

ANTIBACTERIAL PROPERTIES OF ESSENTIAL OILS AND THEIR POTENTIAL APPLICATIONS IN FOOD- A SYSTEMATIC REVIEW

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Abstract

Essential oils have used in a highest rate in the present days. Food industry has its highest uses based on their anti-bacterial and antioxidant property. Important articles' have chosen in this regard to conduct the study. Henceforth, the important chemical methodologies are hydrodistillation, chromatography and chemical analysis. Moreover, all of the chemical components have analyzed based on such methods. Transmission and scanning electron microscopy have used to measure the property of chemical components. Hence, it has said that all of the essential oils have used at a highest rate in the present days to increase the revenue for the country.

Keywords: Essential oils; chemical; food safety; preservation; hydrodistillation

1. Introduction:

Essential oils (EO) have an important role towards the potential application in the food industry. Based on the antibiotic property, the essential oils have composed of antibacterial properties to kill the bacteria and parasites in the food. Moreover, they have also controlled the bacterial growth in the food. A moderate amount of lavender, peppermint, tea tree and ginger essential oils have created a slight change in the food quality, taste and safety. The volatile components of the essential oils have killed and reduced the bacterial growth in the food. Hence, the importance of essential oils has found for the antibacterial property for the food.

2. Background:

The natural and volatile bioactive components of the essential oils have required for killing the bacteria from the food. Essential oils have mostly derived from trees and herbs. In this regard, the preparation of them has increased at a higher rate in the present days. The development of essential oils based on bioactive components has shown their higher efficacy rate in the cosmetics, food and medical sector (Diniz do Nascimento et al. 2020).

(Source: statista, 2021)

Above figure has said that market value of essential oil was 17 billion USD in 2017 and that expectancy has increased to reach a value of 27 USD within 2022 (statista, 2021). On the other hand, 36% of tea tree oil has sold globally (statista, 2021). Tea tree oil has an importance towards antibacterial and antifungal properties. Therefore, based on the sales and revenue it has said that the food industry has used a higher number of essential oils as per requirement.



Figure 1: Market value of essential oils

Moreover, the food borne pathogens have reduced with the help of natural oils. The bioactive components such as zerumbone, limonene, caryophyllene, pinene and linalool have reduced the bacterial effect from the food. Most importantly, such bioactive compounds of essential oils have increased the anti-allergic property and immunity for humans (Cabral et al. 2021).

