorente N., Scull-Lizama R. and Abreu-Payrol J. 2004. Propiedades antiprotozoarias de aceites esenciales extraídos de plantas cubanas. Rev. Cub. de Med. Tropical. 56:230-233.

Nazzaro F., Fratianni F., De Martino L., Coppola R. and De Feo V. 2013. Effect of essential oils on pathogenic bacteria. Pharmac. 6:1451-1474.

Paul S., Dubey R.C., Maheswari D.K. and Kang, S.C. 2011. *Trachyspermum ammi* L. fruit essential oil influencing on membrane permeability and surface characteristics in inhibiting food-borne pathogens. Food Control. 22:725-731.

Perczak A., Gwiazdowska D., Marchwins K., Jus K., Gwiazdowski R. and Waskiewicz A. 2019. Antifungal activity of selected esencial oils against *Fusarium culmorum* and *F. graminearum* and their secondary metabolites in wheat sedes. Arch. Microbiol. 201:1085-1097.

Pfaller M.A. and Diekema D. 2007. Epidemiology of invasive candidiasis: a persistent public health problem. Clin. Microbiol. Rev. 20:133-163.

Powers C.N., Osier J.L., McFeeters R.L., Brazell C.B., Olsen E.L., Moriarity D.M., Satyal P. and Setzer W.N. 2018. Antifungal and cytotoxic activities of sixty commercially-available essential oils. Mol. 23:1-13.

Prasanth R.V., Ravi V.K., Varsha P.V. and Satyam S. 2014. Review on *Thymus vulgaris* traditional uses and pharmacological properties. Medicinal Aromat. Plants. 3:1-3.

Rajkowska K., Nowicka-Krawczyk P. and Kunicka-Styczynska A. 2019. Effect of clove and thyme essential oils on *Candida* biofilm formation and the oil distribution in yeast cells. Mol. 24:1-12.

Ramage G., Martínez J.P., López-Ribot J.L. 2006. *Candida* biofilms on implanted biomaterials: a clinically significant problem. FEMS Yeast Res. 6:979-986.

Sakkas H. and Papadopoulou C. 2007. Antimicrobial activity of basil, oregano, and *Thyme essential* oils. , J. Microbiol. Biotechnol. 27:429-438.

Scalas D., Mandras N., Roana J., Tardugno R., Cuffini A.M., Ghisetti V., Benvenuti S. and Tullio V. 2018. Use of *Pinus Sylvestris L. Pinaceae, Origanum vulgare L. Lamiaceae,* and *Thymus vulgaris L. Lamiaceae* essential oils and their main components to enhance itraconazole activity against azole susceptible/not- susceptible *Cryptococcus neoformans* strains. BMC Complement. and Alt. Med. 18:1-13.

Trombetta D., Castelli F., Sarpietro M.G., Venuti V., Cristani M., Daniele C., Saija A., Mazzanti G., Bisignano G. 2005. Mechanisms of antibacterial action of three monoterpenes. Antimicrob. Agents Chemother. 49:2474-2478.

Wang D., Zhang J., Jia X., Xin L. and Zhai H. 2019. Antifungal effects and potential mechanism of essential oils on *Collelotrichum gloeosporioides* in vitro and in vivo. Mol. 24:3386.

Wińska K., Mączka W., Łyczko J., Grabarczyk M., Czubaszek A. and Szumny A. 2019. Essential oils as antimicrobial agents- myth or real alternative?. Mol. 24:1-21.

Zhu Y., Huang W.E. and Yang Q. 2022. Clinical perspective of antimicrobial resistance in bacteria. Infect. and Drug Resist. 15:735-746.

****