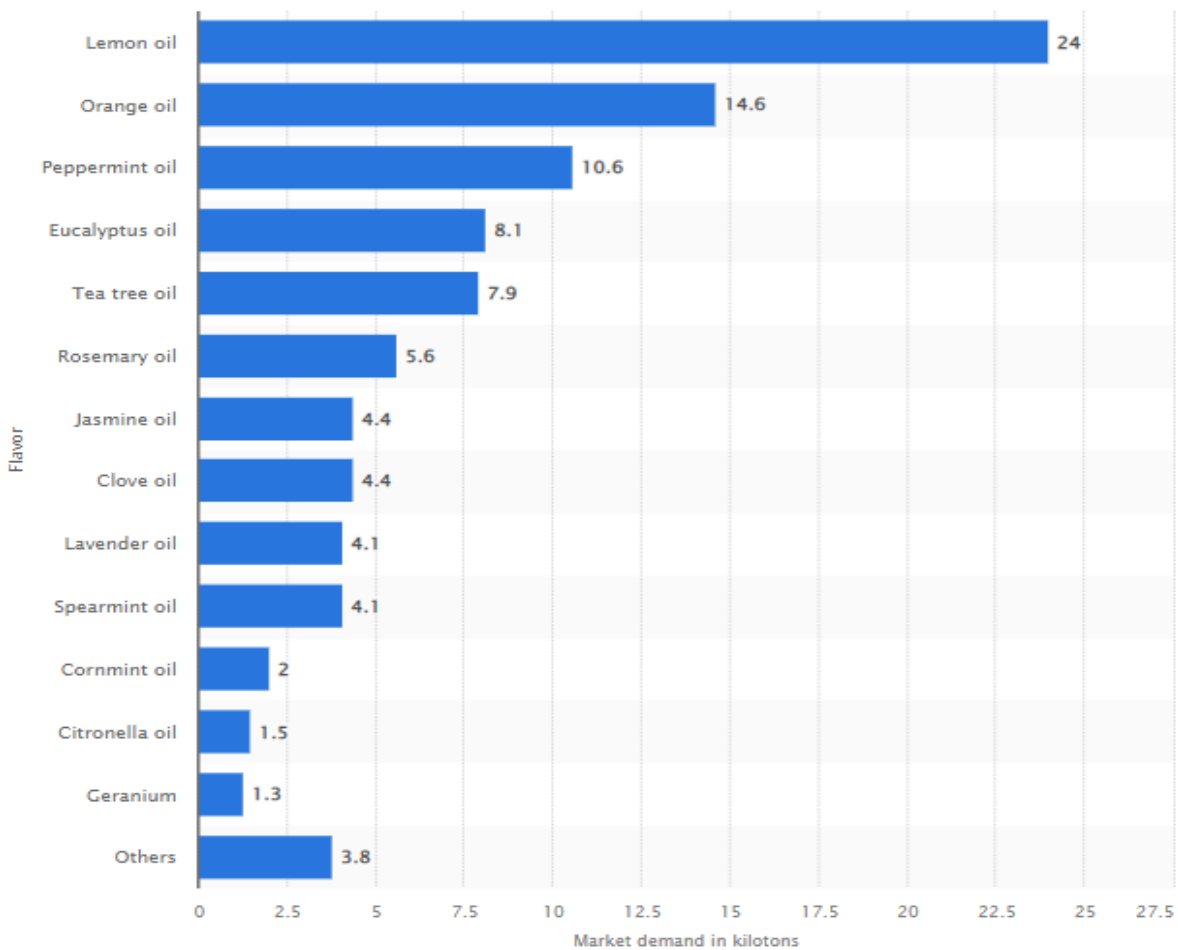


Figure 2: Demand of essential oils based on flavors in the United States

(Source: statista, 2021)

Based on the figure, it has noted that 24 kilotons of lemon oil has used at the highest rate (statista, 2021). However, orange, peppermint and tea tree oil has used at a rate of 14.6, 10.6 and 7.9 kilotons (statista, 2021). As per the observation, it has said that lemon, tea tree and eucalyptus oil has highest efficacy rate based on antimicrobial and antibacterial properties. Moreover, the essential oils have also used as food preservatives for cereals, grains, vegetables and fruits. The most important constituents of essential oils are terpenoids, curcumins, terpenes and carotenoids. Therefore, the essential oils have used as natural products for food safety and preservation. All of the essential oils have derived from natural sources such as plants and herbs (Pandey et al. 2017). Hence, the natural, safe and cost-effective products has expected for higher usage in future. The fungicidal and preservative properties of essential oils have increased the food safety as per its antioxidant property. On the other hand, the aromatic and aliphatic compounds of essential oils have risen in use in the good industry. The antioxidant activity has depended on the phenolic composition of the essential oils. Thus, it has secured the temperature, pH and flavorful properties of foods (Maurya et al. 2021).

3. Method:

The secondary resources from primary based articles have been selected based on the given topic of essential oils in the food industry. Systematic review method has undertaken for the research progress. All of the articles have selected from the last five years. On the contrary, the resources have selected from authenticated database sites such as PubMed and ProQuest. Such sites have chosen for the accurate, reliable and authentic research articles. Moreover, the articles have based on the use of essential oils in the food sector as per their safety, preservation and immunity creation. Therefore, the other articles have chosen also from ProQuest for verifying the topic accuracy. On the other hand, descriptive research design has selected for conducting the research. Such a study design has helped for deep analysis and verification of the research topic. On the other hand, primary five articles have chosen with the help of a purposive sampling method. The relevance and reliability of the research program has maintained with the help of such factors **[refer to appendix 1]**

Along with this the Boolean table has been used for proper identification of the keywords for the research that led to carry forward the present research **[refer to appendix 2]**.

4. Ethical considerations:

All of the sources has undertaken as per the given topic. The selected articles have based on the English language only. Moreover, the articles before the last five years have avoided ensuring the privacy and accuracy of the result. Therefore, the confidentiality of the research has secured with the help of an accurate password. The relevance of the components have undertaken as per the organizational research progress. Besides this, the languages from the selected articles have paraphrased for the creation of present research. No other natural products or animals have hurt at the time of data collection. Moreover, the permission from the organizations and government has secured for carrying out the research successfully.

5. Results:

Author	Year	Study design	Number of samples/resources
Aimad et al.	2021	Experimental study design	20 components of essential oils
Dzięcioł	2021	Experimental study design	3 essential oils with 8 fungi strains
Sedeek et al.	2021	Descriptive study design	4 essential oils from citrus foods
Strasakova et al.	2021	Cross-sectional study design	6 essential oils from polypropylene by caraway
Vasile et al.	2017	Descriptive study design	4 commercial essential oils with 3 fungi and bacterial strains

Table 1: Data extraction table

Authors	Study design	Measured outcomes	Result	Quality review
Aimad et al. (2021)	Experimental study design	Outcome has based on the formation of higher antibacterial and antifungal properties of essential oils from <i>Mentha pulegium</i> leaves.	Results have shown that extraction yield of the essential oils from <i>M. pulegium</i> leaves have shown higher inhibition to bacteria. Hence, the antibacterial property is higher in them.	This article has shown higher antibacterial, antifungal and antioxidant properties of <i>M. pulegium</i> essential oils.

<p>Dzięcioł (2021)</p>	<p>Experimental study design</p>	<p>The fungicidal activity of <i>Rosmarinus officinalis</i> essential oils have analysed and expected for higher antioxidant activity.</p>	<p>Results have based on the hydrodistillation method, chromatography and spectrophotometry. The efficiency of <i>R. officinalis</i> has shown higher antioxidant activity in 5% trisodium citrate and 5% citric acid solution as 12% and 21% than that of water hydrodistillation method.</p>	<p>This article research paper has shown higher antioxidant properties in citric acid (CA-HD) and trisodium citrate (TSC-HD) hydrodistillation methods than that of a standard isolation method.</p>
<p>Sedeek et al. (2021)</p>	<p>Descriptive study design</p>	<p>Expected outcome has based on the efficacy of citrus essential oils with the help of natural fungicides.</p>	<p>Citrus essential oils have shown strong defense against the phytopathogenic fungi. However, <i>Citrus lemon</i> and <i>Citrus aurantifolia</i> have identified for their synergistic effect based on the oxygenated hydrocarbon structure.</p>	<p>This article has shown strong potential activity for fungicidal management with the help of citrus essential oils.</p>

<p>Strasakova et al. (2021)</p>	<p>Cross-sectional study design</p>	<p>The outcome has based on the performance of caraway essential oil with the help of polypropylene matrix and antibacterial activity of <i>Escherichia coli</i> and <i>Staphylococcus aureus</i>.</p>	<p><i>Carum carvi</i> leaves are the important source of caraway essential oils. The result has shown higher food packaging safety with the help of <i>E.coli</i> and <i>S. aureus</i>. In this regard, attachment power of the chemical components of the essential oils has maintained the thermal stability of food.</p>	<p>This article has shown that essential oils have used to reduce the antimicrobial activity for food-borne diseases and safety ensure.</p>
<p>Vasile et al. (2017)</p>	<p>Descriptive study design</p>	<p>Measured outcome has based on the importance of thyme, rosemary, clove and tea tree oils for food safety and packaging.</p>	<p>Results have shown that the four important essential oils have shown higher antifungal properties against <i>F. graminearum</i>, <i>P. corylophilum</i>, <i>A. brasiliensis</i>, <i>S. aureus</i>, <i>E. coli</i> and <i>L. monocytogenes</i>.</p>	<p>This article has shown the importance of essential oils for natural food preservatives and safety.</p>

Table 2: Data synthesis table

Citation	Theme 1: Analysis of essential oil in food safety and preservation based on their chemical composition	Theme 2: Importance of scientific methodologies such as chromatography, dispersion and hydrodistillation method in essential oil	Theme 3: Evaluation of the antioxidant, antifungal and antibacterial properties of essential oils for food safety	Theme 4: Analysis of the chemical components of essential oils for food safety, preservation and packaging
Aimad et al. (2021)	Yes	Yes	Yes	Yes
Dzięcioł (2021)	Yes	Yes	Yes	No
Sedeek et al. (2021)	Yes	Yes	Yes	No
Strasakova et al. (2021)	No	No	Yes	Yes
Vasile et al. (2017)	Yes	Yes	Yes	Yes

Table 3: Axial coding table

6. Analysis:

Theme 1: Analysis of essential oil in food safety and preservation based on their chemical composition

Essential oils have required in food safety and preservation as per their chemical composition. The non-volatile and bioactive components have reduced the amount of bacteria and fungi from foods. On the other hand, another important aspect has observed for food preparation. Moreover, the presence of essential oils has increased the flavor of foods (Aimad et al. 2021). The important components such as terpenes, terpenoids and aliphatic products have reduced the rate of bacteria growth in food. Moreover, citrus and rosemary essential oils are highly important for food preservation. Such uses of natural products have increased the market demand of the essential oils (Sedeek et al. 2021).

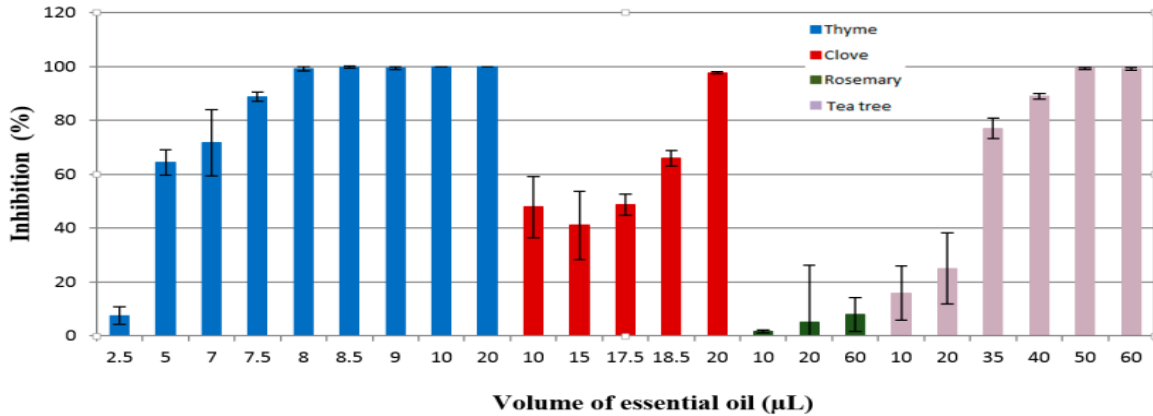


Figure 3: Graphical representation of essential oils for inhibition of *P. corylophilum*

(Source: Vasile et al. 2017)

This representation has shown that 8 µL of thyme essential oil has shown higher inhibition at 100% (Vasile et al. 2017). On the other hand, 100% inhibition rate has also observed at 20 µL and 50 µL of clove and tea tree essential oil (Vasile et al. 2017).

Theme 2:

Importance of scientific methodologies such as chromatography, dispersion and hydrodistillation method in essential oil

The efficacy of essential oils has done with the help of accurate scientific methods. In this regard, the hydrodistillation method based on citric acid and trisodium citrate has done to analyze the chemical components (Dzięcioł, 2021). On the other hand, chromatography has used to verify the action of volatile components such as limonene, acetone and methanol. Henceforth, it has stated that role of the chemical compounds are important for essential oil. The dispersion method has used to understand the method of activity of chemical components for food preparation. In this regard, scanning (SEM) and transmission (TEM) electron microscopy has used to analyze the homogeneity and chemical structure of the components (Sedeek et al. 2021).

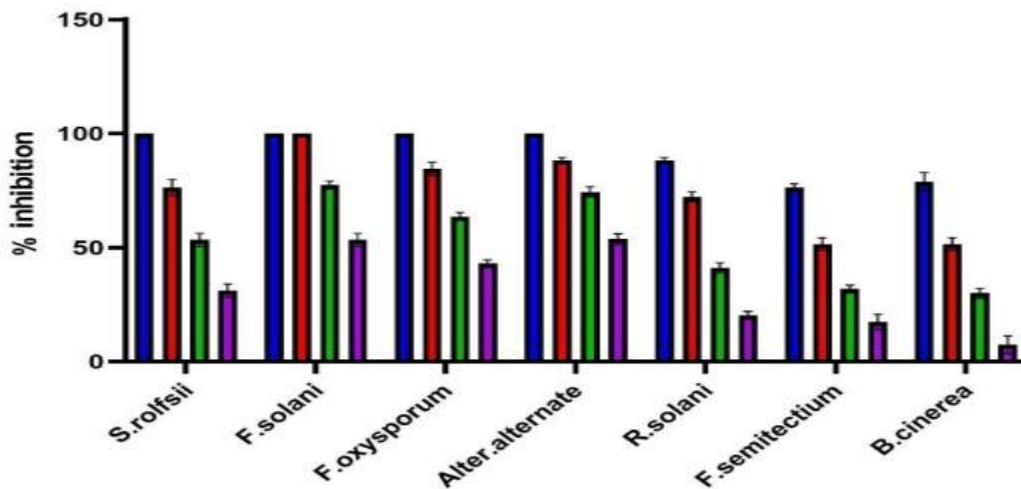


Figure 4: Inhibition of *C. lemon* essential oil by nano-hexosomal dispersion

(Source: Sedeek et al. 2021)

Based on the previous graphical representation, it has said that highest inhibition has observed at *S. rolfsii*, *F. oxysporum* and *F. solani*. The highest rate of inhibition has observed with a value of 100% (Sedeek et al. 2021).

Theme 3:

Evaluation of the antioxidant, antifungal and antibacterial properties of essential oils for food safety

Essential oils have also used for food preservation and safety for health purposes. In this regard, the chemical components of essential oils have regarded as food safety. On the other hand, the most popular used essential oils are thyme, clove, lavender and arborvitae. Therefore, the antibacterial and antifungal properties of the essential oils have increased the food safety.

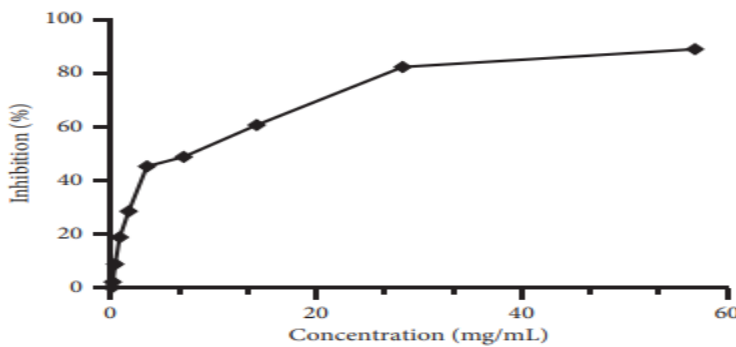


Figure 5:

Graphical representation of antioxidant test of essential oil from *M. pulegium* leaves

(Source: Aimad et al. 2021)

The above figure has shown that higher inhibition has observed with higher concentration of *M. pulegium* essential oil. Based on the observation, it has said that higher concentration of oil components has killed higher amount of bacteria. 60 mg/dl of *M. pulegium* essential oil has inhibited almost 90% of bacteria (Aimad et al. 2021).

Theme 4:

Analysis of the chemical components of essential oils for food safety, preservation and packaging

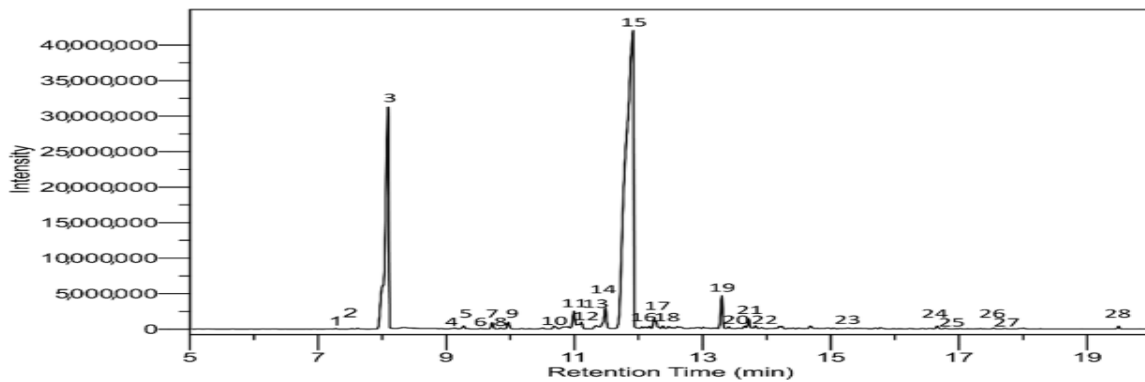


Figure 6:

Chromatographic representation of *Carum carvi* essential oil

(Source: Strasakova et al. 2021)

Based on the above figure, the caraway essential oil has shown its higher activity on the bacteria at 12-minute retention time after the preservation technique (Strasakova et al. 2021). Hence, it has stated from the analysis that most of the bacteria has killed at the time of 12-minute retention time.

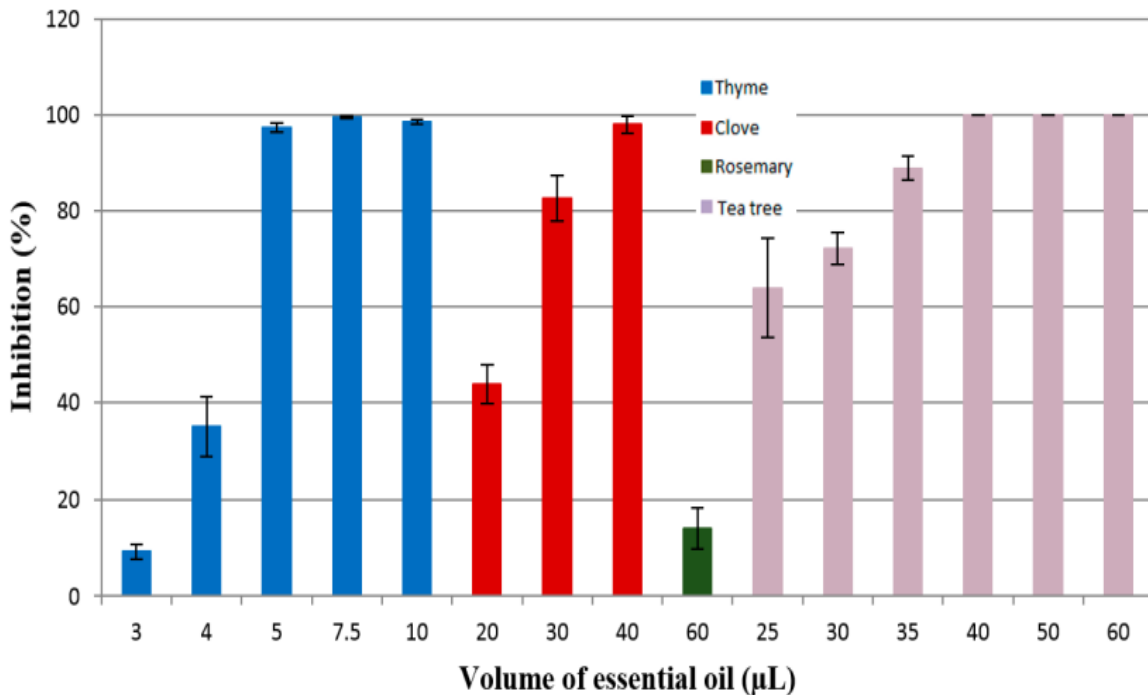


Figure 7:
Graphical representation of essential oils for inhibition of *A. brasiliensis*

(Source: Vasile et al. 2017)

The graphical representation has shown that highest inhibition has observed for thyme, clove and tea tree essential oils. 7.5 uL of thyme essential oil has shown 100% inhibition (Vasile et al. 2017). However, 40 uL and 50 ul of clove and rosemary essential oils have shown higher inhibition rate of 100% (Vasile et al. 2017).

7. Discussion:

The importance of essential oils has shown as per its antibacterial, antifungal and antioxidant properties. In this regard, the study has shown that tea tree, thyme and clove oils have secured higher benefits for food security and preservation. On the other hand, citrus essential oils have increased its demand based on higher inhibition towards bacteria (Bora et al. 2020). Rhizome essential oil has also shown its importance in the agricultural sector and their food application. Therefore, in the agriculture sector, food preparations have higher importance with the help of antioxidant properties (Ibáñez & Blázquez, 2021). On the contrary, nanoparticles of the chemical compounds have highlighted for its strong inhibition towards the fungi and bacteria. As a result, tea tree and clove essential oils have used for food preservation (Maria Graça Miguel et al. 2020).

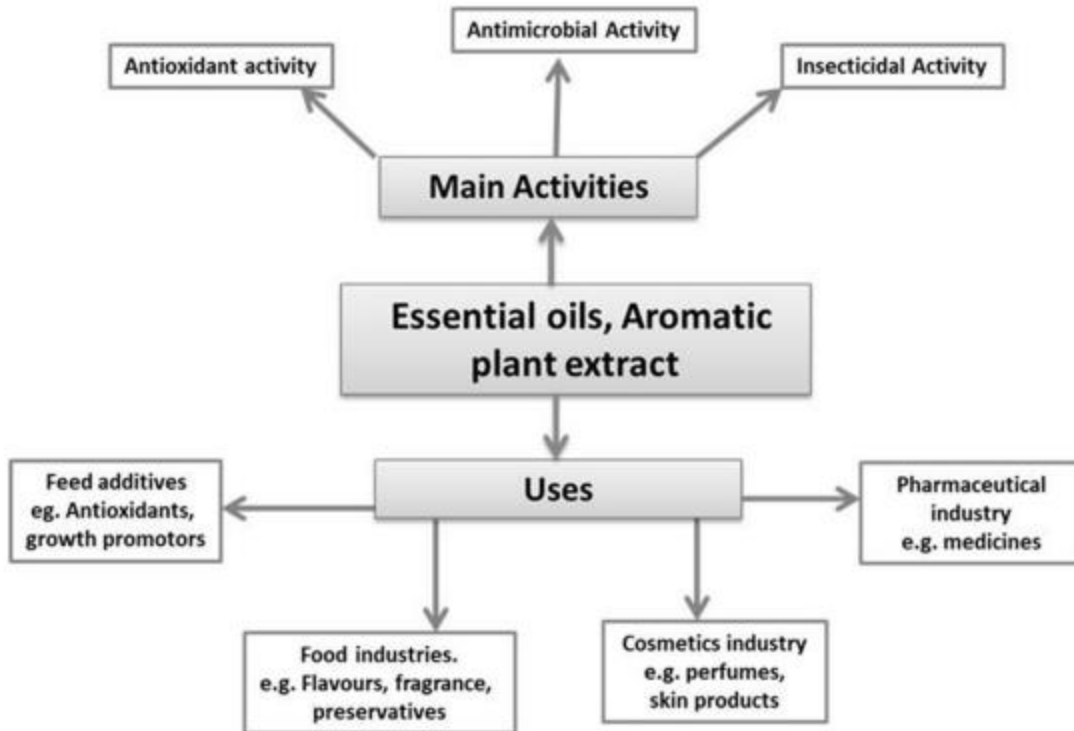


Figure 8: Important uses of essential oils in different sector

(Source: Pandey et al. 2017)

The importance of the essential oils has observed in this regard. Therefore, the essential oils have used as food preservatives, flavored products and in medicines (Pandey et al. 2017). Based on the future perspectives, the importance of essential oils has required for the food industry. Therefore, with the help of antimicrobial properties, the usage of essential oils has needed. The observation from the result has shown that essential oils are important for its food safety. Hence, the essential oils with higher inhibition rate towards bacteria has required for the present research (Chouhan et al. 2017).

8. Conclusion:

Use of essential oils in the food industry has based on its antibacterial and antioxidant properties. In this regard, the volatile and bioactive components of it have measured with the help of hydrodistillation and chromatographic methods. On the other hand, the importance has observed mostly in thyme, tea tree, basil and clove oil as per their antifungal property. Moreover, the rosemary oil has highlighted for its flavored nature. Henceforth, the chemical components have shown their importance based on the inhibition nature towards bacteria and fungi. However, the food contamination and diseases have reduced with the help of such natural and cost-effective products. Bioactivity of essential oils has increased the food quality with the help of proper preservation.

9. Research limitations:

This research has based on the analysis of essential oils in the food industry. The potential applications of essential oils have based on the activity of chemical components. In this regard, the research has

based on the chemical components so that their volatile activities have considered. On the other hand, chemical composition and food packaging has not considered in the present research. On the other hand, the flavors of essential oils based on their aliphatic compounds have not considered in this research study.

10. Future scope:

The research study has based on the analysis of chemical components of the essential oils. In this regard, the importance based on essential oil usages has a vast usefulness in the near future. As per the antibacterial property of essential oils, thyme and tea tree oils have secured the most importance. Therefore, this research has based on higher revenue in case of essential oils as per the market demand.

Acknowledgement:

I would like to thanks to my professor who assisted and provide guidance for this research. The project could not have been possible without prior guidance. I would also like to express my gratitude towards researches whose excellent works has assisted me to complete the work.

Thanking you

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Appendices:
Appendix 1: Database

PubMed.gov Search: essential oils and their potential applications in food

Advanced Create alert Create RSS User Guide

Save Email Send to Sorted by: Best match Display options

MY NCBI FILTERS 390 results Page 1 of 39

RESULTS BY YEAR: 2017-2021

TEXT AVAILABILITY: Abstract Free full text Full text

ARTICLE ATTRIBUTE: Associated data

1 article found by citation matching

Comparative Analysis of the Composition and Active Property Evaluation of Certain Essential Oils to Assess their Potential Applications in Active Food Packaging. Vasile C. et al. Materials (Basel). 2017. PMID: 28772407 Free PMC article.

1 Bioactive Natural Compounds and Antioxidant Activity of **Essential Oils** from Spice Plants: New Findings and **Potential Applications**. Cite: Diniz do Nascimento L, Moraes AAB, Costa KSD, Pereira Galúcio JM, Taube PS, Costa CML, Neves Cruz J, de Aguiar Andrade EH, Faria LJG. Biomolecules. 2020 Jul 1;10(7):988. doi: 10.3390/biom10070988. PMID: 32630297 Free PMC article. Review. In general, these plants have formed the basis of traditional medicine and some of their derived substances have been utilized to treat different human diseases. **Essential oils** (EOs) obtained from these plants have been also used as therapeutic agents and have shown ...

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Essential Oils in Food Preservation, Flavor and Safety 65 results

Applied filters: 2017-2021

Sorted by: Relevance

Limit to: Full text Peer reviewed

1 Current Trends of **Food Analysis**, **Safety**, and **Packaging**. Modi, Bindu; Timilsina, Hari, Bhandari, Sobika, Achhami, Ashma, Pakka, Sangita, et al. International Journal of **Food Science**; Cairo Vol. 2021, (2021). ... 4. **Food Safety Foods** are being adulterated in various ways. Various hazardous... **food quality** and its **safety** is **essential** to deal with public health [2]. **Food**... challenges in **food product safety** is accurately portraying precise information...

2 Application of Natural Preservatives for Meat and Meat Products against **Food-Borne Pathogens** and Spoilage Bacteria: A Review. Yu, Hwan Hee; Young-Wook, Chin; Hyun-Dong Paik **Foods**; Basel Vol. 10, Iss. 10, (2021): 2418. ...Rosemary has been used as a spice and flavoring agent in **food** [65]. Rosemary...vulgaris) is regularly used in Mediterranean **foods**. The oregano **essential oil**... in extracts and **essential oils** have been performed [17]. To solve these...

ProQuest Coronavirus Research Database

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essential oils in food 2,162 results

Applied filters: 2017-2021

Sorted by: Relevance

Limit to: Full text Peer reviewed

1 Curcuma longa L. Rhizome **Essential Oil** from Extraction to Its Agri-Food Applications. A Review. **Plants**; Basel Vol. 10, Iss. 1, (2021): 44. ...of C. longa **Essential Oil** Obtained from Rhizomes in the Agri-Food Industry... In fact, the addition of turmeric **essential oil** in edible coating films could... **essential oil** for **food** crops, a great challenge in the search for natural...

2 Fleeting Beauty—The World of Plant Fragrances and Their Application. Kilszcz, Angelika; Danel, Andrzej; Pula, Joanna; Barabasz-Krasny, Beata; Mozdzeń, Katarzyna. **Molecules**; Basel Vol. 26, Iss. 9, (2021): 2473. ...times. Finally, the fat saturated with **essential oils** is mixed with alcohol in...together in the alembic and vaporised **essential oils** and steam are condensed...it in extractions of antioxidants, dyes or **essential oils** from plant material...

**Appendix 2:
Boolean table**

Keywords	AND/OR	Keywords	AND/OR	Keywords
Chemical components	AND	Essential oil	OR	Chemical components of essential oil
Food safety and preservation	AND	Essential oils	OR	Food safety and preservation by essential oils
Antioxidant and antibacterial nature	AND	Essential oils	AND	Antioxidant and antibacterial nature of essential oils